Pulmonary hypertension (PH) is defined as abnormally increased pressure within the pulmonary vasculature (arterial, venous, or both).\(^1\) Typically, PH is a chronic and progressive disease where structural changes to the pulmonary circulation lead to increased pulmonary vascular resistance and may then result in right-sided heart failure and, in some cases, even death.\(^2\) The important pathophysiological features of PH include endothelial abnormalities, excessive vasoconstriction, vascular remodeling, and thrombosis.\(^2\)\(^,\)\(^5\)\(^,\)\(^6\)

The role of coagulation disturbances in the development and progression of PH is contentious. In human medicine, PH patients have demonstrated dysregulated hemostasis and platelet function abnormalities,\(^4\)\(^,\)\(^7\)\(^,\)\(^8\) including both hypocoagulable (diminished platelet aggregation, defective thrombin formation capacity, and accelerated rate of clot lysis) and procoagulable states.\(^2\)\(^,\)\(^3\)\(^,\)\(^4\)\(^,\)\(^9\)\(^,\)\(^10\) The relationship between coagulation abnormalities and the development and progression of PH remains unclear.

OBJECTIVE
To describe coagulation profiles in dogs with echocardiographic evidence of pulmonary hypertension (PH), to compare them to coagulation profiles in dogs without echocardiographic evidence of PH, and to determine the relationship between coagulation profiles and echocardiographic probability of PH.

ANIMALS
66 dogs with PH (cases) and 86 dogs without PH (controls).

METHODS
Retrospective evaluation of records between 2013 and 2021 of dogs that had both an echocardiogram and a coagulation panel performed within 7 days. Dogs that received antithrombotics within 7 days of evaluation and dogs diagnosed with congenital or acquired coagulopathy or other severe systemic disease that could lead to coagulopathy were excluded. Dogs with a low echocardiographic probability of PH were also excluded. The dogs were divided into a PH group and non-PH group based on echocardiographic results. Demographic, clinicopathologic, and traditional coagulation parameters and VCM Vet (Entegrion) parameters were compared between the 2 groups.

RESULTS
Dogs with PH were significantly older (median, 11 years vs 9.5 years, \(P = .02\)) and had a significantly lower body weight (median, 7.3 kg vs 19.3 kg, \(P < .001\)) than controls. Dogs with PH also had a significantly greater percent increase in prothrombin time (PT; \(P = .02\)), partial thromboplastin time (PTT; \(P < .0001\)), and fibrinogen (\(P = .045\)); however, their antithrombin concentration was lower (\(P = .005\)) compared to controls. Eight of 65 dogs (12.3%) in the PH group and 1/86 (1.2%) dogs in the non-PH group had an elevation of PT and/or PTT greater than 50% above the reference interval (\(P = .005\)). Dogs with PH had 11.9 times (95% CI, 1.5 to 97.9; \(P = .02\)) greater odds of being hypocoagulable than dogs without PH based on PT and PTT.

CLINICAL RELEVANCE
This study demonstrated an association between a moderate to high echocardiographic probability of PH and a hypocoagulable state in dogs as determined by traditional coagulation assays. It underscores the importance of monitoring the coagulation status in canine patients with PH, particularly before initiating antithrombotic medications.

Keywords: pulmonary hypertension, traditional coagulation profile, small animal, dog, hypocoagulability

Received November 10, 2023
Accepted January 21, 2024
doi.org/10.2460/ajvr.23.11.0252

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as well as hypercoagulable (impained fibrinolysis, platelet hyperactivation) phenotypes. A hypocoagulable state identified in some people with chronic PH might be secondary to chronic activation of the patients’ procoagulant pathways that could lead to the exhaustion of coagulation factors and, consequently, to their diminished hemostatic capacity.

To the authors’ knowledge, there are no published studies in veterinary medicine that investigate coagulation abnormalities in client-owned animals with PH. In one unpublished prospective observational case-control study (presented as an abstract), the authors assessed platelet activation, platelet-leukocyte interactions, and thromboelastography (TEG) in dogs with PH. They demonstrated that dogs with PH had hyperreactive platelets that could increase the chance of platelet-leukocyte aggregate formation; however, there were no significant differences in TEG parameters between dogs with and without PH.

