

# M-mode echocardiography measurements of healthy Brazilian random bred cats

Medidas ecocardiográficas em Modo-M de gatos brasileiros sem raça definida

Bruno Ricardo Soares Alberigi da Silva<sup>1\*</sup> , Alexandre José Rodrigues Bendas<sup>2</sup> , Denise do Vale Soares<sup>3</sup> , Carolina Aben Athar<sup>1</sup> , Fabiana Batalha Knackfuss<sup>4</sup> , Renan Salhab Demo<sup>5</sup> , Mateus Fernando Senra Almeida<sup>5</sup>  & Jonimar Pereira Paiva<sup>6†</sup> 

<sup>1</sup>Veterinary, doctorate, MSc. Programa de Pós-graduação em Medicina Veterinária – PPGMV, Universidade Federal Rural do Rio de Janeiro – UFRRJ, Seropédica, RJ, Brasil

<sup>2</sup>Veterinary, doctorate, MSc. Programa de Pós-graduação em Medicina Veterinária (Clínica e Reprodução Animal), Universidade Federal Fluminense – UFF, Niterói, RJ, Brasil

<sup>3</sup>Veterinary, Instituto de Especialidades em Medicina Veterinária – IEMEV, Rio de Janeiro, RJ, Brasil

<sup>4</sup>Zootechnist, MSc, DSc. Universidade do Grande Rio – UNIGRANRIO, Duque de Caxias, RJ, Brasil

<sup>5</sup>Undergraduate students of Veterinary Medicine. Universidade Federal Rural do Rio de Janeiro – UFRRJ, Seropédica, RJ, Brasil

<sup>6</sup>Veterinary, Dr. Departamento de Medicina Veterinária e Cirurgia, Universidade Federal Rural do Rio de Janeiro – UFRRJ, Seropédica, RJ, Brasil

<sup>†</sup>Deceased

## Abstract

To determine the M-mode echocardiography reference measurements for Brazilian random bred cats in Rio de Janeiro, Brazil, cats presenting for routine care were examined by M-mode echocardiography. Animals with free wall values of the left ventricle and/or interventricular septum above 5 mm were not included. A total of 125 cats were included in the study. The correlation of the body score condition (BSC) with the echocardiography measurements was positive for left ventricle wall in systole (LVWs) and left ventricular wall in diastole (LVWd). The LVWd values of BSCs 3 and 4 were different; and those of BSCs 3 and 5 were also different. The LVWs values of BSCs 3 and 5 were different. The correlated effect between BSC and the echocardiography measurements was true for the left atrium, left atrium/aorta ratio, ventricular septum in diastole, ventricular septum in systole, LVWs, LVWd, left ventricle in diastole, left ventricle in systole, ejection fraction and shortening fraction. The M-mode echocardiography evaluation of cats is impacted by the animal's body mass; therefore, the BSC must be taken into consideration when interpreting echocardiography measurements.

**Keywords:** cardiomyopathy, reference values, interventricular septum, left ventricular wall.

## Resumo

Para determinar as medidas de referência da ecocardiografia modo-M para gatos brasileiros aleatoriamente criados no Rio de Janeiro, Brasil, os gatos que se apresentaram para tratamento de rotina foram examinados pela ecocardiografia modo-M. Animais com parede livre do ventrículo esquerdo e / ou septo interventricular acima de 5 mm não foram incluídos. Um total de 125 gatos foram incluídos no estudo. A correlação do escore de condição corporal (ECC) com as medidas do ecocardiograma foi positiva para parede do ventrículo esquerdo na sístole (PLVEs) e parede do ventrículo esquerdo na diástole (PLVEd). Os valores de PLVEd dos ECC 3 e 4 foram diferentes; e os dos ECC 3 e 5 também eram diferentes. Os valores de PLVEs dos ECC 3 e 5 foram diferentes. O efeito correlacionado entre a ECC e a ecocardiografia foi verdadeiro para o átrio esquerdo, relação átrio esquerdo / aorta, septo ventricular em diástole, septo ventricular em sístole, PLVEd, PLVEs, diâmetro do ventrículo esquerdo em diástole e em sístole, fração de ejeção e fração de encurtamento. A avaliação ecocardiográfica do modo M dos gatos é afetada pela massa corporal do animal; portanto, o ECC deve ser levado em consideração ao interpretar medidas de ecocardiografia.

