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Echocardiographic Quantitation of Left Ventricular Size and Function in Indian Mongrel Dogs

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ABSTRACT

Background: No published data on two-dimensional echocardiographic quantitation of left ventricular size and function in Indian mongrel dogs is reported till date.

Methods: Reference intervals for linear and area measurements of left ventricle size and function was generated in fifty healthy mongrel dogs (25 males, 25 females; mean age=1.59±0.13 yr; mean body weight=16.66±0.73 kg) using two-dimensional echocardiography. Dogs deemed healthy after thorough clinico-physiological, hematological, radiographic, electrocardiographic and echocardiographic evaluation were included in study.Relationship between two-dimensional linear and area measurements of left ventricle and body weight and, between same measurements obtained from different tomographic planes was studied using linear regression analysis.

Result: Linear left ventricular measurements, left ventricular internal and external area, mitral valve orifice area showed significant (P<0.001) positive correlation with body weight while fractional shortening and ejection fraction showed significant (P<0.001) weak negative correlation with body weight. Left ventricular internal length in diastole, interventricular septum thickness and left ventricular internal dimension in systole and left ventricular free wall thickness in diastole were significantly (P<0.01) higher in male dogs while mitral valve orifice area was significantly (P<0.01) higher in female dogs. All linear measurements of left ventricular size obtained from different tomographic planes displayed significant (P<0.001) correlation with each other.

Key words: Dogs, Left ventricular, Mongrel, Quantification, Two-dimensional echocardiography.

INTRODUCTION

Two-dimensional echocardiography provides real-time imaging of cardiac structures, cross-sectional information and numerous imaging planes for complete cardiac evaluation (O′Grady *et al.,* 1986), therefore it is the preferred noninvasive modality used for quantitation of cardiac chamber size and function. Two-dimensional echocardiographic images have close resemblance to the gross anatomic appearance of cardiac structures and, therefore provide more useful information about change in shape, size and function of heart in various disease conditions (Visser *et al.,* 2019).

Normal two-dimensional echocardiographic values of left ventricular chamber, interventricular septum and left ventricular posterior wall dimensions and systolic functional indices are required for comparison and evaluation of dogs suspected of having heart diseases (O′Grady *et al.,* 1986). Unlike human medicine, recommended standards for quantitation of cardiac chamber size and function by two-dimensioanl echocardiography in dogs do not currently exist (Lang *et al.,* 2015). Available veterinary literature proposing reference intervals for linear measurements of left ventricular size and function in healthy dogs has been derived using either small number of dogs or single breed (Hansson *et al.,* 2002; Rishniw and Erb, 2000) except few studies in which large sample size and different dog breeds were used (O'Grady *et al.,* 1986; Visser *et al.,* 2019).

To the author′s knowledge, no work on cardiac chamber quantitation using two-dimensional echocardiography is reported in Indian mongrel dogs till date. The present study envisaged quantitative assessment of left ventricular size and function in healthy mongrel dogs using two-dimensional echocardiographic measurements obtained from different tomographic planes with the objectives to standardize and generate reference data of linear and cross-sectional measurements of left ventricle size and function and to study the possible correlationship of data obtained with body weight.

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MATERIALS AND METHODS

The present study was conducted in the session 2021-22 and 2022-23 at the Department of Veterinary Surgery and Radiology, Dr. GC Negi College of Veterinary and Animal Sciences, Chaudhary Sarwan Kumar Himachal Pradesh