The objectives of the present study were to describe coagulation profiles in dogs with echocardiographic evidence of PH, to compare them to coagulation profiles in dogs without echocardiographic evidence of PH, and to determine the relationship between coagulation profiles and echocardiographic probability of PH. We hypothesized that a proportion of dogs with PH would have a hypocoagulable phenotype that could be diagnosed via traditional coagulation assays.

Methods

Case selection

Retrospective evaluation of records was performed in dogs that presented to a small animal teaching hospital between 2013 and 2021 that had both an echocardiogram and a coagulation panel performed within 7 days of each other. No ethical approval was required according to the local institutional policies. The following criteria were used for exclusion: dogs that received any antithrombotic agents within 7 days of evaluation, dogs diagnosed with congenital or acquired coagulopathy or severe systemic disease that could lead to coagulopathy (anaphylaxis, heat stroke, liver failure, disseminated intravascular coagulation, and anticoagulant toxicity), and dogs with a low echocardiographic probability of PH. Dogs diagnosed with comorbidities that could promote a hypercoagulable state (eg, hyperadrenocorticism, protein-losing nephropathy) were not excluded. In dogs with echocardiography and coagulation testing performed on multiple visits, the echocardiographic and bloodwork results from the first visit when PH was diagnosed were used for analysis. Dogs were divided into a PH group and non-PH group based on echocardiographic results.

Procedures and data collection

Data collected from the medical records included signalment, medication history, body weight, presence or absence of left-sided heart disease, heartworm disease, and pulmonary thromboembolism (PTE). All other comorbidities identified during review of the medical record were grouped into the following categories: respiratory, cardiovascular, renal/urogenital, gastrointestinal/hepatobiliary, endocrine, musculoskeletal, neoplastic, neurologic, hematologic, and infectious.

Clinicopathologic data recorded included WBC count, neutrophil count, platelet count, Hct, albumin, urine protein-to-creatinine ratio, prothrombin time (PT), partial thromboplastin time (PTT), concentration of fibrinogen (determined by the Clauss method), antithrombin III, and D-dimers. When available, VCM Vet (Entegrion) results were also recorded, including clot time (CT), clot formation time, α-angle, maximum clot firmness (MCF), and lysis indices at 30 and 45 minutes after CT. Percent change from the upper reference intervals (RIs) for PT, PTT, and fibrinogen was used for comparison between the groups because new RIs were introduced to the local facility in 2018, preventing direct comparison of absolute values. Any values within the RI are reported as zero change. Additionally, a comparison of the proportion of dogs presented before and after 2018 was performed, offering insight into the impact of the RI and coagulation analyzer transition on the analyses. Before 2018, the IL ACL 9000 coagulation analyzer was employed for coagulation assessments. Subsequently, post-2018, the ACL TOP 300 CTS by Werfen became the designated coagulation analyzer. Dogs were diagnosed as hypercoagulable if the PT or PTT measurements were greater than 50% (hypocoagulable ≥ 50%) above established RIs. When VCM Vet results were available, samples were considered hypercoagulable if the MCF value was above the upper end of the established RI for the analyzer and hypocoagulable if the MCF value was lower than the low end of the RI.

