

Quantitative evaluation of left ventricular systolic function M-mode echocardiography in healthy German Shepherd dog

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Abstract

The primary goal of this study was to quantitatively evaluate the functioning of left ventricle by two-dimensional and M-mode echocardiography and to assess if age, gender and body weight have an influence on the echocardiographic variables. We prospectively enrolled thirty client-owned German Shepherd dogs presented to small animal clinics in the medicine unit of Teaching Veterinary Hospital, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab, India, that were considered healthy based on unremarkable history, normal physical examination, six-lead electrocardiography and transthoracic echocardiography. M-mode echocardiography was performed, and measurements of the various parameters of the left ventricle were done. These German Shepherds were classified according to body weight, age and gender. Twenty-two dogs were in the body weight range of 20-40 kg, and eight in 40-60 kg. Dogs were divided into four groups as per age. Echocardiographic reference intervals were generated from 30 healthy adult German Shepherds. There was significant effect of body weight on LVIDd in German Shepherds. No significant effect of age and gender was observed on any of M-mode echocardiographic parameters.

Keywords: Dogs, Echocardiography, German Shepherds, M-mode

Highlights

- M-mode echocardiography in healthy German Shepherd dogs as a reference data
- Quantitative evaluation of the left ventricle function using these modalities
- Significant effect of body weight on left ventricular dimensions

INTRODUCTION

Echocardiography allows assessment of cardiac chamber sizes, cardiac function and blood flow, all of which provide information on hemodynamic status and extent of disease process, together with the follow-up on therapy (Boon et al., 2011). In addition to qualitative estimation, measurement of cardiac dimensions and estimation of cardiac function parameters are inevitable to determine cardiac performance of healthy individuals, and to diagnose pathological conditions (Knight et al., 2005). In canine cardiology, many studies have been done to evaluate the cardiac function in different breeds (Ajibola et al., 2017; Saini et al., 2017; Bodh et al., 2019). Variations among the breeds have been considered as the most important factor that affects the echocardiographic values. Reliable, normal echocardiographic values for chamber size, wall dimensions and myocardial function need to be established breed-wise for comparison and evaluation of dogs suspected of having heart diseases (Sidhu et al., 2018a; Sidhu et al., 2018b). There is a scarcity of breed-specific data in the literature, particularly for the German Shepherd. More

breed-specific literature is required for M-mode and two-dimensional echocardiography-derived left ventricular volumes and ejection fraction. The present study aimed at determining reference echocardiographic parameters in German shepherd dogs and to assess the relationship between body weight, age and gender with various echocardiographic indices.

MATERIALS AND METHODS

Animals: Thirty apparently healthy German shepherd dogs above one year of age presented at the Teaching Veterinary Hospital of Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, for routine deworming, vaccination and general health check-up, with normal results on physical examination, and no electrocardiographic and echocardiographic abnormality, were selected for determining echocardiographic reference values (Sidhu et al., 2018a). For studying the effect of age, gender and body weight on echocardiographic parameters, the animals were divided into two groups according to body weight (20-40 kg and 40-60 kg), gender and age (four groups, i.e., 1-2, 2-3, 3-5 and >5 years of age).

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Echocardiography: Two-dimensional and M-mode echocardiography was performed in all the selected animals using GE Logiq P5 Color Doppler (GE Healthcare, Chicago, United States) equipped with sector probe 3S, 5S and 7S. Selection of the probe was done depending on the size/weight of the animal.

Patient preparation positioning: All the dogs were clipped on the right and left thoracic wall from 4th to 6th intercostal space and placed in the lateral recumbency on a specially designed table with a semicircular cut on one side of the table (Boon et al., 2011). The transducer was placed through the cut on the dependent side of the chest. None of the animals were given sedation or tranquilisation. The mouth of the animal was closed sometimes to avoid respiratory disturbances during examination.

Measurements: M-mode echocardiographic images were used for the measurement of left ventricular dimensions in systole and diastole. The M-mode images recorded from the right parasternal long axis view of the left ventricle displayed the right ventricle at the top of the image, followed by the interventricular septum (IVS), the left ventricular chamber, and left ventricular free wall at the bottom of the image in the healthy German Shepherds and mixed breed dogs. The M-mode parameters recorded were interventricular septal wall thickness (IVSd and IVSs), left ventricular internal dimensions (LVIDd and LVIDs) and left ventricular posterior wall thickness (LVPWd and LVPWs).