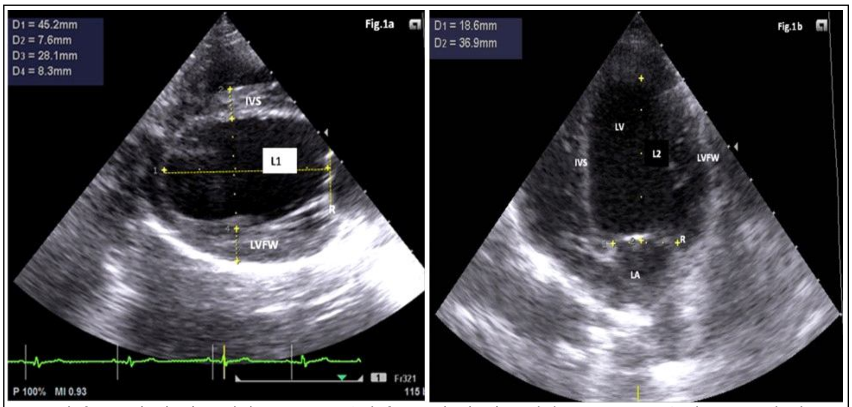
Krishi Vishvavidyalaya, Palampur as a part of first authors MVSc thesis. Fifty client owned healthy mongrel dogs (25 male; 25 female) presented for routine health check-up, vaccination and elective surgeries were the subjects of study. Selection criteria for clinically healthy dogs involved thorough assessments, including clinical evaluation, hematological analyses, radiological examination, electrocardiographic and routine echocardiographic evaluation. Dogs deemed healthy after preliminary examination underwent two-dimensional echocardiographic examination. A verbal consent was obtained from each dog owner prior to imaging studies.

The dogs were restrained manually on a specially designed table with a cut-out hole. The thorax was prepared on both sides sides from 3rd-7th rib and 1-5 cm lateral to sternum for right and left parasternal echocardiographic examination. Echocardiography was performed with an ultrasound machine, ACUSON X300 Premium Edition Diagnostic Ultrasound System, Siemens Medical Solutions USA, Inc. equipped with a 4.0-8.0 MHz multi-frequency phased array probe. Simultaneous electrocardiogram was recorded and superimposed on image display. Gain settings and gray scales were adjusted for better imaging of endocardial and epicardial surfaces. The vedio-tape recorded images were later replayed and measured using software available in ultrasound machine. Two-dimensional linear and area measurements of left ventricle was performed in right parasternal and left parasternal imaging planes (Thomas *et al.,* 1993) using the methods described by O'Grady *et al.* (1986). Same standardized imaging protocol was followed for each examination. In right parasternal long axis four-chamber imaging plane, care was taken to avoid left ventricle foreshortening. Left ventricle chamber dimension and wall thickness were measured in end-diastolic and end-systolic frames using blood-tissue interface (ie, inner edge-to-inner edge measurement technique). Following measurements of left ventricle were obatined in different tomographic planes.

1. Left ventricular internal length in diastole (L1d) and systole (L1s) was obtained from right parastemal long axis (RPLAx) view optimized for the left ventricular apex and mitral valve. L1 was measured from the midpoint of the left ventricular side of the mitral annulus extending to the apical endocardium (Fig 1a). Left ventricle internal length in diastole (L2d) and systole (L2s) was obtained from left parasternal apical long axis (LPALAx) optimized for left ventricle and mitral valve. L2 was measured from the midpoint of a reference line connecting the left ventricular side of the mitral annulus and extending to the apical endocardium (Fig 1b).
2. Left ventricular internal dimension, interventricular septum and free wall thickness in diastole and systole was measured in RPLAx view optimized for interventricular septum, left ventricular outflow tract, mitral valve and left ventricular free wall (excluding papillary muscle images) (O'Grady *et al.,* 1986) (Fig 2a).
3. Left ventricular internal dimension, interventricular septum and free wall thickness in diastole and systole was measured in RPSAx view optimized for chordate tendinae level of left ventricle (Fig 2b) (O'Grady *et al.,* 1986).
4. Left ventricular internal and external area was measured from RPSAx view at the left ventricular high papillary muscle level. Internal area was measured by tracing the trailing edge echo of the left ventricular septal endocardium and leading-edge echo of the left ventricular free wall endocardium in end-diastole.External area was measured by tracing the trailing edge echo of the right ventricular septal endocardium and the leading-edge echo of the pericardium in end-diastole (Fig 3).
5. Mitral valvular orifice area was measured from RPSAx view of mitral valve in the frame showing maximal opening of anterior and posterior mitral leaflets (Fig 4)

Following systolic function indices were derived:

1. Fractional shortening, FS (%), calculated from left ventricular internal dimensions in RPLAx and RPSAx using Teichloz formula (Teichloz *et al.,* 1976).