All echocardiographic examinations at the authors’ institution are performed by board-certified cardiologists. A standard transthoracic echocardiogram includes 2-D, M-mode, and Doppler imaging obtained from dogs restrained in right and left lateral recumbency. Echocardiographic reports for all dogs in the study were reviewed and initially categorized as being in the PH group or the non-PH group based on final diagnoses made by the attending cardiologist or cardiology resident at the time of evaluation. Stored images, cine loops, and echocardiographic reports of all dogs identified as having PH were then retrospectively reviewed by a board-certified cardiologist (SW). Current consensus guidelines were utilized to confirm the diagnosis of PH and categorize cases into a low, moderate, or high probability of PH based on the peak tricuspid regurgitation velocity and the number of different anatomic sites that exhibited echocardiographic signs of PH:

- Low probability (< 3 m/s and 0 to 1 anatomic sites with echocardiographic signs of PH)
**Results**

**Population baseline characteristics**

A total of 152 dogs were included in the study, with 66 dogs in the PH group and 86 dogs in the non-PH group. In the PH group, breeds included Dachshund (n = 9), Chihuahua (7), Yorkshire Terrier (6), Toy Poodle (4), Boston Terrier (4), Shih Tzu (4), Rat Terrier (3), Welsh Corgi (3), Brussels Griffon (3), Maltese (3), mixed breed (3), Australian Shepherd (3), Jack Russell Terrier (3), West Highland White Terrier (2), Pit Bull (2), and 1 dog from each of the following breeds: Golden Retriever, Dogue de Bordeaux, Siberian Husky, Fox Terrier, Smooth Coated Collie, Frenchie Terrier, Great Pyrenees, Pug, Boxer, Goldendoodle, Miniature Poodle, and Scottish Terrier. In the non-PH group, breeds included Labrador Retriever (n = 11), mixed breed (7), German shepherd (5), Cocker spaniel (4), Cavalier King Charles spaniel (3), Shetland Sheepdog (3), Boxer (3), Dachshund (3), Schnauzer (2), Beagle (2), Poodle (2), Miniature Schnauzer (2), Golden Retriever (2), Labradoodle (2), Great Pyrenees (n = 2), Doberman Pinscher (n = 2), and 1 dog from each of the following breeds: Miniature Poodle, Saluki, English Springer Spaniel, Bull Mastiff, Collie, English Bulldog, Rhodesian Ridgeback, Great Dane, Mastiff, Staffordshire Terrier, Border Collie, Pit Bull Terrier, Rat Terrier, Italian Greyhound, Saint Bernard, Bernese Mountain Dog, Blue Heeler, Shiba Inu, Chihuahua, Lhasa Apso, Toy Poodle, Greyhound, Yorkshire Terrier, Havanese, and Irish Wolfhound.

There was no difference in sex distribution between the groups. Dogs with PH were significantly older (P = .02) and had a significantly lower body weight (P < .001) compared with the non-PH group. Dogs with PH also had significantly higher WBC count (P < .001), neutrophil count (P < .001), and Hct (P = .007) than dogs without PH, and they were more likely to have been evaluated before 2018 (Table 1).

In the PH group, respiratory diseases were the most frequently reported comorbidities (21/66 dogs [31.8%]), whereas renal or urogenital disorders were the most commonly reported comorbidities in the non-PH group (26/86 dogs [30.2%]; Figure 1).

**Echocardiographic PH probability and etiologic classification of PH**

Out of 66 dogs with PH, 17 (25.8%) had intermediate probability and 49 (74.2%) had a high probability of PH. The etiologic PH group could be determined in 57/66 dogs, with dogs categorized as group 4 (pulmonary embolic/thromboembolic disease) being the most common (23/57 dogs [40.4%]). One of 57 dogs (1.8%) was categorized as group 1 (PAH), 6/57 dogs (10.5%) as group 2 (left-sided heart disease), 12/57 (21.1%) as group 3 (respiratory disease/hypoxia), 7/57 (12.3%) as group 5 (parasitic disease), and 8/57 (14.0%) as group 6 (multifactorial). Sixty dogs (90.9%) were determined to have precapillary PH and 6 dogs (9.1%) had postcapillary PH. There

