Article
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FAST ASSESSMENT OF PULMONARY HYPERTENSION TYPE IN DOGS USING BASIC ULTRASONOGRAPHY TECHNIQUES

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Abstract

Pulmonary hypertension (PH) is a complex hemodynamic condition defined by increased pulmonary vasculature pressure. The precise diagnostic can be obtained by evaluating the clinical status of the patient, performing complex imaging methods and by direct assessment of pulmonary arterial pressure. Invasive methods are considered golden standard; however, these techniques are limited in animals with respiratory failure. Previous studies aimed to evaluate the cut-off value of the PV/PA ratio in different types of PH in dogs. Therefore, the aim of this study is to correlate the type of PH with the changes of the pulmonary vein to pulmonary artery ratio (PV/PA) in dogs assessed by transthoracic echocardiography. The ratio was assessed using the right parasternal long axis view of the heart in B-mode and M-mode. This retrospective study included thirty-nine dogs presented for cardiologic examination at our Veterinary Teaching Hospital. Dogs were divided in three groups as following: control group (n=10), precapillary PH group (n=16) and postcapillary PH group (n=13). The median and interquartile range (M±IQR) of the PV/PA ratio were 0.95 (0.79–1.5) in the control group, 0.85 (0.55-0.92) in precapillary PH group and 1.86 (1.44-2.16) in the postcapillary PH group. The area under the curve (AUC) for the PV/PA ratio comparison between the control and postcapillary PH groups was 1 ($P<0.05$), suggesting a cut-off ratio of 1.17 for the postcapillary PH group. This value is lower than the previous suggested value (>1.7). The importance of this finding derives from the ability to observe early changes induced by PH in dogs diagnosed with different stages of myxomatous mitral valve disease (MMVD), even when the tricuspid regurgitating jet cannot be assessed.

Key words: pulmonary hypertension; precapillary; postcapillary; pulmonary vein; pulmonary artery; PV/PA ratio.

INTRODUCTION

Pulmonary hypertension (PHT) is defined by increased pressure in the pulmonary vasculature and represents a pathophysiological and hemodynamic status associated with cardiovascular, respiratory or systemic pathologies (Reinero et al. 2020). Assessing the severity of postcapillary PH is performed by evaluating the pulmonary artery wedge pressure (PAWP) by right heart catheterization. In veterinary medicine this invasive diagnostic method is not commonly used in the clinical setting, however the pulmonary arterial pressure is estimated by measuring the tricuspid regurgitation jet (Soydan et al. 2015). Another proposed ultrasonography technique for characterizing PH is assessing the right ventricular end-diastolic area (RVEDA) as an indicator for the right ventricle size and to evaluate the right ventricle systolic function assessing the tricuspid annular plane systolic excursion (TAPSE) and the fractional area change (FAC) (Vezzosi et al. 2018). Due to the fact that the measurement of tricuspid regurgitation jet is sometimes difficult to perform to animals in respiratory failure, and the evaluation of the right ventricle area and function require advanced ultrasonography techniques, this study aims to describe the changes of PV/PA ratio associated with PH using simple ultrasonography techniques. Two studies aimed to characterize the normal value of the PV/PA ration in dogs and concluded it is approximately equal to 1 (Merveille et al. 2015; Birettoni et al. 2016).

The PV/PA ratio has been described as a simple and reproducible measurement that may help discriminate dogs in congestive heart failure from asymptomatic dogs with MMVD, concluding that with advancing stages of the pathology the ratio will increase above 1.7 (Merveille et al. 2015). Another study which evaluated 76 dogs with varying degrees of precapillary PH concluded that the value of the ratio decreases proportionally to the severity of the disease (Roels et al. 2019). Decreased pulmonary vein diameter was speculated based on the decreased left ventricular pressure and increased pulmonary arterial

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resistance, on the compression of the vein caused by increased volume on the adjacent artery, or a combination of these factors. In West Highland white terrier (WHWT) dogs with PH consecutive to breed-specific pulmonary fibrosis, the ratio value was used for estimating the survival time (Roels et al. 2021). Subsequently, another study evaluated the ratio in dogs diagnosed with heartworm disease in order to estimate the severity of PH, concluding that a PV/PA value ≤0.845 is correlated to moderate and severe stages, with increased sensitivity and specificity values (Matos et al. 2023).