L1- left ventricular length in RPLAx; L2- left ventricular length in LPALAx; IVS - interventricular septum; LVFW-left ventricular free wall; LV-left ventrcile; LA-left atrium; R-reference line.

Fig 1 a, b: Measurement of left ventricular internal lengths (L1) and (L2) from right parasternal long axis (1a) and left parasternal apical long axis (1b).

$$FS = \frac{[LVIDd\text{-}LVIDs]}{LVIDd} \times 100$$

where:

LVIDd: Left ventricular internal dimension at end-diastole.

LVIDs: Left ventricular internal dimension at end-systole.

2. Ejection fraction, EF (%), derived from left ventricular diastolic and systolic volumes obtained using monoplane Simpson′s method of discs (SMOD) in RPLAx.

Statistical analysis

Data was analyzed by IBM SPSS Statistics 29.0 software. Bivariate Pearson′s correlation test was used to establish body weight correlation with echocardiographic parameters. Linear regression analysis was performed to assess relationship between echocardiographic parameters and body weight and, between same measurements obtained from different tomographic planes. Linear regression equation Y=bX+a was utilized to model and quantify relationship between dependent echocardiographic parameter (Y) and independent variable body weight (X). One-way analysis of variance (ANOVA) was used to compare mean values among males and females.

RESULTS AND DISCUSSION

Two-dimensional linear and cross-sectional measurements of left ventricle,interventricular septum, left ventricular free wall and mitral valve was standardized in 50 healthy mongrel dogs ageing 6 months-5 year (mean age= 1.59± 0.13 yr) and weighing 7-30 kg (mean body weight=16.66±0.73 kg).Two-dimensional echocardiographic images obtained in study resembled images documented by Thomas (1984) and O'Grady *et al.* (1986).Right parasternal location provided superior images compared to left parasternal, similar to findings of O′Grady *et al.*(1986). When measuring left ventricle dimensions, it was found that systolic and diastolic dimensions in short axis views were consistently greater compared to long-axis views (Table 1), aligning with the findings of O'Grady *et al.* (1986).

Left ventricular internal lengths

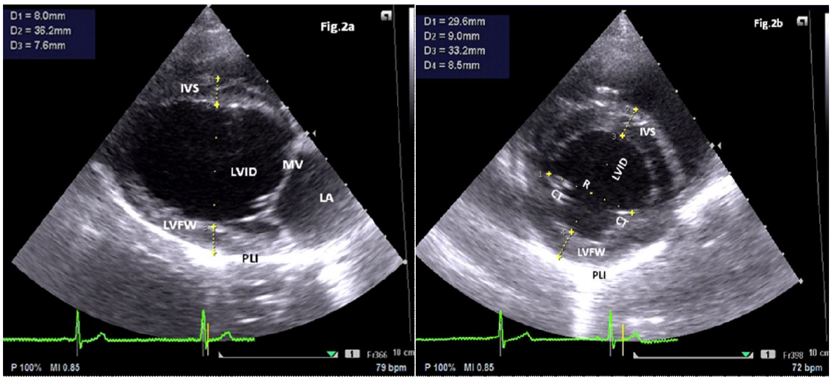
Left ventricular internal lengths in diastole and systole in RPLAx (L1d and L1s) and LPALAx (L2d and L2s) (Table 1) were lower than values (58.16±10.82 and 44.86±8.38 mm) and (51.74±10.42; 39.68±8.89 mm), respectively reported by O′Grady *et al.* (1986) in normal dogs.