**Palavras-chave:** cardiomiopatia, valores de referência, septo interventricular, parede ventricular esquerda.

## Introduction

Echocardiography is a noninvasive exam that allows a safe morphofunctional evaluation of the heart (Boon, 2011). The M-mode is especially helpful for evaluating echogenic tissues, allowing objective measurements of the cardiac chambers, the wall thickness, and valvar movements, as well as functional index calculations, such as the shortening fraction. The Doppler analysis



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### \*Correspondence

Bruno Ricardo Soares Alberigi da Silva  
Programa de Pós-graduação em Medicina Veterinária – PPGMV, Universidade Federal Rural do Rio de Janeiro – UFRRJ  
Rodovia BR 465, Km 07, s/n Zona Rural  
CEP 23890-000 - Seropédica (RJ), Brasil  
E-mail: bruno.alberigi@gmail.com

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evaluates the velocity and pressure gradient of the blood flow inside the cardiac chambers and large vessels, as well as diastolic function (Chetboul et al., 2012; Bright, 2006). Therefore, M-mode echocardiography is the exam to detect the silent life-threatening myocardopathies that represent the most frequent feline cardiopathy (Côté et al., 2011; Schwartz, 2003), (Tilley et al., 1977; Fox, 1999; Gundler et al., 2008).

M-mode echocardiography measurements for domestic cats have been standardized for the large breed Maine Coon (mean weight of 7.7 kg) (Gundler et al., 2008). For this breed, left ventricular wall in diastole (LVWd) and ventricular septum in diastole (VSd) values above 6 mm are diagnostic of cardiac hypertrophy (Moise et al., 1986; Schwartz, 2003; Fox et al., 2009; Ferasin, 2009; Côté et al., 2011). For smaller cats, such as the American domestic short hair (mean weight 4.76) (include reference), the normal measurements are an LVWd of 4.6 mm and a VSd of 4 mm (Moise et al., 1986) or an LVWd of 5.5 mm and a VSd of 5 mm (Ware, 2011).

Therefore, considering the varying measurements according to the size of the animal and that Brazilian random bred cats are small and have no weight or echocardiography standards, the aim of this study was to determine M-mode echocardiography standard measurements and correlate them with the BSC in order to allow early detection of silent, life-threatening myocardopathies.

## Material and methods

This study was approved by the animal use committee CEUA-FAPUR protocol number 01-05-13. After the owners' consent, 135 cats independent of sex or age, with no history of cardiopathy, presented for routine care at the Universidade Federal Rural do Rio de Janeiro or at the Instituto de Especialidades em Medicina Veterinária, a private hospital in Rio de Janeiro, were subjected to a physical exam and echocardiography. Cats presenting with clinical signs of disease or measurements of left ventricular wall and ventricular septum, in diastole, over 5 mm (Ware, 2011; Häggström et al., 2016) were not included.

A total of 125 cats were included, weighed and classified according to their BSC from 1 to 5 (Edney & Smith, 1986)

The history data capture and physical exam were performed by one operator, and the echocardiography was performed by a separate operator to maintain a blind study. The echocardiography equipment used was Esaote, model MyLab 50 Xvision cardiovascular®, using two transducers (1-4 MHz and 4-11 MHz). The echocardiographic examination was performed without anesthesia or a tranquilizer. The cats were manually restrained by their owners and positioned on the left lateral recumbence. The echocardiogram exam was performed as proposed by Madron (2016) using the following views: left parasternal long axis, left cranial paraesternal, right ventricular outflow tract, left paraesternal apical chambers 4 and 5, and right paraesternal short axis left ventricular. The left atrium (LA), left atrium/aorta ratio (LA/AO), ventricular septum in diastole (VSd), ventricular septum in systole (VSs), left ventricular wall in diastole (LVWd), left ventricular wall in systole (LVWs), left ventricle in diastole (LVd), left ventricle in systole (LVs), shortening fraction (SF) and ejection fraction (EF) were recorded.

Based on the resampling technique by Bootstrap with 1000000 replicas, the confidence intervals (CIs) of the analyzed variables were calculated to generate reference values according to the results. Analysis of variance was performed to test the significance of each measure, and when significant, Tukey's test was used to determine the difference between the means. To test correlation, the Pearson correlation coefficient was used.

