Echocardiographic Parameters and Indices in Healthy Labrador Retriever Dogs

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ABSTRACT

The normal echocardiographic parameters in Labrador retriever dogs were determined and correlated with body weight, age and sex. Thirty-one clinically healthy Labrador retriever dogs of both sexes (18 males and 13 females) were used for determining echocardiographic reference values. Twenty four dogs were in the body weight range of 20-40 kg and 7 dogs in 40-60 kg range. To study the effect of age on various echocardiographic measurements dogs were divided into 4 age groups (1-2, 2-3, 3-5 and >5 years of age). M-mode and 2 dimensional echocardiographic parameters were carried out by using GE Logiq P5 Color Doppler. The right ventricular internal dimensions during diastole (RVIDd), left ventricular internal dimension at end-diastole (LVIDd), left ventricular internal dimension at end-systole (LVIDs) were significantly (P<0.05) affected by body weight. E-Point-to Septal Separation (EPSS), End Diastolic Volume (EDV), End Diastolic Volume Index (EDVI), End Systolic Volume (ESV), End Systolic Volume Index (ESVI) were significantly (P<0.05) affected by body weight. There was significant (P<0.05) effect of age on left ventricular internal and wall dimensions, EDV and EPSS. Gender has no significant effect on any M mode parameter except for significant effect on RVIDd.

Keywords: Echocardiography; M mode; Labrador retrievers; body weight.

INTRODUCTION

The normal echocardiogram indices are essential for evaluation of dogs for assessment of cardiac chambers and valves in order to diagnose cardiac problems. Although some normal echocardiographic values for dogs have been published, but there is variation depending on breeds, body size and somatotype (1-2). In canine cardiology, reference echocardiographic values are obtained from a large population of healthy dogs of different breeds and arranged according to body weight and/or body surface area (BSA) (3-5). Variations between breeds is considered to be the most important factor affecting echocardiographic reference values. Therefore, echocardiographic reference ranges derived from a variety of breeds may be misleading (6). There is a need for reliable, normal echocardiographic values for chamber size, wall dimensions and myocardial function for comparison and evaluation of dogs suspected for having heart diseases (7). Breed specific data are scarce in the literature and breed specific reference ranges are required to obtain more narrow reference ranges required for M-mode dimensions or two-dimensional echocardiographic derived left ventricular volumes or ejection fractions (8).

This study was carried out to determine normal echocardiographic parameters in Labrador retriever dogs and to determine the relationship between body weight, age and sex with various echocardiographic parameters.

MATERIALS AND METHODS

Animals

Thirty-one clinically healthy adult Labrador retriever dogs, 18 males and 13 females, ranging in age from 1 year to 5 years and older, presented for routine examination, deworming and vaccination at Teaching Veterinary Hospital of GADVASU were included in this study. Complete physical examination for cardiovascular system, electrocardiographic and radiographic examination was performed. Echocardiographic examination was performed for confirmation of the absence of any valvular regurgitations and myocardial lesions. For echocardiographic study, healthy Labrador retriever dogs were grouped into two groups based on their body weight. Out of 31 dogs taken for study, 24 dogs were in body weight range of 20-40 kg and 7 dogs in 40-60 kg. To study the effect of age on various echocardiographic measurements, dogs were divided into 4 age groups (1-2, 2-3, 3-5 and >5 years of age).

Echocardiography

M-mode and 2 dimentional echocardiographic examinations of dogs were carried out by using GE Logiq P5 Color Doppler (GE healthcare, Chicago, United States) equipped with sector probe 3S, 5S and 7S, depending on the size of the animal.

Patient preparation and positioning

All the dogs were clipped on their right and left thoracic walls from the 4^{th} to 6^{th} intercostal space and placed in the lateral recumbency on a specially designed table with a semicircular cut on one side of the table (9). The transducer was placed through a hole underneath the table. Ultrasound gel was used for coupling of transducer with skin. None of the animals were sedated or tranquilized.