Left ventricular internal dimensions (RPLAx)

Diastolic interventricular septum thickness (IVSd) (Table 1) was greater than value given by O'Grady *et al.* (1986) (6.91± 1.65 mm) but lower than values reported by Oliveira *et al.* (2014) (10.1±1.1 mm). Systolic interventricular septum thickness (IVSs) was near to value reported by O'Grady *et al.* (1986) (10.08±2.43 mm) but lower than value reported by Oliveira *et al.* (2014) (13.7±1.9 mm). Diastolic left ventricular internal dimension (LVIDd) was near to value reported by O'Grady *et al.* (1986) (33.92± 5.54 mm) but lower than value reported by Oliveira *et al.* (2014) (38.80±4.00 mm). Systolic left ventricular internal dimension (LVIDs) was lower than values reported by O′Grady *et al.* (1986) (24.64±4.79 mm) and Oliveira *et al.* (2014) (27.7± 3.10 mm) in normal dogs. Diastolic left ventricular free wall thickness (LVFWd) was slightly lower than value reported by Oliveira *et al.* (2014) (9.90±1.30 mm) but greater than value reported by O′Grady *et al.* (1986) (7.88± 2.16 mm). Systolic left ventricular free wall thickness (LVFWs) was slightly greater than value reported by O′Grady *et al.* (1986) (10.85±2.25 mm) but lower than value given by Oliveira *et al.* (2014) (14.80±2.00 mm).

Left ventricular internal dimensions (RPSAx)

Diastolic interventricular septum thickness (IVSd) was near to value reported by Oliveira *et al.* (2014) (9.5± 0.80 mm) but greater than value reported by O′Grady *et al.* (1986) (8.26±1.97 mm). Systolic interventricular septum thickness (IVSs) was near to value reported by O′Grady *et al.* (1986)



IVS-Interventricular septum; LVID-left ventricle internal dimension; LVFW-left ventricular free wall; LA- left atrium; CT-chordae tendineae, MV-mitral valve; PLI- pericardium lung interface; R-reference line.

Fig 2 a, b: Measurement of interventricular septum thickness, left ventricular internal dimension and left ventricular free wall thickness in RPLAx (2a) and RPSAx (2b).

(10.19±2.15 mm) but lower than that given by Oliveira *et al.* (2014) (12.8± 0.06 mm). Diastolic and systolic left ventricular internal dimensions (LVIDd and LVIDs) in RPSAx were near to values reported by O'Grady *et al.* (1986) (34.55±1.97 mm and 25.89±4.77 mm) but lower than value given by Oliveira *et al.* (2014) (40.0±4.3 mm and 28.9±3.40 mm).Diastolic left ventricular free wall thickness (LVFWd) was near to value reported by Oliveira *et al.* (2014) (9.7±0.11 mm) but slightly greater than value reported by O' Grady *et al.* (1986) (8.01±2.32 mm). Systolic left ventricular free wall thickness (LVFWs) was lower than value reported by Oliveira *et al.* (2014) (14.3±0.16 mm) but near to value reported by O′Grady *et al.* (1986) (10.33±2.77 mm).

Left ventricular internal and external area and mitral valve orifice area (RPSAx)

Internal and external area of left ventricle and mitral valve orifice area (Table 1) were slightly lower than values reported by O′Grady *et al.* (1986) (9.17±2.17 cm^2, 22.85±7.6 cm^2 and 3.69±69 cm^2, respectively).

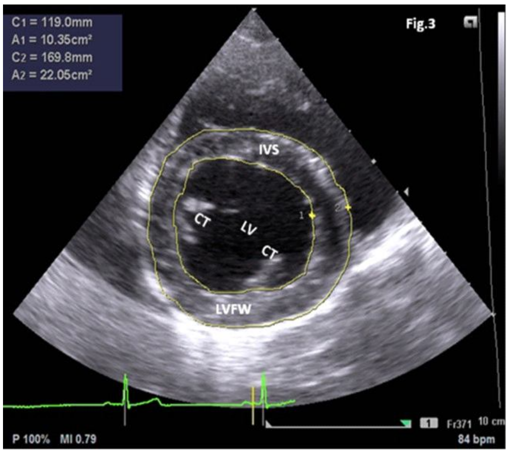
Left ventricular systolic function indices (Fractional shortening and ejection fraction)