**Statistical analysis**

Data were recorded on the Microsoft Excel version MS Office 2019. For the descriptive analysis, quantitative variables were expressed as mean (SD) or median (range) depending on whether the data was normally distributed. To evaluate the distribution of the variables, histograms and the Shapiro-Wilk test were used. Statistical analysis was performed using commercial software (SAS 9.4; SAS Institute Inc). For categorical variables, the absolute and relative frequencies were reported. To compare differences in quantitative variables between the 2 groups, the t test for independent data or the Wilcoxon rank-sum test was used. Categorical variables were compared using the Fisher exact test or $\chi^2$ test as appropriate, with the Fisher exact test applied when the frequencies in contingency tables were less than 5. A univariate logistic regression analysis was performed with hypocoagulability as the dependent variable and the presence of PH, postcapillary versus precapillary PH, or intermediate versus high probability of PH as independent variables. Demographic, clinicopathologic, and hemostatic data were preplanned for a priori comparisons. The comparison of urinary protein-to-creatinine ratio between dogs with and without PH and the analysis of platelet counts in dogs with suspected PTE versus those without PTE were conducted on a post hoc basis. These specific comparisons were not predetermined and were explored based on observed data during the course of our analysis. A P value of less than .05 was considered statistically significant.
was no statistical difference in coagulation profiles in dogs with intermediate versus high echocardiographic probability of PH or in dogs with pre- versus postcapillary PH.

**Hemostatic variables**

Dogs in the PH group had a significantly greater percent increase in PT ($P = .02$), PTT ($P < .0001$), and fibrinogen ($P = .045$); however, their antithrombin concentration was lower ($P = .005$) compared to dogs in the non-PH group (Figure 2). More dogs in the PH group had elevation of PT and/or PTT greater than 50% above the RI compared with dogs in the non-PH group ($P = .005$) (Table 2). Dogs with PH had 11.9 times (95% CI, 1.5 to 97.9; $P = .02$) greater odds of being hypocoagulable than dogs without PH based on PT and PTT.

Of all hypocoagulable dogs in both groups combined ($n = 9$), only 1 dog had elevated PT and 1 dog had prolongation of both PT and PTT, whereas all other hypocoagulable dogs had an isolated prolongation of PTT. Six of 8 hypocoagulable dogs in the PH group had suspected or confirmed pulmonary thromboembolism based on computed tomography or postmortem examination as the presumed cause of PH (group 4), 1 dog had respiratory disease/hypoxia (group 3), and 1 dog had multifactorial or unclear mechanisms of PH (group 6). There was no statistical difference in platelet count between the PH dogs with suspected pulmonary thromboembolism versus other etiologies of PH ($P = 0.34$).

Concurrent VCM Vet results were available in only 6 of 66 dogs in the PH group. One of 6 dogs with PH was hypocoagulable as determined by MCF; however, its PT and PTT were within reference limits. Five of 6 dogs had normal coagulation status as determined by MCF. Two of 6 dogs with PH had prolonged CT. One of these 2 dogs was considered hypocoagulable based on prolonged PTT $\geq 50\%$. VCM Vet results were also available in 31 of 86 dogs in the non-PH group. Three of 31 dogs without PH were hypocoagulable, 10 of 31 dogs were hypercoagulable, and 18 of 31 dogs had normal coagulation status as determined by MCF. Eight of 31 dogs without PH had prolonged CT, and none of these dogs had PT or

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**Table 1**—Demographic and clinicopathologic data of described dogs (Figure 1).