## Results

Of the 125 cats included, 72 were female and 53 were male. The mean weight was 4.7±1.5 kg (CV 31%), the BSC mode was 3 for 69 cats, 46 cats presented with a BSC of 4, 8 cats presented with a BSC of 5, and 2 cats presented with a BSC of 2. The fact that 92% of the animals presented with a BSC of 3 or 4 indicates homogeneity of the body size of the cats.

The correlation of BSC with the echocardiographic measurements was positive when LVWs ( $p = 0.0013$ ) or LVWd ( $p = 0.0009$ ) was considered (Table 1). When the measurements of LVWd were compared among different BSC cats, LVWd was larger in BSC 4 cats than that in BSC 3 cats

**Table 1.** Analysis of variance of the echocardiography measurements with significance levels (p).

Variants	f	p
Left atrium	0.2583	0.8564
Left atrium aorta ratio	1.0552	0.3523
Ventricular septum in diastole	2.4427	0.0892
Ventricular septum in systole	1.4138	0.2459
Left ventricular wall in diastole	7.9748	0.0009
Left ventricular wall in systole	7.3676	0.0013
Left ventricle in diastole	1.0372	0.3588
Left ventricle in systole	0.8347	0.5601
Shortening fraction	0.1237	0.9452
Ejection fraction	0.6943	0.5059

f = analysis of variance.

( $Q = 5.05$ ;  $p < 0.01$ ) and was larger in BSC 5 cats than that in BSC 3 cats ( $Q = 3.50$ ;  $p < 0.05$ ). A difference in the LVWs measurements was observed only between BSC 3 and 5 cats ( $Q = 5.00$ ;  $p = < 0.01$ ).

The systolic function of the myocardium evaluation measurements showed an LVd mean of  $1.39 \text{ mm} \pm 0.17$  and an LVs mean of  $0.65 \pm 0.13$ . The SF mean was  $52.87 \pm 7.46$ , and the ejection fraction mean was  $85.74 \pm 7.25\%$ . These results show significant sample homogeneity with all the coefficients of variation below 20% (Table 1).

The correlated effect of the BSC and echocardiographic measurements estimated using Pearson's correlation coefficient were: LA ( $r = -0.0347$ ;  $p = 0.7008$ ), LA/AO ( $r = -0.1341$ ;  $p = 0.1358$ ), IVSd ( $r = 0.2152$ ;  $p = 0.0159$ ), IVSs ( $r = 0.2152$ ;  $p = 0.0159$ ), LVFWs ( **$r = 0.3403$** ;  **$p = 0.0001$** ), LVFWd ( **$r = 0.3444$** ;  **$p = < 0.0001$** ), LVDD ( $r = 0.2409$ ;  $p = 0.0068$ ), LVSD ( $r = 0.1355$ ,  $p = 0.1318$ ), EF ( $r = 0.1318$ ;  $p = 0.6711$ ) and SF ( $r = -0.046$ ;  $p = 0.6105$ ).

The reference values of the M-mode echocardiography measurements are shown in Table 2.

**Table 2.** Proposed reference values (mm) of the M-mode echocardiography measurements for Brazilian domestic short hair cats.

Variant	Lower Limit	Mean	Upper limit
Left atrium	1.21	1.23	1.26
Left atrium aorta ratio	1.21	1.24	1.26
Ventricular septum in diastole	0.39	0.40	0.41
Ventricular septum in systole	0.71	0.73	0.75
Left ventricular wall in diastole	0.38	0.39	0.40
Left ventricular wall in systole	0.65	0.67	0.68
Left ventricle in diastole	1.36	1.39	1.41
Left ventricle in systole	0.63	0.65	0.67
Shortening fraction	51.68	52.98	54.09
Ejection fraction	85.28	86.30	87.15

## Discussion

The demonstrated positive correlation of systolic and diastolic left ventricle wall (LVW) measurements with BSC shows that cats with a higher BSC must be examined with caution, as their measurement values will tend to be larger. This suggests that the LVW tends to develop an

adaptive concentric hypertrophy, probably because the heart needs to enhance its contraction force to maintain blood flow in a large body mass. Different from the results reported here, a previous study using allometry observed that echocardiographic measurements were influenced by body weight, mainly VSd (Karsten et al., 2017); the discrepancy between results can be due to the different methods used. Another study observed the influence of body weight on cardiac measurements, mainly in the left atrium/aorta ratio, but they did not use BSC (Häggsström et al., 2016). The mean of the left atrium diameter measurements showed no difference compared with that found in other studies (Moise et al., 1986; Sisson et al., 1991).