Measurements

All M-mode dimensional measurements were obtained in centimeters from the right parasternal short axis view of the left ventricle with the cursor positioned at chordae tendinae level (5, 10-11). All M mode echocardiographic measurements were made in accordance with the guidelines of the American Society of Echocardiography by using the leading-edge to leading-edge method of measurement (10). Measurement of the cardiac structures was made from the frozen M-mode images on the screen. All the measurements of each variable were taken in duplicate from different heart cycles and the average of the data was used (12). The following M-mode measurements were made: Left ventricular internal dimension at end-systole (LVIDs), left ventricular internal dimension at end-diastole (LVIDd), left ventricular posterior wall thickness at end-systole (LVPWs), left ventricular posterior wall thickness at end-diastole (LVPWd), interventricular septal thickness at end-systole (IVSs) and interventricular septal thickness at end-diastole (IVSd). On the basis of the LVIDd and LVIDs measurements in M-mode, end diastolic volume (EDV), end systolic volume (ESV) were calculated according to the Teichholz formula by the ultrasound's computer software. The end diastolic volume index (EDVI, ml/m^2) and end systolic volume index (ESVI, ml/m^2) were normalized to body surface area (BSA). Fractional shortening (FS %) was calculated using the formula reported by previous workers (3).

The internal diameter of the aortic root diameter (Ao) was measured along the commissure between the non-coronary and right coronary aortic valve cusps, on the first frame after aortic valve closure. The internal diameter of the left atrium (LA) was measured in the same frame in a line extending from, and parallel to, the commissure between the non-coronary and left coronary aortic valve cusps to the distant margin of the left atrium (13). The LA diameter and Ao were measured in centimeters. LA/Ao ratio was calculated as an index for atrial size.

Calculations

$$\text{Fractional shortening (FS\%)} = \text{LVIDd-LVIDs/LVIDd}$$

$$\text{Ejection Fraction (EF\%)} = \frac{\text{EDV - ESV}}{\text{EDV}} \times 100$$

$$\text{EDVI (ml/m}^2\text{)} = \frac{\text{EDV}}{\text{BSA (m}^2\text{)}}$$

$$\text{ESVI (ml/m}^2\text{)} = \frac{\text{ESV}}{\text{BSA (m}^2\text{)}}$$

Statistical analysis

The statistical analysis was carried out using the multiple ANOVA with Tukey's post hoc test. Linear regression and Pearson's correlation analysis was done by using software 'SAS' version 9.3. The significance level was set at ≤0.05

RESULTS

Mean ± SEM of M mode echocardiographic parameters of healthy Labrador dogs and the effect of body weight, age and gender on all M mode parameters are presented in Table 1.

Effect of body weight on echocardiographic parameters

LVIDd and LVIDs were significantly ($p \leq 0.01$) affected by body weight. The values of RVIDd, LVID during diastole and systole showed positive correlation with the body weight which was significant with correlation coefficient values of 0.309, 0.222 and 0.150, respectively (Table 2). In contrast, the IVSd, IVSs, LVPWd and LVPWs were not significantly ($p \leq 0.05$) affected by body weight. The thickening of IVS during diastole and systole were negatively correlated with bodyweight but the association was non-significant. LVPW during diastole and systole were directly correlated with body weight but the dependence of these factors on body weight was statistically non-significant i.e. the correlation was weak.

The values of LA, LA: Ao and E-Point-to Septal Separation (EPSS) were unaffected by body weight, however Ao was significantly ($p \leq 0.05$) affected by body weight (Table 1).

FS% and EF % were significantly ($p \leq 0.05$) affected by body weight. Mean EDV and ESV values were also significantly ($p \leq 0.01$) affected by body weight. EDV and ESV had direct positive relationship with body weight with correlation coefficient of 0.258 and 0.201 respectively.

ESVI was significantly ($p \leq 0.05$) affected by body weight with higher values in higher body weight groups. EDVI and ESVI had direct positive relationship with body weight with r^2 values 0.100 and 0.087, respectively (Table 2).