Fractional shortening (FS) in RPLAx was slightly greater than value reported by O′Grady *et al.* (1986) (28 %; 21-34%) and Oliveira *et al.* (2014) (28.4 %; 26.89-29.94%) while in RPSAx, FS was near to values reported by O'Grady *et al.* (1986) (26%; 14-39 %) and (Oliveira *et al.*, 2014) (28.1 %; 26.52-29.68%).Visser *et al.* (2019) reported a cut-off value of FS of 22 % suggesting that many apparently large breed healthy dogs can have a FS close to 20% for years without a known cardiac event. Ejection fraction in RPLAx (53 %; 45-72%) was within the reference range proposed by O'Grady *et al.* (1986) (54 %; 42-64%) and Visser *et al.* (2019) (46-82.5%).

Correlation of two-dimensional echocardiographic measurements with body weight

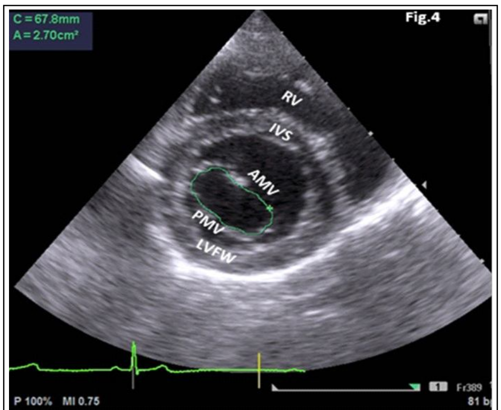
Two-dimensional echocardiographic measurements showed significant (P<0.01) positive linear correlationship with body weight (Table 2), concurring with previous findings in normal dogs (O′Grady *et al.,* 1986; Muzzi *et al.,* 2006; Visser *et al.,* 2019) and with those of left atrium and left ventricle size in cats (Haggstorm *et al.,* 2016; Karsten *et al.,* 2017). Significant (P<0.001) positive correlation between body weight and diastolic and systolic left ventricular length (L1d, LIs) in RPLAx and LPALAx (L2d, L2s) was in consonance with the findings of O'Grady *et al.* (1986). Significant (P<0.001) positive correlation between body weight and diastolic and systolic interventricular septum thickness (IVSd, IVSs), left ventricular internal dimension (LVIDd, LVIDs) and left ventricular free wall thickness (LVFWd, LVFWs) in right parasternal long and short axis views was in agreement with findings of other investigators (O'Grady *et al.*, 1986; Oliveira *et al.,* 2014 and Visser *et al.,* 2019). Significant (P<0.001) positive correlation between body weight and left ventricular internal and external area and mitral valve orifice area was in line with findings of O′Grady *et al.* (1986).

Significant weak negative correlation between body weight and FS (RPLAx, RPSAx) observed during this study (Table 2) substantiate the findings of Kayar *et al.* (2006), Oliveira *et al.* (2014) and Visser *et al.* (2019) but negate the findings of other investigators who reported no correlation between FS and body size, suggesting that FS is independent of body weight (Cornell *et al.*, 2004; Bodh *et al.,* 2019). Visser *et al.* (2019) observed significant weak negative correlations of EF and fractional area change with body weight suggesting that larger dogs might exhibit relatively decreased systolic function compared to smaller dogs owing to their higher resting vagal tone, calmer demeanor and increased athleticism. Variation in the observation of FS and EF might result due to dependence



CT- Chordae tendineae; IVS-Interventricular septum; LV-Left ventricle; LVFW-Left ventricle free wall

Fig 3: Measurement of left ventricular internal (endocardial) and external (epicardial) area from right parasternal short axis.



