Journal of Veterinary Cardiology (2018) ■, ■–■

ELSEVIER

Journal of Veterinary Cardiology
ESVC

www.elsevier.com/locate/jvc

Two-dimensional, long-axis echocardiographic ratios for assessment of left atrial and ventricular size in dogs

L.E. Strohm, DVM, MS [a], L.C. Visser, DVM, MS [a,b,*], E.H. Chapel, DVM, MS [a], W.T. Drost, DVM [a], J.D. Bonagura, DVM, MS [a]

[a] *Department of Veterinary Clinical Sciences, College of Veterinary Medicine, The Ohio State University, 601 Vernon Tharp Street, Columbus, OH 43210, USA*
[b] *Department of Medicine & Epidemiology, School of Veterinary Medicine, University of California, Davis, One Shields Ave, Davis, CA 95616, USA*

Received 29 November 2017; received in revised form 18 July 2018; accepted 23 July 2018

KEYWORDS
Canine;
Cardiomegaly;
Ultrasound;
Mitral regurgitation;
Myxomatous mitral valve disease

Abstract *Introduction:* Left ventricular (LV) and left atrial (LA) enlargement affect management and outcome of dogs with cardiac disease. Short-axis, two-dimensional echocardiographic (2DE) images, indexed to the aorta (Ao), are frequently used to identify cardiomegaly. Long-axis images offer complementary views of the left heart.
Animals: Eighty healthy dogs and 25 dogs with MMVD.
Methods: Healthy dogs were prospectively recruited to determine reference intervals (Clinical Laboratory Standards Institute methodology) for long-axis ratios. Measurement variability and repeatability were quantified by intraclass correlation coefficient and coefficient of variation. Mean long-axis ratios from dogs with MMVD were compared with healthy dogs (unpaired t-test). In addition, the proportion of MMVD dogs exceeding the 97.5 percentile by LV/Ao and a conventional, allometric method were compared (McNemar's test).
Results: Two-dimensional echocardiographic long-axis reference intervals were as follows: left ventricular to aortic dimension (LV/Ao) 1.8–2.5; left atrial to aortic dimension (LA/Ao) 1.8–2.4, and left atrial to left ventricular dimension (LA/LV) 0.9–1.1. Intraobserver and interobserver measurement agreement was good-to-excellent (intraclass correlation coefficients $\geq$0.84), and day-to-day variability was

Presented in abstract form as an oral presentation at the American College of Veterinary Radiology 2016 Annual Scientific Meeting, Orlando, FL.

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

https://doi.org/10.1016/j.jvc.2018.07.008

Please cite this article in press as: Strohm LE, et al., Two-dimensional, long-axis echocardiographic ratios for assessment of left atrial and ventricular size in dogs, Journal of Veterinary Cardiology (2018), https://doi.org/10.1016/j.jvc.2018.07.008

low (coefficient of variations <4%). Left ventricular to aortic dimension, LA/Ao, and LA/LV were significantly greater in canine MMVD compared with healthy dogs ($p<0.001$). The percentages of MMVD dogs demonstrating LV dilatation by LV/Ao and conventional method were 68% and 36%, respectively ($p=0.043$, 95% confidence interval for difference 7.9%, 56.1%).

Conclusions: Simple 2DE long-axis ratios of LV/Ao, LA/Ao, and LA/LV are repeatable and demonstrate clinical utility for identifying LV and LA enlargement in dogs with MMVD.

Abbreviations

2DE	two-dimensional echocardiography (echocardiographic)
Ao	aorta (aortic)
AoD	aortic diameter
wAo	weight-based aortic diameter
CLSI	Clinical Laboratory Standards Institute
LA	left atrium (atrial)
LAD	left atrial dimension
LV	left ventricle (ventricular)
LVIDd	left ventricular internal dimension at end-diastole
LVIDdN	left ventricular internal dimension at end-diastole normalized to body weight
MMVD	myxomatous mitral valve disease
MR	mitral regurgitation
RC	repeatability coefficient
VHS	vertebral heart score (scale, sum)

Introduction

Cardiac diseases in dogs often lead to enlargement of the left atrium (LA) and left ventricle (LV). This situation is typified by dogs with chronic mitral regurgitation (MR) secondary to myxomatous mitral valve disease (MMVD). In this important canine disease, quantitation of LA and LV chamber dimensions predicts the risk of congestive heart failure [1,2], guides monitoring and medical intervention during the preclinical stage [3—5], and influences short- and long-term prognosis [3,6—10].

Although real-time, three-dimensional echocardiographic imaging can quantify LA and LV volumes, these technologies are largely unavailable in veterinary practice due to cost and limitations of some transducers, when applied to smaller animals. Most clinicians rely on linear or area measurements of the left heart that are derived from M-mode or two-dimensional echocardiography (2DE). These are surrogates for chamber volumes. Linear measurements are the simplest and most efficient to perform, and various methods for measuring the LA and LV have been published [11—16].

Conventional methods for assessing LA and LV size in dogs include subjective evaluation, measurement of minor axis dimensions from M-mode echocardiography, and various linear and area measurements from 2DE images. Given the range of canine bodyweights, measurements must be indexed or normalized in some way. Breed-specific reference values are one approach [15], but of limited availability. Another weight-adjustment approach involves nonlinear or allometric scaling [13,14], a method predominantly used in recent clinical trials [3,8]. Brown et al have reported indexing cardiac measurements to the aorta (Ao) with ratio indices derived from M-mode studies of the Ao [11,12,17]. These investigators also developed a weight-based aortic indexing method that obviated actual measurement of the Ao. Left atrial and LV size also has been indexed to the Ao using mainly short-axis, 2DE image planes with measurements obtained during diastole [1,15,16]. Potential limitations to these different methods include defining the path of aortic measurement relative to valve sinuses; excluding pulmonary veins from the LA measurement; consistently timing LA measurements during the cardiac cycle; and potential insensitivity of multibreed, allometrically derived reference intervals for identification of LV enlargement when traditional 95 percentiles [13] are selected as the reference standard. For example, in a study of dogs with preclinical MMVD, cardiomegaly, and substantial risk of developing heart failure [3], an enlarged LV was defined as an LV internal dimension at end-diastole, normalized to body weight (LVIDdN) $\geq$1.7 [3]. This LVIDdN value falls within the 95% prediction interval of LVIDdN 1.27 to 1.85, as

Please cite this article in press as: Strohm LE, et al., Two-dimensional, long-axis echocardiographic ratios for assessment of left atrial and ventricular size in dogs, Journal of Veterinary Cardiology (2018), https://doi.org/10.1016/j.jvc.2018.07.008