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Assessment of mitral valve morphology using three-dimensional echocardiography. Feasibility and reference values☆

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Abstract *Objectives:* To evaluate the feasibility of real time transthoracic three-dimensional echocardiography (RT3DE) for evaluation of normal canine mitral valves (MVs), and to provide reference values for this technique.
Animals: Forty-three cardiologically healthy, not sedated dogs.
Methods: Transthoracic RT3DE mitral datasets were acquired during two consecutive 6-month periods. The datasets were analyzed using commercially available software. An MV model was drawn using a semiautomated procedure and MV variables were obtained and calculated. The ratio between annulus height and

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commissural diameter was used as an index of the annulus' saddle-shaped non-planarity. After evaluation of associations between measured variables and body size, the datasets were used to generate reference intervals. Coefficients of variation (CVs), variance components, and repeatability coefficients were calculated for the evaluation of intra-observer, inter-observer, and day-to-day variability.
Results: Datasets could be analyzed in 34 of 43 (79%) dogs. 68 percent of datasets obtained during the first 6-month period could be analyzed and 90% obtained during the second period could be analyzed. An allometric relationship was identified for most MV variables. The MV annulus appeared elliptical and saddle-shaped. Inter- and intra-observer CVs were less than 20%. Coefficient of variation greater than 20% was calculated for the inter-day variation for some variables. Operator and observer were primarily responsible for the variation of most of the variables.
Conclusions: Evaluation of canine mitral valves by transthoracic RT3DE is feasible. Canine MVs of healthy dogs analyzed using RT3DE are elliptical and saddle-shaped. Reference intervals for the measured MV variables are proposed.

Abbreviations

AHCWR	annulus height to commissural width ratio
ALA	anterior leaflet area
ALL	anterior leaflet length
ALPMD	anterolateral—posteromedial annulus diameter
AnA	annulus area
AnCirc	annulus circumference
AnH	annulus height
APD	antero-posterior annulus diameter
BW	body weight
CmD	commissural diameter
CV	coefficient of variation
MV	mitral valve
NPA	non-planar angle
PLA	posterior leaflet area
PLL	posterior leaflet length
RT3DE	real time transthoracic three-dimensional echocardiography
SI	annulus sphericity index
TnA	tenting area
TnH	tenting height
TnV	tenting volume

Introduction

The mitral valve (MV) apparatus has a complex, three-dimensional structure [1—3]. The effect of geometry on valve stress is well established, [4,5] and for this reason, MV replacement and repair techniques that preserve or approximate normal valve morphology are associated with superior outcomes [6—8]. Furthermore, it has been hypothesized that structural alteration of the MV apparatus has a role in the pathogenesis of myxomatous MV disease [5,9]. Specifically, changes in MV morphology can alter forces acting on valvular structures, and possibly trigger the activation of signaling pathways responsible for the valve degeneration and leakage [9—13]. Studying the morphology of the MV and its apparatus in vivo is challenging because the complexity of valvular structure makes two-dimensional echocardiographic investigation incomplete and sometimes difficult to interpret. Real-time three-dimensional echocardiography (RT3DE), allows acquisition and visualization of volumes, rather than tomographic planes, in real-time, providing the operator with a comprehensive, in vivo image of valvular structures. Moreover, off-line analysis of acquired volumes, provides different perspectives on valvular structures, and discloses features that could otherwise be missed with conventional 2D examination. In humans, RT3DE is superior to conventional 2D echocardiography for evaluation of the MV and is becoming an essential component of the diagnostic evaluation of patients prior to MV valvular surgery [14—19].

The first objective of this study was to evaluate the feasibility of using transthoracic RT3DE for assessing the canine MV and its apparatus with a dedicated software.[c] Secondly, we wanted to evaluate inter- and intra-observer variability of the variables measured on the MV using this technique. Finally, we wanted to evaluate the morphology of the MV, and provide RT3DE reference values and ranges for MV variables in healthy dogs.

[c] 4D MV-Analysis 3.1, TomTec Imaging Systems, Unterschleissheim, Germany.