RV- Right ventricle; IVS-Interventricular septum; AMV-Anterior mitral valve; PMV-Posterior mitral valve; LVFW-Left ventricular free wall

Fig 4: Measurement of mitral valve orifice area from right parasternal short axis.

of these parameters on multiple factors such as preload, afterload and contractility, which influence them (O'Leary *et al.*, 2003). In general, linear measurements are linearly related to body length or body weight$^{1/3}$ and area and volume measurements are linearly related to body weight$^{2/3}$. Few studies reported a non-linear relationship between body weight and linear measurements of cardiac chamber size in dogs (Cornell *et al.,* 2004; Hall *et al.,* 2008) and cats (Scansen and Morgan, 2015). Contrary to above findings, our study supports the notion that linear cardiac measurements in dogs are indeed linearly related to body weight.

Effect of gender on two-dimensional echocardiographic measurements

Diastolic left ventricular internal length (Ld; RPLAx), systolic interventricular septum thickness (IVSs, RPLAx), systolic left ventricular internal dimension (LVIDs, RPSAx) and diastolic left ventricular free wall thickness (LVFWd, RPSAx) and internal and external area of left ventricle (RPSAx) showed significant (P<0.05) gender-based differences, with male dogs having greater values than females corroborating earlier reports (Muzzi *et al.* 2006; Bavegems *et al.* 2007). Mitral valve orifice area was significantly (P<0.05) greater in female dogs compared to males, substantiating the findings of Bodh *et al.* (2019) who reported significantly (P<0.05) higher mitral valve excursion amplitude in Indian Spitz dogs. Significantly (P<0.05) greater LVIDs (RPSAx) in male dogs was in line with finding of Muzzi *et al.* (2006) but contrary to findings of Bavegems *et al.* (2007) who reported significantly larger values of left ventricle internal diameters in female Whippets, attributable to their greater mean heart weight to body weight ratio compared to males. Significantly (P<0.05) greater LVFWs (RPSAx) in male dogs was in line with findings of Muzzi *et al.* (2006) who attributed increased thickness of left ventricular free wall due to work hypertrophy and higher body of males dogs. Other parameters *viz*. L2d and L2s (LPALAx), IVSd and IVSs (RPSAx), LVIDd and LVIDs (RPLAx), LVFWd and LVFWs (RPLAx), were unaffected by gender. Non-significant effect of gender on FS and EF supported previous findings in dogs (Muzzi *et al.*, 2006; Visser *et al.*,2019) and cats (Haggstorm *et al.*, 2016; Karsten *et al.*,2017).

Correlation between structures imaged and measured from different tomographic planes

All two-dimensional linear and cross-sectional measurements of left ventricle measured from the right parasternal long axis, right parasternal short axis, left parasternal long axis and left parasternal apical long axis

Table 1: Mean±SE of pooled data, minimum and maximum values of two-dimensional echocardiographic measurements and indices of left ventricular function in 50 mongrel dogs.