Effect of age on echocardiographic parameters

Mean values of LVPWs and IVSd were significantly affected by age with $p \leq 0.01$ and $p \leq 0.05$ respectively. The mean values of LVPWs of young dogs belonging to age group 1-2 & 2-3 years was significantly ($p \leq 0.05$) different from dogs of age groups 3-5 years. RVIDd, LVIDd, LVIDs, IVSs and LVPWd were not affected by age. Similarly, no significant effect ($p \geq 0.05$) of age was observed on LA, Ao, LA: Ao, EPSS, EDVI and ESVI. FS% and EF % were significantly affected by age with $p \leq 0.01$ and $p \leq 0.05$ respectively. The values of age group 3-5 years were significantly different from dogs belonging to 1-2 year age group.

Effect of gender on echocardiographic parameters

In healthy Labradors, the gender had significant effect on RVIDd ($p \leq 0.001$), LVIDd ($p \leq 0.05$) and LVIDs ($p \leq 0.05$) and the aortic root dimensions ($p \leq 0.001$). Other LV dimension parameters of the M mode were not affected by gender. The RVID in diastole, LVIDd, LVIDs and the aortic root dimensions was higher in males than in females and these differences were statistically significant. EDV, ESV EDVI and ESVI were also significantly ($p \leq 0.05$) higher in males as compared to females.

Table 1: Effect of body weight, age and sex on M mode echocardiographic reference parameters in healthy Labrador dogs

Parameters		RVIDd (cm)	LVIDd (cm)	LVIDs (cm)	IVSd (cm)	IVSs (cm)	LVPWd (cm)	LVPWs (cm)	FS %	Ao (cm)
BW (Kg)	20-40 Kg (n= 24)	1±00.05	3.56^{b}±0.07	2.36^{b}±0.06	1.20^{b}±0.04	1.46±0.05	0.85±0.02	1.22±0.03	33.77^{a}±0.97	2.14^{a}±0.04
	40-60 Kg (n= 7)	1.22±0.11	4.02^{a}±0.14	2.87^{a}±0.13	1.02^{a}±0.08	1.21±0.11	0.9±0.05	1.14±0.07	28.48^{b}±2.01	2.38^{b}±0.08
	p value	(0.082)	(0.0071)	(0.001)	(0.054)	(0.065)	(0.345)	(0.310)	(0.027)	(0.015)
Age (Years)	1-2 years (n= 6)	1.19±0.11	3.76±0.15	2.76±0.14	1.08^{ab}±0.08	1.26±0.12	0.81±0.05	1.03^{b}±0.07	26.70^{b}±2.11	2.41±0.09
	2-3 Years (n= 10)	1.06±0.09	3.79±0.12	2.68±0.11	0.99^{b}±0.06	1.26±0.09	0.86±0.04	1.10^{b}±0.06	29.37^{ab}±1.7	2.23±0.07
	3-5 Years (n= 8)	1.28±0.09	3.97±0.11	2.56±0.1	1.29^{a}±0.06	1.59±0.09	0.88±0.04	1.34^{a}±0.05	35.86^{a}±1.6	2.17±0.07
	>5 Years (n= 7)	0.92±0.11	3.62±0.14	2.45±0.13	1.08^{ab}±0.07	1.23±0.11	0.94±0.05	1.24^{ab}±0.06	32.58^{ab}±1.95	2.24±0.08
	p value	(0.071)	(0.311)	(0.248)	(0.026)	(0.064)	(0.199)	(0.0031)	(0.008)	(0.161)
Gender	Female (n = 13)	0.94^{b}±0.08	3.65^{b}±0.10	2.48^{b}±0.10	1.11^{b}±0.06	1.32±0.08	0.87±0.04	1.18±0.05	32.18±1.46	2.13^{b}±0.06
	Male (n= 18)	1.27^{a}±0.07	3.93^{a}±0.09	2.75^{a}±0.08	1.11^{a}±0.05	1.35±0.07	0.88±0.03	1.17±0.04	30.07±1.22	2.39^{a}±0.05
	p value	(0.0006)	(0.019)	(0.017)	(0.917)	(0.716)	(0.895)	(0.871)	(0.209)	(0.0003)
All Dogs (n= 31)		1.08±0.05	3.7±0.06	2.5±0.06	1.15±0.03	1.41±0.05	0.86±0.02	1.2±0.03	32.43±0.85	2.22±0.04
Range		0.46-2.27 (1.81)	2.14-4.85 (2.71)	1.35-3.81 (2.46)	0.74-1.9 (1.16)	0.85-2.45 (1.6)	0.55-1.17 (0.62)	0.78-1.63 (0.85)	21.5-41.77 (34.46)	1.64-2.87 (1.23)

Values with different superscript within a parameter differ significantly.

