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Evaluation of tricuspid annular plane systolic excursion measured by two-dimensional echocardiography in healthy dogs: repeatability, reference intervals, and comparison with M-mode assessment

L.C. Visser, DVM, MS*, D.J. Sintov, BS , M.S. Oldach, DVM

Department of Medicine & Epidemiology, School of Veterinary Medicine, University of California, Davis, One Shields Ave, Davis, CA 95616, USA

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Abstract *Introduction:* We sought to determine the feasibility, measurement variability, and within-day repeatability of tricuspid annular plane systolic excursion (TAPSE) measured by two-dimensional echocardiography (2D TAPSE), generate reference intervals for 2D TAPSE, assess agreement and correlation between 2D TAPSE and the conventional TAPSE measured by M-mode echocardiography (MM TAPSE), and to assess the ability of 2D TAPSE to track a drug-induced decrease in right ventricular (RV) function compared with MM TAPSE.
Animals: Seventy healthy privately owned dogs of varying bodyweight.
Methods: All dogs underwent a single echocardiogram to quantify RV function by both TAPSE methods. Ten dogs underwent a second echocardiogram 2–3 h after the first to assess within-day repeatability, and 20 different dogs underwent a second echocardiogram 3-h after atenolol (1 mg/kg per os (PO)). Intraobserver and interobserver measurement variabilities were assessed in 12 randomly selected studies using coefficients of variation. Statistical relationships between 2D TAPSE and bodyweight, gender, heart rate, and age were explored.
Results: 2D TAPSE could be measured in all dogs. Coefficients of variation for repeatability and measurement variability were low (≤12%). Bodyweight-dependent reference intervals for 2D TAPSE were generated using allometric scaling. TAPSE

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* Corresponding author.
E-mail address: lcvisser@ucdavis.edu (L.C. Visser).

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methods were strongly correlated ($r = 0.72$; $p<0.0001$) but 2D TAPSE measured consistently less than MM TAPSE (−1.6 [2.2] mm) when analyzed by Bland−Altman's method. Both TAPSE methods were significantly ($p\leq0.014$) reduced after atenolol but percent decrease in 2D TAPSE (−16.2 [9.3]%) was significantly greater ($p=0.03$) than MM TAPSE (−7.5 [13.8]%).

Conclusions: Two-dimensional echocardiography TAPSE appears well suited for clinical assessment of RV function. The TAPSE methods should not be used interchangeably.

Abbreviations

2D	two-dimensional echocardiography
MM	M-mode echocardiography
PI	prediction interval
RV	right ventricular/ventricle
TAPSE	tricuspid annular plane systolic excursion

Introduction

The clinical value of the echocardiographic assessment of right ventricular (RV) systolic function in dogs with cardiovascular disease is becoming increasingly apparent [1−3]. Tricuspid annular plane systolic excursion (TAPSE) represents one attractive echocardiographic index of RV systolic function that appears to be well suited for routine clinical use, as it is easy to acquire and measure, and less dependent on optimal RV image quality and endomyocardial border resolution [4,5]. It is conventionally acquired using M-mode echocardiography (MM TAPSE) from a left apical 4-chamber view. The M-mode cursor is aligned through the RV apex to the lateral tricuspid annulus in the longitudinal plane to quantify the distance (in millimeters) the tricuspid annulus moves in systole. Several studies in a large number of healthy dogs have demonstrated its validity and repeatability, and bodyweight-dependent reference intervals have been published [3,6−8].

One disadvantage of MM TAPSE is its acquisition angle dependence. If the M-mode cursor is misaligned to the longitudinal axis of the RV or the RV does not lie along the axis of the ultrasound signal, the measurement may become inaccurate and misleading. One way to overcome misalignment is using the anatomic M-mode technique where one can generate M-mode studies independent of the ultrasound signal on previously acquired two-dimensional echocardiography (2D) cine loops [9]. Retrospective studies in the veterinary literature have previously used this technique [1,10]. Unfortunately, this feature is vendor specific and therefore not widely available.

Tricuspid annular plane systolic excursion can also be quantified using solely 2D echocardiography (2D TAPSE) [4,11−13]. Measuring TAPSE by 2D echocardiography eliminates the disadvantage of acquisition angle dependence and cursor misalignment. Also, 2D TAPSE permits retrospective quantification of RV systolic function as it can be quantified from any 2D echocardiography cine loop acquired from the standard left apical 4-chamber view [14]. Thus, in contrast to TAPSE measured by anatomic M-mode, 2D TAPSE is widely available and not limited by the echocardiography system vendor.

To our knowledge, 2D TAPSE has yet to be evaluated or validated in dogs. Before clinical application of 2D TAPSE, studies comparing the difference in conventional MM TAPSE and 2D TAPSE are needed to help determine if these methods can be used interchangeably as slight but important differences exist between these methods. Evaluation of repeatability data, the ability to track changes in inotropic state, and generation of reference intervals based on the relationship of 2D TAPSE with bodyweight, age, heart rate, and gender derived from a large and diverse sample of dogs would also be ideal before clinical use.

The present study addressed the hypotheses that (1) 2D TAPSE is feasible to acquire in a large sample of healthy dogs and demonstrates clinically acceptable variability and repeatability; (2) similar to MM TAPSE, 2D TAPSE will correlate with bodyweight; and (3) 2D TAPSE will consistently track the anticipated decrease in RV systolic function after a single oral dose of atenolol in healthy dogs (as proof of concept). Our study objectives were (1) to determine the intraobserver and interobserver measurement variability and within-day repeatability of 2D TAPSE; (2) to determine the effect of bodyweight, heart rate, age, and sex on 2D TAPSE and based on these,

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