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Echocardiographic assessment of right ventricular systolic function in conscious healthy dogs: Repeatability and reference intervals

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Abstract *Objectives:* To determine the feasibility, repeatability, intra- and inter-observer variability, and reference intervals for 5 echocardiographic indices of right ventricular (RV) systolic function: tricuspid annular plane systolic excursion (TAPSE), fractional area change (FAC), pulsed wave tissue Doppler imaging-derived systolic myocardial velocity of the lateral tricuspid annulus (S'), and speckle-tracking echocardiography-derived global longitudinal RV free wall strain and strain rate. To explore statistical relationships between RV systolic function and age, gender, heart rate, and bodyweight.
Animals: 80 healthy adult dogs.
Methods: Dogs underwent 2 echocardiographic examinations. Repeatability and intra-observer and inter-observer measurement variability were quantified by average coefficient of variation (CV). Relationships between RV function and age, heart rate and bodyweight were estimated by regression analysis.
Results: All indices were acquired with clinically acceptable repeatability and intra- and inter-observer variability (CVs $< 10\%$). No differences were identified between male and female dogs. Allometric scaling by bodyweight demonstrated significant, clinically relevant correlations between RV function and bodyweight (all $p \leq 0.001$) as follows: TAPSE — strong positive correlation ($r^2 = 0.75$); S' — moderate positive correlation ($r^2 = 0.31$); strain rate — moderate negative correlation

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($r^2 = 0.44$); FAC and strain — weak negative correlations ($r^2 = 0.22$ and 0.14, respectively). Strain rate and FAC were positively correlated with heart rate ($r^2 = 0.35$ and 0.31, respectively). Allometric scaling generated bodyweight-based reference intervals for these RV systolic function indices.
Conclusions: Echocardiographic indices of RV systolic function are feasible to obtain, repeatable, and affected by bodyweight. Studies of these indices in dogs with cardiovascular disease are needed.

Abbreviations

2D	two-dimensional
CV	coefficient of variation
FAC	fractional area change
RV	right ventricular
S'	pulsed wave tissue Doppler imaging-derived systolic myocardial velocity of the lateral tricuspid annulus
SD	standard deviation
STE	speckle tracking echocardiography
TAPSE	tricuspid annular plane systolic excursion
TDI	tissue Doppler imaging

Introduction

The right ventricle is affected by a number of diseases, including pulmonary hypertension caused by lung disease, pulmonary vascular disease, or left-sided heart disease; right ventricular (RV) cardiomyopathies, such as arrhythmogenic RV cardiomyopathy; pericardial disease; pulmonary or tricuspid valve malformations; cardiac shunts; and complex congenital heart disease. The clinical recognition of RV dysfunction in veterinary medicine is underdeveloped and has traditionally relied on qualitative assessment or overt signs of right-sided congestive heart failure. The qualitative assessment of RV structure and function in human patients is inaccurate, with low interobserver agreement.[1] Consequently, measured and calculated indices that quantify RV function might be clinically useful in identifying the presence and progression of RV dysfunction.

The importance of the quantitative assessment of RV function is increasingly apparent in people affected with both cardiac and non-cardiac diseases.[2] Quantitative analysis of RV function provides prognostic data and guides the clinical decision-making process not only in right heart-specific diseases[3] but also left heart disorders, including mitral and aortic valve disease[4–6] and dilated cardiomyopathy,[7–12] often independent of pulmonary hypertension status. Similar studies of quantitative RV function in dogs could potentially be of similar clinical value. However, when compared to the left ventricle, the assessment of RV function is more difficult owing to its complex geometry. Specific anatomical challenges include separate inflow and outflow regions, prominent endocardial trabeculations, ventricular interdependence, and the marked load-dependence of most indices of RV function.[13]

Echocardiography is the most practical method for assessment of RV structure and function in veterinary medicine as it is noninvasive, readily available, relatively inexpensive, and does not require general anesthesia. Both guidelines and reference intervals are available for a number of RV echocardiographic indices in people.[14] Although each index has inherent advantages and disadvantages, nearly all human RV indices have been validated against a catheterization- or magnetic resonance imaging derived gold standard. These include the M-mode-derived tricuspid annular plane systolic excursion (TAPSE), the 2-dimensional (2D) correlate to RV ejection fraction — percent fractional area change (FAC), tissue Doppler imaging (TDI)-derived systolic myocardial velocity of the lateral tricuspid annulus (S'), and speckle-tracking echocardiography (STE)-derived strain and strain rate.[14–18]

Aside from TAPSE,[19] canine reference intervals for RV systolic function indices based on estimates of central tendencies in a large sample of the healthy canine population are lacking. Such reference intervals along with repeatability data are essential prior to widespread clinical application of echocardiographic indices in diseased dogs. As several echocardiographic indices of cardiac structure and function are known to be affected by age, gender and body size in humans[20–27] and in animals,[28–32] these variables also should be considered when establishing reference intervals. The impact of bodyweight particularly warrants