Parameter	Pooled (n=50)	Male (n=25)	Female (n=25)	P value
LV Length L1d (mm) (RPLAx)	48.79±0.54 (33.00-57.60)	49.02±0.93	48.57±0.56	0.009(S)
LV Length L1s (mm) (RPLAx)	38.92±0.70 (3.44-50.20)	38.92±1.12	38.91±0.87	NS
LV Length L2d (mm) (LPALAx)	40.73±0.59 (26.45-49.47)	41.03±0.95	40.43±0.71	NS
LV Length L2s (mm) (LPALAx)	31.94±0.73 (15.98-42.78)	32.22±1.20	31.66±0.83	NS
IVSd (mm) (RPLAx)	8.56±0.21 (5.10-12.34)	8.68±0.31	8.45±0.30	NS
IVSs (mm) (RPLAx)	10.04±0.20 (6.24-13.61)	10.11±0.31	9.96±0.25	0.003 (S)
LVIDd (mm) (RPLAx)	32.59±0.56 (20.50-41.39)	33.15±0.87	32.03±0.70	NS
LVIDs (mm) (RPLAx)	22.70±0.53(12.80-30.80)	23.51±0.79	21.90±0.67	NS
LVFWd (mm) (RPLAx)	9.67±0.18 (6.40-12.76)	9.51±0.27	9.83±0.23	NS
LVFWs (mm) (RPLAx)	11.17±0.16 (7.50-14.89)	11.04±0.26	11.30±0.21	NS
IVSd (mm) (RPSAx)	9.12±0.21 (6.00-12.10)	9.24±0.29	9.00±0.30	NS
IVSs (mm) (RPSAx)	10.52±0.22 (7.00-14.20)	10.75±0.33	10.28±0.27	NS
LVIDd (mm) (RPSAx)	34.03±0.56 (21.80-42.32)	34.40±0.87	33.65±0.72	NS
LVIDs (mm) (RPSAx)	25.34±0.56 (14.40-34.23)	25.64±0.71	25.04±0.89	0.05 (S)
LVFWd (mm) (RPSAx)	9.69±0.19 (6.40-12.67)	9.89±0.29	9.48±0.25	0.003 (S)
LVFWs (mm) (RPSAx)	10.86±0.25 (7.89-14.34)	10.83±0.46	10.88±0.23	NS
LV Internal area (RPSAx) (cm^2)	7.58±0.16 (4.38-10.35)	7.83±0.26	7.33±0.19	0.025 (S)
LV Ext. area (RPSAx) (cm^2)	20.52±0.50 (12.30-29.50)	21.32±0.74	19.73±0.65	NS
MV orifice area (RPSAx) (cm^2)	2.38±0.07 (1.15-4.54)	2.34±0.08	2.41±0.12	0.004 (S)
FS (LAx) (nu)	0.31±0.01 (0.25-0.45)	0.29±0.01	0.32±0.01	NS
FS (SAx) (nu)	0.26±0.01 (0.14-0.39)	0.26±0.01	0.26±0.01	NS
EF (Lax) (nu)	0.53±0.01 (0.45-0.72)	0.51±0.01	0.55±0.01	NS

RP-right parasternal; LP-left parasternal ; SAx- short axis ; LAx- long axis ; ALA- apical long axis; LV-left ventricle; LA- left atrium; LVID-left ventricular internal dimension; IVS-interventricular septum; LVPW-left ventricular free wall; s-systole; d-diastole; MV-mitral valve; L1- left ventricular internal length; L2- left ventricular internal length; FS-fractional shortening; EF-ejection fraction; nu-no unit; S- significant; NS-non-significant.

Table 2: Body weight correlation of two-dimensional echocardiographic parameters and indices of left ventricular function in 50 mongrel dogs.

Parameter	r	R^2	Regression equation (y)	P value
LV Length L1d (mm) (RPLAx)	0.92**	0.84	y=37.56+0.67x	<.001
LV Length L1s (mm) (RPLAx)	0.88**	0.78	y=24.83+0.85x	<.001
LV Length L2d (mm) (LPALAx)	0.89**	0.79	y=28.77+0.72x	<.001
LV Length L2s (mm) (LPALAx)	0.79**	0.63	y=18.81+0.79x	<.001
IVSd (mm) (RPLAx)	0.95**	0.91	y=3.91+0.28x	<.001
IVSs (mm) (RPLAx)	0.93**	0.87	y=5.85+0.25x	<.001
LVIDd (mm) (RPLAx)	0.90**	0.81	y=21.77+0.68x	<.001
LVIDs (mm) (RPLAx)	0.87**	0.76	y=12.31+0.62x	<.001
LVFWd (mm) (RPLAx)	0.77**	0.59	y=6.58+0.19x	<.001
LVFWs (mm) (RPLAx)	0.81**	0.65	y=8.15+0.18x	<.001
IVSd (mm) (RPSAx)	0.94**	0.88	y=4.73+0.26x	<.001
IVSs (mm) (RPSAx)	0.91**	0.82	y=6.10+0.27x	<.001
LVIDd (mm) (RPSAx)	0.86**	0.73	y=23.10+0.66x	<.001
LVIDs (mm) (RPSAx)	0.85**	0.72	y=14.40+0.66x	<.001
LVFWd (mm) (RPSAx)	0.92**	0.85	y=5.71+0.24x	<.001
LVFWs (mm) (RPSAx)	0.58**	0.34	y=7.51+0.20x	<.001
LV internal area (RPSAx) (cm^2)	0.53**	0.28	y=5.61+0.12x	<.001
LV external area (RPSAx) (cm^2)	0.84**	0.71	y=10.97+0.57x	<.001
MV orifice area (RPSAx) (cm^2)	0.58**	0.33	y=1.43+0.06x	<.001
FS (Lax) (nu)	-0.55**	0.31	y=-0.01x+0.39	<.001
FS (SAx) (nu)	-0.50**	0.24	y= -0.01x+0.35	<.001
EF (Lax) (nu)	-0.57**	0.32	y= -0.01x+0.65	<.001

