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Common two-dimensional echocardiographic estimates of aortic linear dimensions are interchangeable

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Abstract *Objective:* To compare two echocardiographic methods of measuring aortic diameter in short-axis projections.
Methods: Right-parasternal short-axis 2-dimensional projections of the left atrium and aorta were obtained from dogs and cats undergoing routine cardiac evaluation. Two investigators measured the aortic valve linear dimension using 2 methods: along the commissure between the non-coronary and right-coronary cusps and along the commissure between the non-coronary and left-coronary cusps. Inter-observer and intra-observer variability and agreement were assessed by comparing blinded measurements with each method by 4 trained observers on a standardized set of images. Measurements were compared for agreement using the limits of agreement analysis. Variability between observers was compared by examining residuals and intraclass correlation.
Results: 274 canine and 100 feline aortic valve images were measured in the first part of the study. One observer demonstrated slight proportional bias, while the other observer showed more variability (less agreement). When results were pooled for both investigators, no bias was identified, and 95% limits of agreement were $\pm$10% of the mean measurement for both species. In the second part of the study, 106 images were measured. Intraobserver variability was $<$4% for all observers. Inter-observer agreement was very high. Individual bias was identified in some

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observers, but was considered clinically inconsequential. Normalized differences between the 2 methods of measurement were below ±15% of the measured value for all observers.
Conclusions: Our results show sufficient agreement between two common methods used to measure aortic linear dimensions to suggest that these methods are interchangeable.

Abbreviations

2D	two-dimensional
LA:Ao	left-atrial-to-aortic ratio
RPSA	right parasternal short-axis

Introduction

Left atrial size is commonly used to estimate severity of left-sided heart diseases associated with volume overload or myocardial dysfunction. Normalization of left atrial dimensions and left ventricular walls and chambers to an internal reference structure allows comparison of disease severity between individuals, or populations of animals.[1–4] It also gives clinicians and investigators a method to compare treatment responses or prognosis in animals with comparable left-sided heart diseases of similar severity. Linear left atrial and left ventricular dimensions are most commonly normalized by comparing them with a linear aortic dimension (either absolute or weight-adjusted), because both of these dimensions scale linearly with each other, unlike scaling to body-weight or body surface area, and because the absolute size and shape of the aortic valve is rarely altered with disease in domestic animals.[1,5]

Two methods of obtaining a linear aortic dimension from two-dimensional (2D) right parasternal short-axis (RPSA) projections have been described in dogs.[3,4] The authors of these studies used the aortic dimensions to define reference intervals for normalized left atrial size (Left-atrial-to-aortic ratios; LA:Ao) in healthy adult dogs. However, the reference intervals, specifically, the upper limit of "normal", obtained from these 2 studies differed: the first study found an upper limit for the LA:Ao of 1.6, while the second study found an upper limit of 1.3. A separate study used one of these methods to define reference intervals for LA:Ao in healthy adult cats.[6] However, our clinical experience suggests that both methods of aortic measurement are used clinically in cats. Whether the differences in reference intervals were an effect of differences in the aortic linear dimensions or some other factors remains unknown.

Therefore, we compared the two 2D RPSA echocardiographic methods of measurement of the aortic valve linear dimensions in dogs and cats. We hypothesized that the two methods would agree with each other sufficiently to allow them to be used interchangeably, and that this agreement would be independent of investigator.

Animals, materials and methods

The study was designed in two parts. In the first part, images of the aortic valve in the RPSA view were obtained from dogs and cats undergoing routine echocardiographic evaluation at two clinical centers: at a specialty veterinary practice in Sofia, Bulgaria, and at Cornell University Hospital for Animals in Ithaca, New York. All images were stored in a digital format.

Two of the investigators (A and B) measured the aortic valves from their own image series using each of the two methods — referred to forthwith as the Rishniw (R) method[3] and the Hansson (H) method[4] — from static echocardiographic 2D images obtained from the RPSA projection. Measurements were performed on the first frame after aortic valve closure in which all 3 aortic valve cusps could be clearly discerned as described in the original studies. Briefly, for the R-method, the diameter of the aortic valve was measured along a line drawn from the commissure of the right coronary and non-coronary cusps to the opposite edge (in the middle of the left coronary cusp) extending from the inner edge to inner edge (Fig. 1A). For the H-method, the line was drawn from the commissure of the left coronary and non-coronary cusps to the opposite edge (in the middle of the right coronary cusp) also extending from the inner edge to inner edge (Fig. 1B). Images with obvious distortion of the aortic valve due to suboptimal imaging and images of abnormal aortic valves (e.g. bicuspid, quadricuspid, infected) were excluded from analysis. Images from animals with other