Table 1 Continued

Parameters		LA (cm)	LA_Ao	EDV (ml)	ESV (ml)	EF %	EDVI (ml/m2)	ESVI (ml/m2)	EPSS (cm)
BW (Kg)	20-40 Kg (n= 24)	2.62±0.06	1.23±0.03	54.37^{b}±2.4	20.50^{b}±1.44	62.93^{a}±1.41	51.28±2.13	19.41^{b}±1.32	0.45±0.02
	40-60 Kg (n= 7)	2.81±0.12	1.19±0.06	72.07^{a}±5.0	31.81^{a}±3.01	55.51^{b}±2.94	58.53±4.43	26.1^{a}±2.75	0.55±0.05
	p value	(0.176)	(0.519)	(0.0035)	(0.002)	(0.034)	(0.165)	(0.041)	(0.112)
Age (Years)	1-2 years (n= 6)	2.73±0.13	1.12±0.07	62.45±5.24	29.92±3.15	52.80^{b}±3.08	54.11±4.64	25.87±2.88	0.47±0.05
	2-3 Years (n= 10)	2.80±0.10	1.28±0.05	63.13±4.23	27.34±2.54	56.75^{ab}±2.49	57.11±3.75	24.75±2.33	0.46±0.04
	3-5 Years (n= 8)	2.70±0.10	1.26±0.05	70.03±3.99	24.91±2.4	65.49^{a}±2.34	59.07±3.53	20.98±2.19	0.57±0.04
	>5 Years (n= 7)	2.63±0.12	1.18±0.06	57.26±4.84	22.44±2.91	61.85^{ab}±2.84	49.33±4.28	19.42±2.66	0.5±0.05
	p value	(0.637)	(0.145)	(0.287)	(0.231)	(0.011)	(0.312)	(0.192)	(0.389)
Gender	Female (n = 13)	2.63±0.09	1.24±0.05	57.81^{b}±3.63	23.12^{b}±2.18	60.92±2.13	50.50^{b}±3.22	20.11^{b}±1.99	0.48±0.04
	Male (n= 18)	2.80±0.07	1.18±0.04	68.63^{a}±3.04	29.19^{a}±1.83	57.53±1.79	59.31^{a}±2.69	25.39^{a}±1.67	0.52±0.03
	p value	(0.101)	(0.282)	(0.011)	(0.017)	(0.167)	(0.019)	(0.023)	(0.305)
All Dogs (n= 31)		2.69±0.05	1.23±0.03	59.64±2.35	23.65±1.32	61.00±1.24	54.16±1.86	21.53±1.15	0.48±0.02
Range		1.97-3.74 (1.77)	0.78-1.73 (0.95)	15.04-110.04 (95)	4.62-62.18 (57.56)	43.49-74.34 (50.6)	16.15-93.15 (77)	4.96-52.64 (47.68)	0.18-0.82 (0.64)

Values with different superscript within a parameter differ significantly.

No significant effect of gender on FS%, EF% was observed in the present study.

DISCUSSION

The left ventricular wall thickness (LVPWd=0.86±0.02cm, LVPWs=1.22±0.03cm), interventricular septal wall thickness (IVSd=1.15±0.03cm, IVSs=1.41±0.05cm) and the left ventricular internal dimensions (LVIDd=3.70±0.06cm, LVIDs=2.50±0.06cm) recorded in healthy Labradors in this study were according to the range of values which were considered to be normal for the dogs of this body size (9). Left ventricular dimensions taken during echocardiography have quite a significant correlation with the clinical manifestation of cardiac diseases (9). Left ventricular internal diameter at end diastole (LVIDd) and systole (LVIDs) is of great help in the direct assessment of cardiomyopathies. In case of dilated cardiomyopathy, the left ventricular internal diameter increases in both systole (LVIDs) and diastole (LVIDd), while in hypertrophic cardiomyopathy both these parameters decrease (14). In any kind of pressure overload on the heart that may result in hypertrophic cardiomyopathy as seen in aortic stenosis, measurement of left ventricular posterior wall thickness becomes a very important diagnostic parameter (14).