<table>
<thead>
<tr>
<th>Group 1 (PH)</th>
<th>Group 2 (control)</th>
<th>$P$ value</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>11 (0.3–17); n = 66</td>
<td>9.5 (1–15); n = 86</td>
<td>.016</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>7.3 (2.3–12.6); n = 65</td>
<td>19.3 (2.1–79); n = 86</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intact male</td>
<td>6/66 (9.1%)</td>
<td>10/86 (11.6%)</td>
<td>.68</td>
</tr>
<tr>
<td>Neutered male</td>
<td>19/66 (28.8%)</td>
<td>31/86 (36%)</td>
<td>.8</td>
</tr>
<tr>
<td>Intact female</td>
<td>6/66 (9.1%)</td>
<td>7/86 (8.1%)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Neutered female</td>
<td>35/66 (53%)</td>
<td>38/86 (44.2%)</td>
<td>.007</td>
</tr>
<tr>
<td>Patient presented after 2018</td>
<td>29/66 (43.9%)</td>
<td>78/86 (90.7%)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>WBC count (X 10$^3$/μL)</td>
<td>15.8 (6.8–44); n = 62</td>
<td>12 (4.1–54.9); n = 83</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Platelet count (X 10$^3$/μL)</td>
<td>299 (3–568); n = 57</td>
<td>290 (24–815); n = 81</td>
<td>.8</td>
</tr>
<tr>
<td>Neutrophils (X 10$^3$ cells/μL)</td>
<td>13 (5–39.6); n = 62</td>
<td>9.8 (2.8–51); n = 83</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Hct (%)</td>
<td>44.6 (20–65); n = 63</td>
<td>40 (10–55); n = 83</td>
<td>.007</td>
</tr>
<tr>
<td>Albumin (g/dL)</td>
<td>3.1 (1.9–4.6); n = 61</td>
<td>3.1 (1–4.2); n = 81</td>
<td>.4</td>
</tr>
<tr>
<td>UPC</td>
<td>0.42 (0–24); n = 27</td>
<td>0.86 (0–24.9); n = 16</td>
<td>.7</td>
</tr>
<tr>
<td>Proteinuria with UPC &gt; 0.5</td>
<td>13/27 (48.1%)</td>
<td>13/16 (81.3%)</td>
<td>.053</td>
</tr>
</tbody>
</table>

Data are reported as median (range) or proportion of dogs (%). $n =$ Number of dogs with available data. PH = Pulmonary hypertension. UPC = Urine protein-to-creatinine ratio.

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**Figure 1**—Distribution of comorbidities in dogs presented between 2013 and 2021 with (black) and without (gray) pulmonary hypertension (PH). Dogs were divided into a PH group and non-PH group based on echocardiographic results. Respiratory diseases were the most frequently reported comorbidities (21/66 dogs [31.8%]) in dogs with PH, whereas renal or urogenital disorders were the most commonly reported comorbidities in dogs without PH (26/86 dogs [30.2%]).
Figure 2—Box-and-whisker plots comparing percent change from the upper reference intervals (RIs) for PT (A), PTT (B), and fibrinogen (C) as well as absolute values of antithrombin III (D) and D-dimers (E) in the described dogs (Figure 1). Dogs in the PH group (red) had a significantly greater % increase in PT ($P = .02$), PTT ($P < .0001$), and fibrinogen ($P = .045$); however, their antithrombin concentration was lower ($P = .005$) compared to dogs in the non-PH group (blue). For each plot, the lower and upper boundaries of the box represent the 25th and 75th percentiles, respectively; the horizontal line in the box represents the median, and the whiskers represent the range. NH% = Normalized hemostasis percentage. PT = Prothrombin time. PTT = Partial thromboplastin time.
Table 2—Coagulation tests results in described dogs (Figure 1).

<table>
<thead>
<tr>
<th></th>
<th>PH group</th>
<th>Control group</th>
<th>P value</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT (% change*)</td>
<td>0 (0 to 63.2); n = 65</td>
<td>0 (-1.6 to 29.3); n = 86</td>
<td>.02</td>
<td>Wilcoxon rank sum</td>
</tr>
<tr>
<td>PTT (% change*)</td>
<td>0 (-8.6 to 264); n = 64</td>
<td>0 (-17.2 to 131); n = 86</td>
<td>&lt; .0001</td>
<td>Wilcoxon rank sum</td>
</tr>
<tr>
<td>D-dimers (ng/ml*)</td>
<td>517 (137 to 5,250); n = 61</td>
<td>510 (44 to 5,350); n = 80</td>
<td>.55</td>
<td>Wilcoxon rank sum</td>
</tr>
<tr>
<td>Antithrombin (NH4**)</td>
<td>96.3 (± 33.8); n = 66</td>
<td>112.4 (± 31); n = 85</td>
<td>.003</td>
<td>t test</td>
</tr>
<tr>
<td>Fibrinogen Clauss (% change*)</td>
<td>83.2 (−74.1 to 269); n = 64</td>
<td>45.1 (−49.1 to 269.1); n = 86</td>
<td>.045</td>
<td>Wilcoxon rank sum</td>
</tr>
<tr>
<td>Hypocoagulable &gt; 50%</td>
<td>8/65 (12.3%)</td>
<td>1/86 (1.2%)</td>
<td>.005</td>
<td>Fisher exact</td>
</tr>
</tbody>
</table>