MATERIAL AND METHOD

This retrospective study included thirty-nine dogs presented for cardiologic examination at our Veterinary Teaching Hospital. Dogs were divided in three groups as following: control group (n=10), precapillary PH (prePH) group (n=16) and postcapillary PH (postPH) group (n=13) according to the ACVIM consensus (*table 1*) (Reinero et al. 2020). The population consisted of the following breeds: mixed-breed (25.64%; n=10), Maltese (15.38%; n=6), Yorkshire terrier (10.25%; n=4), Chihuahua, Retriever, Pekingese, Poodle, Shih Tzu, West Highland white terrier (WHWT) (5.12%; n=2 each), Beagle, German Shepherd, Mioritic Shepherd, Cocker, Pug, Spitz and Teckel (2.56%; n=1) each. The dogs which presented pericardial effusion have been excluded from this study.

Table 1

Characteristics of the studied population

	Control group	prePH group	postPH group
Age (y/o)	8.6±2.91	12.62±3.18	12.3±2.25
Weight (kg)	13.03±15.12	18.25±15.16	10.55±9.71
Gender (M/F)	9/1	10/6	10/3

The cardiac ultrasonography was performed using General Electric LOGIQ V5 Expert ultrasound machine equipped with two phased array probes (4-8 MHz and 1-4 MHz). The PV/PA ratio was assessed using the right parasternal long axis view of the heart in B-mode and M-mode (*figure 1)*. For each patient, the left atrium to aorta (LA/Ao) ratio and PV/PV ratio have been evaluated along with the PH type according to the ACVIM consensus. The data has been statistically analysed using the IBM® SPSS® software.

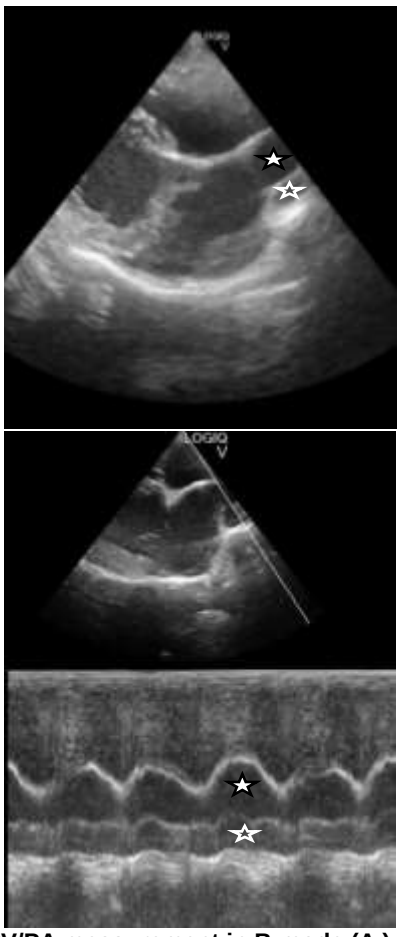

Figure 1 – PV/PA measurement in B-mode (A.) and M-mode (B.) ★ – pulmonary vein (PV); ☆ – pulmonary artery (PA)

RESULTS AND DISCUSSIONS

According to the ACVIM classification, the groups consisted of 41.02% dogs with precapillary PH and 33.33% dogs with postcapillary PH. The prePH group includes 12.5% dogs with arterial pulmonary hypertension (group 1), 15.38% dogs with PH due to respiratory disease (group 3) and 7.68% dogs with parasitic disease (group 5) secondary to *Dirofilaria immitis* infection. For 68.75% of the dogs included in the prePH group, investigations for establishing the cause of pulmonary hypertension have been declined by the owners, therefore these dogs could not be classified. All dogs included in the postPH group had PH due to left heart disease (group 2) and have been diagnosed with myxomatous mitral valve disease (MMVD) stages B2 and C according to the ACVIM consensus (Keene et al. 2018).

The median and interquartile range (M±IQR) of the PV/PA and LA/Ao ratios of each group are shown in *table 2.* The patients in the control group had a mean value of the PV/PA ratio approximately equal to 1, this finding being consistent with the literature (Merveille et al. 2015; Birettoni et al. 2016). The median value of 0.85

obtained for the prePH group is similar to the data obtained in previous studies (Matos et al. 2023). The postPH group had a higher median value compared to the cut-off described in the literature – 1.86 in our population compared to 1.7 (Merveille et al. 2015).

Table 2

Mean and interquartile range (M±IQR) of the PV/PA ratios

	Percentile		
	25	**50**	**75**
PV/PA ratio			
Total	**0.79**	**0.95**	**1.50**
Control group	0.85	0.95	1.08
prePH group	0.55	0.85	0.92
postPH group	1.44	1.86	2.16
LA/Ao			
Total	**1.22**	**1.42**	**1.87**
Control group	1.20	1.25	1.40
prePH group	1.16	1.28	1.46
postPH group	1.81	2.19	3.39

The LA/Ao ratio has not been previously assessed in dogs with PH, to the authors' best knowledge. However, the dogs included in the postPH group developed pulmonary hypertension due to left heart disease, therefore the left atrium will have a significant volumetric increase. In dogs with prePH it is expected to either have a normal volumetric LA or to have a volume decrease due to hypoperfusion. In the study population these assumptions have been confirmed.