The cardiac dimensions are referenced against patient's body weight based on the assumption that the relationship between heart size and patients body weight is linear leading to normal ranges (15). Previous studies reported relative development of heart with body weight when observed by M-mode echocardiography (2). Some previous studies were also of the opinion that reference echocardiographic parameters obtained from groups of healthy dogs of different breeds can be ranged according to either body weight and/or body surface area (BSA) (3-5,16).

We documented a relationship between the majorities of M-mode echocardiographic measurements with BW. Similar to our findings, various other workers also observed positive relationship of various cardiac parameters with body weight in German shepherd dogs (17-18).

Normal echocardiographic parameters have been published for the Cocker Spaniel (19) English Pointer (2), Golden Retriever and Afghan Hounds (16), Beagle (20), Greyhound (21), Spanish Mastiff (22), Boxer (23), Irish Wolfhounds (24), Bull Terrier (6), German shepherd (17-18), Whippet (25), Hungarian Dog breeds (26), Indonesian mongrel dogs (27) and Border Collies (28). Only a single study on echocardiography in Labrador retrievers have been reported and only the effect of body weight and sex was studied on M mode parameters (29). Thus the present study was aimed to establish the echocardiographic reference ranges in healthy Labrador retriever dogs and to evaluate detailed effect of body weight, sex and age, on various echocardiographic parameters.

In present study, LVIDd and LVIDs were significantly

Table 2: Linear regression model showing relationship between body weight (x) (Kg) and echocardiographic parameters (y) in healthy Labrador group dogs

Echocardiographic Parameters	Regression (y =)	Correlation	(r^2)	*p*-Value
RVId (cm)	0.492x+0.027	0.556	0.309	0.000*
LVIDd (cm)	0.577x+2.413	0.471	0.222	0.000*
LVIDs (cm)	0.426x+1.554	0.387	0.150	0.002*
IVSd (cm)	-0.033x+1.228	-0.055	0.003	0.670
IVSs (cm)	-0.045x+1.511	-0.053	0.003	0.680
LVPWd (cm)	0.069x+0.704	0.182	0.033	0.154
LVPWs (cm)	0.071x+1.041	0.133	0.018	0.300
FS%	-1.733x+36.050	-0.151	0.023	0.270
AO (cm)	0.144x+1.896	0.204	0.042	0.109
LA (cm)	0.162x+2.325	0.176	0.031	0.167
LA/AO	-0.003x+1.232	-0.005	0.000	0.966
EDV (ml)	23.592x+7.059	0.508	0.258	0.000*
ESV (ml)	10.830x-0.388	0.448	0.201	0.001*
EF%	-2.993x+67.649	-0.179	0.032	0.191
EDVi (ml/m^2)	11.559x+28.127	0.317	0.100	0.018*
ESVi (ml/m^2)	5.908x+8.285	0.295	0.087	0.029*
EPSS (cm)	0.151x+0.140	0.372	0.138	0.004*

* Correlation and regression value is significantly ($P\leq0.05$) related with the echocardiograhic parameter.

($P<0.05$) affected by body weight. Many previous workers also reported positive correlation of LVIDd and LVIDs with body weight (1, 6, 19) and in contrast some reported positive relationship between RVIDd dimensions and body weight (17, 24).

Mean values of IVSd, IVSs, LVPWd and LVPWs were not significantly ($p\leq0.05$) affected by body weight in the present study. However, a direct relationship between IVS in systole and diastole with BW was observed previously in German shepherd dogs (17) and growing Mastiff dogs (22). Some studies reported weak relationship between IVS in systole and diastole with body weight in Greyhound dogs (21) or lack of correlation between IVS during systole and diastole with body weight in Beagle dogs (20).