Data are reported as median (range), mean (± SD), or proportion of dogs (%). Dogs were diagnosed as hypocoagulable if the PT or PTT measurements were greater than 50% above the established reference interval.

PT = Prothrombin time. PTT = Partial thromboplastin time. NH% = Normalized hemostasis percentage.

*Median (range). **Mean (± SD).

PTT prolongation. There was no statistical difference in the proportion of hypocoagulable dogs between the groups based on VCM Vet (P = 0.52).

Discussion

We hypothesized that a proportion of dogs with PH would have a hypocoagulable phenotype. The results of the current study demonstrated an association between dogs with a moderate to high echocardiographic probability of PH and a hypocoagulable state, as determined by traditional coagulation assays, supporting our hypothesis. Canine patients identified as having a moderately high echocardiographic probability of PH had significantly greater odds of exhibiting elevated PT or PTT ≥ 50% above the RI compared to dogs without PH. In people, PH can be associated with both hypercoagulable and hypocoagulable states; however, comparable veterinary studies investigating hemostatic abnormalities in canine patients with PH are lacking. Coagulation is a complex and dynamic process that has traditionally been described as 2 overlapping phases, primary and secondary hemostasis. Measurement of PT and PTT allows for assessment of secondary hemostasis, and prolongation of coagulation times is an indication of hypocoagulability and factor deficiencies. A cell-based model of coagulation consisting of initiation, amplification, and propagation has been suggested as a better reflection of in vivo coagulation. Viscoelastic testing, such as TEG, rotational thromboelastometry (ROTEM), and VCM Vet is able to measure the global viscoelastic properties of whole blood clot formation under low shear stress, assessing initiation to propagation and fibrinolysis. These tests can better evaluate hypercoagulability, as opposed to PT and PTT, which are designed to detect hypocoagulable states. Unfortunately, only 6 of 66 dogs with PH in our study had concurrent viscoelastic testing results available for review.

The results of this study suggest that dogs with PH may develop a hypocoagulable phenotype similar to people. One of the proposed explanations for these hemostatic derangements is that chronic injury to the pulmonary endothelium could result in chronic platelet and coagulation cascade activation. The chronic activation of the patients’ procoagulant pathways could lead to the exhaustion of coagulation factors and, consequently, to their diminished hemostatic capacity. Vrigkou et al demonstrated that people with PAH had mildly prolonged international normalized ratio and PTT in relation to healthy individuals, probably reflecting the mild coagulation abnormalities described above. In addition, these individuals had prolonged CT values on ROTEM that reflected a diminished ability to generate thrombin and therefore initiate clot formation.

In the current study, dogs in the PH group had a significantly greater percent increase in fibrinogen; however, antithrombin concentration was lower compared to dogs in the non-PH group. Fibrinogen is an acute-phase protein, and its liver synthesis increases in response to inflammatory cytokines such as IL-1 and IL-6. In a previous veterinary study, fibrinogen concentrations showed good discrimination between dogs with localized or systemic inflammation compared to healthy controls, based on receiver operator characteristic curves with area under the curves ranging from 0.868 to 0.906. Hennigs et al found that plasma fibrinogen concentrations were elevated in people with PH compared to non-PH patients who were suspected to have PH based on their clinical signs. On the other hand, antithrombin is a negative acute phase protein with production being decreased in the presence of inflammatory cytokines. The fact that dogs with PH in our study had significantly higher WBC and neutrophil counts than dogs without PH supports this theory. However, it is possible that other comorbidities that were present in dogs with PH resulted in a greater percent increase in fibrinogen and a decrease in antithrombin concentrations. Antithrombin can be decreased with protein-losing diseases like protein-losing nephropathy or enteropathy. In our study, 13 out of 27 dogs (48.1%) with PH and 13 out of 16 dogs (81.3%) with enteropathy or enteropathy. In our study, 13 out of 27 dogs (48.1%) with PH and 13 out of 16 dogs (81.3%) without PH were found to be proteinuric. However, the frequency and severity of proteinuria were not statistically different between the 2 groups.