Calculations: Formulae by Teicholz et al. (1976) were used for calculating the left ventricular volumes at end systole and diastole.

$$\begin{aligned} \text{End diastolic volume (EDV in mL)} \\ = 7 \times \text{LVIDd}^3 / (2.4 + \text{LVIDd}) \end{aligned}$$

$$\begin{aligned} \text{End systolic volume (ESV in mL)} \\ = 7 \times \text{LVIDs}^3 / (2.4 + \text{LVIDs}) \end{aligned}$$

Ejection fraction and fractional shortening (per cent) were calculated from the established formulae given by Boon et al. (2011).

$$\begin{aligned} \text{Ejection Fraction (EF in per cent)} \\ = (\text{EDV} - \text{ESV}) \times 100 / \text{EDV} \end{aligned}$$

$$\begin{aligned} \text{Fractional Shortening (FS in per cent)} \\ = [(\text{LVDd} - \text{LVDs}) / \text{LVDd}] \times 100 \end{aligned}$$

The statistical analysis was done for each response variable with the help of independent 't' test, paired 't' Test, and one way ANOVA by using software 'SPSS-16'.

RESULTS

The measurements of M-mode echocardiographic parameters and comparison of these parameters in different groups as per body, age and gender are presented in Table 1.

Effect of body weight, age and gender on Left ventricular dimensions: In the present study the left ventricular internal diameter during diastole (LVIDd) was significantly higher ($P < 0.05$) in the 40-60 kg body weight group as compared to 20-40 kg body weight group (Table 1). However, the interventricular septum during both diastole and systole (IVSd and IVSs) and left ventricular posterior wall thickness during diastole and systole (LVPWd and LVPWs) were not significantly affected by the body weight.

In healthy German shepherd dogs, age and gender had no significant effect on left ventricular internal diameter (LVIDd and LVIDs), left ventricular posterior wall (LVPWd and LVPWs) and interventricular septum (IVSd and IVSs) (Table 1).

Left ventricular contractility indices-FS% and EF%: The Fraction shortening (FS%) and ejection fraction (EF%) were recorded from the M-mode recordings of left ventricle. The mean $\pm$ SEM values of FS% and EF% for healthy German Shepherd dogs in the present study were observed to be $32.46 \pm 1.65\%$ (20.69-40.42%) and $61.16 \pm 2.34\%$ (43.25-78.45%), respectively (Table 1).

Body weight, age and gender showed no significant effect on FS% and EF% in healthy German Shepherds.

Effect of body weight, age and gender on left ventricular volumes: EDV and ESV of the healthy German Shepherds were not significantly ($P < 0.05$) affected by the body weight, age and gender (Table 1). The EDV and ESV of healthy German Shepherds showed no significant difference among different age groups.

Systolic indices (EDVI and ESVI): This index can be used to compare the ventricular diastolic and systolic volume between dogs irrespective of size. In the present study the range of EDVI and ESVI for healthy German Shepherd dogs was within range of EDVI and ESVI ($< 100 \text{ mL/m}^2$ and $< 30 \text{ mL/m}^2$ respectively).

Effect of body weight, age and gender on EDVI and ESVI: EDVI and ESVI are derived from EDV and ESV ($\text{EDVI} = \text{EDV}/\text{BSA}$ and $\text{ESVI} = \text{ESV}/\text{BSA}$). Statistically, no significant ($P < 0.05$) effect of body weight, age and gender was observed on EDVI and ESVI for the healthy German Shepherds.

Effect of body weight, age and gender on FS% and EF%: In the present study no significant relation was found between FS% and EF% with body weight, age and gender in healthy German Shepherds (Table 1).

Table 1. Effect of body weight, age and sex on M-mode echocardiographic reference parameters in healthy German Shepherd dogs (n=30)

	LVIDd (cm)	LVIDS (cm)	IVSd (cm)	IVSs (cm)	LVPWd (cm)	LVPWs (cm)	FS%
Body Wt (kg)							
20-40 (n=22)	2.99±0.17 ¹ A ²	2.04±0.14A	0.81±0.06A	1.09±0.1A	1.04±0.06A	1.11±0.08A	32.09±1.95A
40-60 (n=8)	3.76±0.21B	2.31±0.21A	1.07±0.13A	1.53±0.16A	1.18±0.11A	1.17±0.05A	33.46±2.88A
Age (yrs)							
1-2 (n=9)	3.15±0.30A ³	2.03±0.24A	0.71±0.08A	0.9±0.19A	1.04±0.15A	1.01±0.16A	36.15±3.37A
2-3 (n=4)	2.85±0.23A	1.5±0.15A	1.34±0.15A	1.28±0.17A	1.41±0.13A	1.21±0.15A	38.6±2.25A
3-5 (n=5)	3.08±0.18A	2.15±0.15A	1.0±0.10A	1.36±0.03A	1.09±0.08A	1.29±0.06A	29.9±4.34A
>5 (n=12)	3.05±0.25A	2.16±0.21A	0.79±0.08A	0.94±0.1A	1.005±0.05A	1.14±0.08A	30.45±2.48A
Gender							
Male (n=24)	3.12±0.14A ⁴	2.12±0.12A	0.93±0.06A	1.12±0.08A	1.12±0.06A	1.19±0.06A	32.32±1.83A
Female (n=6)	2.66±0.43A	1.84±0.37A	0.68±0.15A	0.98±0.25A	0.91±0.14A	0.8±0.14A	32.99±3.94A
Overall							
Range	1.55-4.54	0.97-2.95	0.34-1.63	0.31-1.86	0.27-1.84	0.25-1.59	20.69-40.42
	EDV(mL)	ESV(mL)	EF%	EDVI(mL/m²)		ESVI(mL/m²)	
Body Wt (kg)							
20-40 (n=22)	37.59±4.53A	15.23±2.14A	60.81±2.86A	38.35±4.68A		15.57±2.19A	
40-60 (n=8)	50.42±6.41A	20.3±3.05A	62.14±3.62A	40.93±5.81A		16.42±2.46A	
Age (yrs)							
1-2 (n=9)	44.23±8.44A	15.97±3.82A	65.7±4.7A	45.35±9.03A		16.47±4.03A	
2-3 (n=4)	31.03±4.51A	8.47±2.06A	70.56±2.99A	26.84±4.29A		7.31±1.81A	
3-5 (n=5)	39.91±4.91A	15.6±2.88A	57.49±6.18A	41.92±5.43A		16.44±3.03A	
>5 (n=12)	41.32±7.28A	18.58±3.48A	58.53±3.67A	36.07±5.81A		16.24±2.88A	
Gender							
Male (n=24)	43.29±4.13A	17.17±2.01A	60.8±2.59A	41.01±4.05A		16.26±1.93A	
Female (n=6)	31.9±11.75A	14.24±5.82A	62.6±5.98A	31.14±10.05A		13.95±5.31A	
Range	6.59-76.76	1.89-33.63	43.25-78.45	7.84-64.99		2.25-29.85	