LVPW during diastole and systole were not correlated with body weight in present study. Similar to our findings, body weight has been found to have no effect on LVPWd in Afghan Hounds and Miniature Poodles (16) while others also observed no correlation between body weight and LVPW in diastole as well as systole in beagles (20). However, in contrary to our findings, only a few studies observed positive correlation between LVPWd and LVPWs with BW (1, 10).

EPSS is a qualitative indicator of the left ventricular function. Body weight was positively correlated with EPSS and the association was significant ($p\leq0.05$). Similarly, other workers have also noted significant correlation between EPSS and body weight in different sized adult dog breeds (20).

Left ventricular systolic function is measured by fractional shortening and is affected by preload, afterload and contractibility. Mean value of FS% in healthy Labradors in this study was in the normal range (21.5-41.77%). FS % and EF% were significantly ($p\leq0.05$) decreased with increase in body weight. The decrease in FS in relation to an increase in BW may be interpreted as a reduction of the fractional contraction in relation to BW increase in dogs (2). Similar results were observed by other workers (20, 30). Our results with regard to the lack of correlation between echocardiographic parameters of cardiac heart function (FS% and EF %) and body weight were in agreement with those reported previously (4, 15).

It was observed that the EDV and ESV were increasing significantly ($p\leq0.01$) with body weight suggesting left ventricular dimensions increased with increase in body weight.

The indices (EDVI and ESVI) can be used to compare the ventricular diastolic and systolic volume between dogs irrespective of size. An M-mode derived systolic volume index <30 ml/m^2 and a diastolic volume index <100 ml/m^2 in the present study is considered normal in all breeds and sizes of dog (31). Elevation of values of EDVI and ESVI with increase in body weight in this study was probably due to elevation of EDV and ESV with increase in body weight.

In present study, IVSd and LVPWs were significantly affected with age with $p\leq0.05$ and $p\leq0.01$ respectively in Labrador dogs. In line with our findings, others also reported direct a relationship of age with LVIDd, LVIDs, LVPWs and RVID in Irish Wolfhounds (24). In divergence to this, others did not find any effect of age on any of the echocardiographic parameters in German Shepherd dogs (17). While some identified that LVIDs, LVIDd were independent of age in Spanish mastiffs (22) but others observed no effect of age on LVIDd in Estrela mountain dogs (32).

In this study, mean values of EPSS was higher although statistically non-significant in age group of 3-5 years as compared to other age groups. Similarly, previous workers also reported significant increase in EPSS value in Spanish mastiffs from an average of 1.79 mm at 1 month of age to 6.71 mm in 2-4 year old dogs (22).

Age showed significant effect on FS% as well as EF% at (p≤0.01) and (p≤0.05) respectively. The alteration in FS % cannot be considered to be part of a normal ageing process, but a result of cardiac disease as was suggested in previous studies (22). No significant effect of age on LA, Ao, EDVI and ESVI in this study was in agreement with similar observations in De Bordeaux dogs (33).

In the present study, gender had a significant effect only on RVIDd (p≤0.001), LVIDd (p≤0.05), LVIDs (p≤0.05) and aortic dimensions (p≤0.001). However, many previous studies (4, 24) reported no effect of gender on echocardiographic parameters. While others found significant relationship between gender and LVPW in systole and diastole (17). Similarly, in other investigations a higher LVPW was reported in males as compared to females in German Shepherd (17) and Beagle dogs (20).

Similar to our findings, other investigators also reported higher values of Ao in males as compared to females in Indonesian Mongrel Dogs (27).

CONCLUSIONS

Reference echocardiographic values were established in thirty-one clinically healthy Labradors. Body weight has significant effect on most of the echocardiographic parameters. So within a given breed, echocardiographic reference data need to be established in different body weight categories, so that reference data can be used for diagnosis of various cardiac problems in dogs of different body weights.

CONFLICT OF INTEREST STATEMENT

We declare that we have no conflict of interest.

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