Dogs with PH also had significantly higher Hct than dogs without PH. An increased Hct could prolong PT and PTT due to more dilution with citrate in the smaller volume of plasma present. In human medicine, some sources consider this as a possible contributing factor if Hct reaches a value of greater than 65%. In our study, the median value for Hct in the PH group was 44.6%, and none of the dogs had an Hct exceeding 65%. It was therefore unlikely that
Another limitation was the fact that we reported per-all dogs; thus, diagnoses could have been missed.

and exhaustive diagnostics were not performed on analysis due to the retrospective nature of the study, was not standardized across all dogs included in the result in changes to PT and PTT; however, testing cases that had apparent disease processes that could confounding effects. We were diligent in excluding echocardiographic probability of PH were not com-

sided heart disease is reported as one of the most nature, dogs with and without a moderate to high sided heart disease. In our study, dogs with hypercoagulable states (such as hyperadrenocorticism and protein-losing nephropathy) were not excluded. This decision was made because PTE plays a significant role in veterinary medicine as a cause of PH, a fact supported by a high proportion of dogs classified as group 4 in the current study.

Six of 8 hypo-coagulable dogs in the PH group had suspected or confirmed PTE as the main cause of PH. One possible explanation for this finding is that patients with PTE could have developed consumptive coagulopathy, as discussed earlier, that resulted in the prolongation of PT or PTT. To provide other evidence of consumption, we compared platelet count between the PH dogs with suspected PTE versus other etiologies of PH, but there was no statistically significant difference. Traditional coagulation assays were not designed to reliably detect hypercoagulable states, although a single veterinary study suggested that shortened PT or PTT may indicate the presence of a hypercoagulable state. While none of the 6 dogs with PH and available viscoelastic testing results in the present study had evidence of hypercoagulability, the case sample is too low to draw any conclusions.

Our study has a number of limitations, including its retrospective nature, a small sample size, and a single-center source. Due to its retrospective nature, dogs with and without a moderate to high echocardiographic probability of PH were not completely similar at baseline, which could have led to confounding effects. We were diligent in excluding cases that had apparent disease processes that could result in changes to PT and PTT; however, testing was not standardized across all dogs included in the analysis due to the retrospective nature of the study, and exhaustive diagnostics were not performed on all dogs; thus, diagnoses could have been missed. Another limitation was the fact that we reported percent change from the upper RIs for PT, PTT, and fibrinogen for comparison between the groups because new RIs were introduced at the authors’ institution in 2018, preventing direct comparison of absolute values. This approach enhances comparability across pre- and posttransition periods. However, it is crucial to acknowledge potential variations in sensitivity among different reagents and measurement methods. Different coagulation reagents may respond differently to factor deficiencies, cautioning against a direct interchange of percentage increases between tests. Finally, our study should be considered only as hypothesis generating. Future prospective studies will be required to globally assess all aspects of the hemostatic system in veterinary patients with PH.

In conclusion, dogs with a moderate to high echocardiographic probability of PH had a significantly greater increase in PT, PTT, and fibrinogen; however, their antithrombin concentration was lower compared to dogs in the non-PH group. Neither the degree of echocardiographic probability of PH nor the type of PH was associated with hypo-coagulability.

Acknowledgments

None reported.

Disclosures

The authors have nothing to disclose. No AI-assisted technologies were used in the generation of this manuscript.

Funding

The authors have nothing to disclose.

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AJVR