The LA/AO ratio is the most used measurement to evaluate the left atrium size, and the normal reference value for cats is 1:7 (Boon, 2011). In the present study, the mean LA/AO ratio was  $1.24 \pm 0.13$ , (c.v of 11%) with high sample homogeneity and a somewhat smaller reference value.

Measurements were compared with those registered before (Table 3), and the differences in LA/AO, VSD, LVWd, LVWs, LVD and LVs were assigned to the studied animals' size and breed (Tilley et al., 1977; Fox, 1999, 2014; Boon, 2011; Ware, 2011; Chetboul et al., 2012).

**Table 3.** Echocardiography measurements (mean  $\pm$  standard deviation) of Brazilian random bred cats (BRBC).

Variant	Weight (kg)	LA (cm)	LA/AO	VSd (cm)	VSs (cm)	LVWd (cm)	LVWs (cm)	LVD (cm)	LVs (cm)	SF (%)	EF (%)
BRBC N = 125	4.7 $\pm$ 1.5	1.23 $\pm$ 0.17	1.24 $\pm$ 0.13	0.4 $\pm$ 0.05	0.73 $\pm$ 0.11	0.39 $\pm$ 0.06	0.67 $\pm$ 0.11	1.39 $\pm$ 0.17	0.65 $\pm$ 0.13	52.87 $\pm$ 7.46	85.74 $\pm$ 7.25

N = number of animals included; LA = left atrium; LA/AO = left atrium/aorta ratio; VSd = ventricular septum in diastole; VSs = ventricular septum in systole; LVWd = left ventricular wall in diastole; LVWs = left ventricular wall in systole; LVD = left ventricle in diastole; LVs = left ventricle in systole; SF = shortening fraction; EF = ejection fraction.

Studies that included American domestic short hair cats registered cardiac measurements similar to those presented in this study (Table 3) (Fox et al., 1985; Moise et al., 1986; Sisson et al., 1991; Häggström et al., 2016), indicating that breed and therefore size range plays an important role in reference values. When analyzing different studies measurements it must be considered that many studies included sedated cats (Fox et al., 1985) or sampled only a small number of cats (Fox et al., 1985; Moise et al., 1986; Sisson et al., 1991). A large sampling was performed, but the authors did not list breeds or BSC they included (Häggsström et al., 2016). Reference values of VSd and LVWd were established using Maine Coon and Ragdoll, two large breeds, with no attention to the body mass that impacts on the size of the heart, therefore the reference was settled below 6 mm (Côté et al., 2011; Schwartz, 2003; Fox et al., 2009; Ferasin, 2009). Since the Brazilian random bred cats included in this study were smaller, the LVWd and VSd measurements were also smaller (Table 2).

In the present study, the mean EF was  $85.74\% \pm 7.25$  (c.v 8%). In most reports, the EF was not determined (Fox et al., 1985; Moise et al., 1986; Sisson et al., 1991), and there is no reference value established for adult cats (Moise et al., 1986; Sisson et al., 1991; Branquinho et al., 2010; Boon, 2011; Côté et al., 2011; Häggström et al., 2016); however, for growing kittens from two to 11 weeks of age, the reference EF measurement ranged from 61% to 87% (Schille & Skrodzki, 1999). According to Morcef (2001), a subjective analysis performed by an experienced echocardiographer is the best EF evaluation; however, an objective parameter can avoid biases and help less experienced echocardiographers to properly evaluate EF.

## Conclusions

The M-mode echocardiography evaluation of cats is impacted by the animal's body mass; therefore, the BSC must be taken into consideration when interpreting echocardiography measurements. Since Brazilian random bred cats and breeds or local varieties in other countries are smaller than most breeds used for establishing reference measurements, further studies must be conducted to determine the reference measurements for different breeds.

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