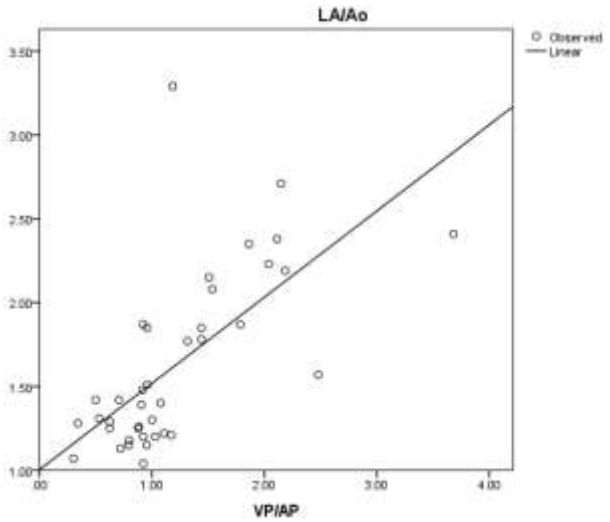

Figure 2 – Spearman R correlation of the LA/Ao ratio with the PV/PA ratio

Figure 2 depicts the Spearman R correlation of the LA/Ao and PV/PA ratios, indicating a moderate correlation between them, with increased significance. Thus, an increase of the LA/Ao ratio suggests an increase of the PV/PA ratio, as observed in the postPH group.

The statistical difference by non-parametric groups was assessed using the Kruskal-Wallis test and post-hoc pairwise comparison for multiple groups using the SPSS software. The result of the analysis of the PV/PA ratio between the evaluated groups emphasizes the statistically significant differences between the prePH - postPH groups ($P<0.05$) and the control - postPH groups ($P=0.004$). No statistical significance was observed for the prePH – control groups ($P=0.685$). Thus, the volumetric changes in the pulmonary vessels of the dogs diagnosed with precapillary PH did not indicate marked differences compared to the control group and a cut-off value could not be estimated.

The same methodology was used to compare the LA/Ao ratio between the three groups, showing a statistically significant difference between the same studied populations: prePH – postPH groups, respectively control – postPH groups ($P<0.05$), but no statistical significance for the pre-PH – control group.

Further analysis of the comparison between the control and postPH group has been performed by calculating the Area Under the Curve (AUC) and the value 1 ($P<0.05$) was obtained, indicating a very good predictability value. A cut-off ratio of 1.17 has been obtained for this class. The 95% confidence intervals for PV/PA values in postPH and control population are depicted in *figure 3* (Turcu 2023). The previously evaluated cut-off value of 1.7 has been proposed for patients with severe heart failure (International Small Animal Cardiac Health Council ISACHC class III) (Merveille et al. 2015). In our population the postPH group consisted of dogs with mild and severe left heart failure, stages B2 (23.07%) and C (76.9%) of MMVD according to the ACVIM consensus.

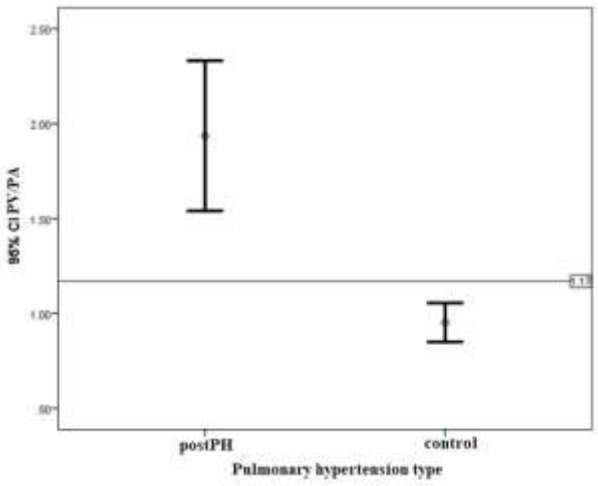

Figure 3 – 95% Confidence interval (95% CI) of the mean PV/PA values for the postPH and control groups

Further research is warranted to characterize the hemodynamic particularities of

patients with precapillary pulmonary hypertension, focusing on the tricuspid and/or pulmonary regurgitation jet assessment.

CONCLUSIONS

The evaluation of PV/PA ratio is a simple and feasible method used to assess the type of pulmonary hypertension in dogs in whom the tricuspid regurgitation jet cannot be properly evaluated.

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