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Systolic arterial blood pressure estimated by mitral regurgitation velocity, high definition oscillometry, and Doppler ultrasonography in dogs with naturally occurring degenerative mitral valve disease



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KEYWORDS

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Abstract *Introduction:* To determine if systolic blood pressure estimated by mitral regurgitation (MR) velocity can be used interchangeably with that estimated by high definition oscillometry (HDO) and Doppler ultrasonography (DU) in dogs with naturally occurring mitral valve disease (MVD).

Animals: Forty-nine client-owned dogs with naturally occurring MVD.

Materials and Methods: This is a retrospective study. Medical records were reviewed and dogs with MR caused by degenerative MVD were included if systolic blood pressure was estimated from MR velocity determined by continuous wave Doppler (CW), DU and HDO at the same visit. A Pearson product moment correlation coefficient was determined for each combination of measures and tested for significance with a paired *t*-test. Limits of agreement between 2 measures were determined by the 95% confidence interval of the average difference of the means and illustrated by Bland–Altman plots.

This work was performed at Oklahoma State University.

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Results: Systolic pressure estimated from CW was significantly but only moderately correlated to DU ($r = 0.42$, $p=0.0015$) and HDO ($r = 0.40$, $p=0.0021$). Pressure estimated from DU was significantly but only moderately correlated to HDO ($r = 0.57$, $p \leq 0.0001$). Limits of agreement were wide for all measures including DU and CW (-61.9 to 44.6 mmHg), HDO and CW (-65.2 to 26.9 mmHg), and HDO and DU (-63.1 to 42.06 mmHg).

Discussion: Systolic blood pressure estimated by CW cannot be used interchangeably with HDO or DU in dogs with naturally occurring MVD.

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Abbreviations

CW	continuous wave Doppler
DU	Doppler ultrasonography
HDO	high definition oscillometry
ISACHC	International Small Animal Cardiac Health Council
MR	mitral regurgitation
MVD	mitral valve disease
SD	standard deviation

Introduction

Blood pressure measurement is indicated in dogs with neurologic, renal, cardiac, and certain endocrine and ocular disease [1]. In addition blood pressure should be monitored at times of possible hypotension including during anesthesia and in the case of shock and critical illness. The 'gold standard' of assessing blood pressure in dogs is direct intraarterial measurement. This is invasive, requires special equipment and is technically challenging especially in awake, non-sedated dogs. As such, blood pressure is commonly measured by indirect means. The most commonly used indirect means of measurement include Doppler ultrasonography (DU), standard definition oscillometry, and high definition oscillometry (HDO). Both oscillometric devices analyze the effect of the arterial turbulence caused by the inflation of the cuff and subsequent oscillation generated. The HDO device allows for real-time visual inspection of the pulsatile arterial wave (Fig. 1) [2]. Inspection of the arterial wave may aid in screening for artifacts affecting the blood pressure measurements [2,3].

Measurement of systemic blood pressure in dogs is affected by many confounders. Breed, age, sex, body condition, recumbency and limb used, device used, and experience of the person obtaining the measurements may all affect blood pressure readings [4–7]. In addition white coat hypertension

can affect measurements [1,8,9]. Commonly blood pressure studies have been conducted on anesthetized dogs which cannot be extrapolated to non-anesthetized dogs. In one study, within day intra-observer variability for systolic blood pressure as measured by DU and HDO was 6.2%–10.0% and 8.6%–11.2%, respectively [5]. In the same study between day intraobserver variability was higher [5]. This degree of repeatability and reproducibility when the same device used in the same dog measured by the same person was considered good. This does not hold true when 2 different devices are used by the same person to measure blood pressure on the same dog. Multiple studies have shown unacceptably wide limits of agreement between results obtained from different modalities [5,10,11]. In addition, agreement decreases with hypertension or hypotension, which is when accurate blood pressure measurement is most crucial [10,12,13].

Degenerative mitral valve disease (MVD) is the most common cardiac disease of older dogs [14]. With longstanding and/or severe mitral regurgitation (MR), left atrial volume and pressure increases. This may lead to left atrial remodeling and enlargement and eventually left sided congestive heart failure. Increased systemic blood pressure or afterload may have deleterious effects on left sided heart pressures and MR. As such, blood pressure should be measured in all dogs with MVD. Echocardiography is commonly used to confirm MVD, to assess left sided heart remodeling, and to detect other common comorbidity or sequelae such as other valvular insufficiency, ruptured chordae tendinae, atrial tear, and pulmonary hypertension. Doppler echocardiography can also be used to measure MR velocity which can be used to estimate systolic arterial pressure. Mitral regurgitation velocity is directly related to the difference between left ventricular and left atrial pressures. This velocity can be used to estimate left ventricular systolic pressure by using the Bernoulli equation ($\text{pressure gradient} = 4 \times \text{velocity}^2$)

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