**P<0.01 - highly significant at 95% confidence interval.

r= Correlation coefficient indicating strength of relationship (r= 0.6-1, strong; r= 0.3-0.59, moderate and r = <0.3, weak); R^2= Coefficient of determination; RP- Right parasternal; LP- Left parasternal ; SAx- Short axis ; LAx- Long axis ; ALA- Apical long axis; LV-Left ventricle; LVID-Left ventricular internal dimension; IVS-Interventricular septum ; LVFW-Left ventricular free wall; s-Systole; d-Diastole; MV-Mitral valve ; L1- Left ventricular internal length L1; L2- Left ventricular internal length L2 ; FS-fractional shortening; EF-Ejection fraction; cm^2-Centimeter square; mm- Millimeter; nu-No unit.

Table 3: Correlation between two-dimensional linear measurements of left ventricular size measured from different tomographic planes.

Dependent variable	Independent variable	r	P value
LV length L1 d (mm) (RPLAx)	LV length L2 d (mm) (LPALAx)	0.94	<0.001
LV length L1 s (mm) (RPLAx)	LV length L2 s (mm) (LPALAx)	0.83	<0.001
IVSd (mm) (RPLAx)	IVSd (mm) (RPSAx)	0.94	<0.001
IVSs (mm) (RPLAx)	IVSs (mm) (RPSAx)	0.88	<0.001
LVIDd (mm) (RPLAx)	LVIDd (mm) (RPSAx)	0.92	<0.001
LVIDs (mm) (RPLAx)	LVIDs (mm) (RPSAx)	0.85	<0.001
LVPWd (mm) (RPLAx)	LVPWd (mm) (RPSAx)	0.69	<0.001
LVPWs (mm) (RPLAx)	LVPWs (mm) (RPSAx)	0.57	<0.001

** P<0.01- data highly significant at 95% confidence interval.

r= Correlation coefficient indicating strength of relationship (r= 0.6-1; strong, r= 0.3-0.59; moderate and r= <0.3; weak); RP-Right parasternal; LP- Left parasternal; SAx- Short axis; LAx- Long axis; ALA-apical long axis; LV-left ventricle; LVID-Left ventricular internal dimension; IVS-Interventricular septum; LVFW-Left ventricular free wall; s-Systole; d-Diastole; L1-left ventricular internal length; L2-Left ventricular internal length; mm- Millimeter.

imaging planes displayed significant positive correlations (P<0.01) with each other (Table 3) consistent with findings reported by O'Grady *et al.* (1986) in normal dogs.

CONCLUSION

All linear and area measurements of left ventricle correlated positively and significantly (P<0.001) with body weight while fractional shortening and ejection fraction showed significant (P<0.001) negative correlation with body weight. Majority of parameters exhibited non-significant effect of gender except diastolic left ventricular internal length (L1d, RPLAx),systolic interventricular septum thickness (IVSs, RPLAx), systolic left ventricular internal dimension (LVIDs, RPSAx), diastolic left ventricular free wall thickness (LVFWd, RPSAx) that were significantly (P<0.01) higher in male dogs. All linear and area measurements obtained from different tomographic planes correlated positively and significantly (P<0.001) with each other.Reference values of left ventricular size and function generated in this study will aid in cardiac disease diagnosis in Indian mongrel dogs.

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Conflict of interest

The authors declare that they have no conflict of interest.

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