¹Values are mean±SEM²Values with different upper case alphabets in same column differ significantly (P≤0.05) between different body weight groups.³Values with different upper case alphabets in same column differ significantly (P≤0.05) between different age groups.⁴Values with different upper case alphabets in same column differ significantly (P≤0.05) between different gender groups.

DISCUSSION

Effect of body weight, age and gender on Left ventricular dimensions

Results of our study were in agreement to the results of Muzzi et al. (2006) who identified significant correlation between body weight and systolic and diastolic left ventricular dimensions. Similar were the findings of Saini et al (2017) who reported that mean values of LVIDd and LVIDs were significantly high in higher body weight groups in healthy Labrador retrievers. Further, Muzzi et al (2006) reported a direct relationship between IVSd and IVSs with body weight in German Shepherd dogs.

Similar to the findings of present study, Muzzi et al. (2006) also did not find any effect of age on any of the echocardiographic parameters. Similarly, Boon et al. (2011) reported that diastolic and systolic diameter of left ventricle were not influenced by age. In another

study on Labrador retrievers, no significant effect of gender on all the echocardiographic parameters was reported (Gugjoo et al., 2014).

Left ventricular contractility indices-FS% and EF%

Similar to the findings of this study, Saini et al. (2017) also reported non-significant effect of body weight on FS% and EF% in Labrador retriever dog. However, another researcher reported that FS% is negatively associated with body weight, but body weight has no significant effect on EF% in healthy German Shepherds (Muzzi et al., 2006)

Age and gender showed no significant effect on FS% and EF% in healthy German Shepherds. Similarly, Muzzi et al (2006) found no significant difference between different age groups and FS% in healthy German Shepherds. Saini et al. (2017) also reported non-significant effect of age on FS% and EF% in healthy

Labrador retrievers as well as mixed breed dogs. As the FS% is not significantly influenced by age, it should be kept in mind while evaluating any case of decreasing FS%. Therefore, the changes in FS% cannot be considered to be part of a normal ageing process, but can be as a result of cardiac disease (Boon et al., 2011). No effect of gender on FS% and EF% in healthy Labrador retrievers and mixed breed dogs has been reported (Saini et al., 2017). The small number of females as compared to males, in the study population, could be the reason of no association of gender with FS% and EF%.

Effect of body weight, age and gender on left ventricular volumes:

Saini et al. (2017) reported a significant effect of body weight on EDV and ESV in healthy Labradors and mixed breed dogs. Saini et al. (2017) reported that only EDV showed significant difference among different age groups in healthy Labrador retrievers, but no gender difference was observed in this study.

Systolic indices (EDVI and ESVI)

This index can be used to compare the ventricular diastolic and systolic volumes between dogs irrespective of size.

Effect of body weight, age and gender on EDVI and ESVI

Muzzi et al. (2006) reported a negative relation between body weight and EDVI and ESVI, but reported that EDVI and ESVI are not influenced by age and gender of the dogs.

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This study shows that most of the M-mode echocardiographic parameters are not affected with age, gender and bodyweight except the left ventricular internal diameter. So these values can be replicated in disease diagnosis and for comparison between healthy and diseased German Shepherd dogs, irrespective of their body weight, age and gender. Basic breed-specific data is very important for the correct disease diagnosis. This study is first of its type as already existing literature does not show any relation of the echocardiographic parameters with body weight, age and gender.

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