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Motion Mode and Two-Dimensional Echocardiographic Measurements of Cardiac Dimensions in Local Dogs in Malaysia

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ABSTRACT

Echocardiographic measurements of the dog's heart are known to be breed-specific. The establishment of normal echocardiographic measurements for each breed of dog increases the accuracy of echocardiographic examination. The purpose of this preliminary study was to determine the value of normal echocardiographic measurements of local dogs from Malaysia. A total of 20 clinically healthy client-owned pet dogs were recruited, in accordance to the pre-determined inclusion criteria of the study. Two dimensional and M-mode echocardiograms image of both long and short axis of the left ventricle were obtained in accordance to recommendation by the American Society of Echocardiography. From this study, the reference echocardiographic measurements of local dogs in Malaysia were established. The measurements of intra-cardiac dimensions, wall thickness, and contractility varied from the Indonesian mongrel dogs, as well as the general population of dogs that have the same average body weight. There is no association between echocardiographic measurements with gender and bodyweight of local dogs in Malaysia.

Key words: Malaysia, Local dogs, Breed specific, Echocardiography, Reference measurements, Heart

INTRODUCTION

Echocardiography, also known as ultrasound of the heart, is a useful diagnostic tool routinely used to evaluate dogs suspected with cardiovascular disease. It is non-invasive and provides valuable information of the cardiac structures (i.e. myocardium, valves, chambers and lumens) and functions (Oyama, 2004; Hassan and Abdelgalil, 2020). In dogs, the clinical manifestation of cardiovascular diseases ranges from inapparent clinical signs to involvement of multiple organs as the disease progresses (Martin *et al.*, 2009; Falk *et al.*, 2010). Hence, early detection of cardiac changes and diagnosis of cardiovascular disease is important for treatment decisions. Early detection of cardiac changes in dogs requires evaluations which consist of information from history, clinical observation by the owner, physical examination specifically cardiac auscultation, electrocardiography and various diagnostic imaging modalities such as thoracic radiography, but most importantly the echocardiography, as it often provides definitive ante-mortem diagnosis (Tilley *et al.*, 2008). The basic modalities of echocardiography are inclusive of two-dimensional (2D), M-mode and Doppler for the investigation of both cardiac function and disease diagnosis. Combination of these echocardiographic modalities is an adjunct to qualitative and quantitative assessment of cardiac structures and functions (Thomas *et al.*, 1993).

Echocardiographic measurements for the general dog populations have been well established (Lombard, 1984; Boon, 2011). Studies have shown that the echocardio-graphic measurement of the heart varied between different breeds of dog, growing stage, different somatotype and is dependent the body surface area and growing stage (Sission and Schaeffer, 1991; Morisson *et al.*, 1992). These measurements are often used and compared upon assessment of the heart during ultrasound. Therefore, it is crucial to know the normal echocardiographic measurements reference range to allow an accurate comparison between the hearts from a healthy versus a cardiac diseased dog. This practice is conducted in order to increase the accuracy of echocardiographic examination and to provide a correct diagnosis for the canine patient (Bonagura *et al.*, 1985; Thomas *et al.*, 199; Qayyum *et al.*, 2020).

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From 2011 to 2013, approximately 23% of local dogs among other breeds of dogs presented to University Veterinary Hospital, Universiti Putra Malaysia was diagnosed with cardiovascular diseases (unpublished data) (Lam and Khor, 2014). Therefore, with the high prevalence of heart disease diagnosed among our local dogs population in Malaysia, there is a need to establish a reference echocardiographic measurement from a population of healthy local dogs. This reference values would aid in the diagnosis of heart disease in Malaysia local dogs. Therefore, this preliminary study determined the normal reference range of echocardiographic measurements from healthy local dog in Malaysia and determined the influence of gender and bodyweight on echocardiographic measurements obtained.

MATERIALS AND METHODS

This cross-sectional study proposal was submitted and approved by the Institutional Animal Care and Use Committee (IACUC) of Universiti Putra Malaysia (Reference Number: UPM/IACUC/AUP-R086/2014). Owners consent was obtained for each dog respectively prior to recruitment.

Apparent healthy local dogs and their owners, whom visited the University Veterinary Hospital of Faculty of Veterinary Medicine (UVH-UPM) were conveniently approached to participate in this study. All the dogs between the age of 1 to 5 years old either male or female with body weight of between 10.0-25.0kg was thoroughly screened prior to recruitment to ensure that each dog was clinically healthy with a normal healthy heart free from heart diseases or any underlying systemic diseases that may contribute to early heart diseases. The inclusion criteria of the local dogs were based on medical history, clinical signs, physical examination findings, routine blood test and urinalysis, radiography, electrocardiography and echocardiography. Upon health screening, any dogs that did not meet any of the inclusion criteria were excluded from the study. Any local dogs that were non-compliance or ill-behaved during the study were excluded from the study to avoid unnecessary stressful event that may affect the data collection.

Signalment, medical records, clinical sign and management of the local dog

Information such as gender, age, and body weight were obtained. Information on the medical history and observed clinical signs was obtained from their respective owners and the patient medical records (if have any) from UVH-UPM. These dogs should be free from any possible signs of illness and especially clinical signs of congestive heart failure (such as exercise intolerance, lethargy, coughing, dyspnea and syncope). Other information on management, heartworm prevention and the routine activities of each dog was noted.

Criteria of recruitment of healthy local dogs

All the dogs had a normal physical examination all the body system. Specifically, the cardiac auscultation of the heart revealed normal heart rate, heart sound and rhythm whereas the lung auscultation revealed normal lung sound. Each local dog was gently restrained manually. Approximately 2mL of blood was obtained via cephalic venipuncture. Blood collected was stored in plain tubes for hematology analysis and ethylenediaminetetraacetic acid (EDTA) for serum biochemistry tests, respectively. Hematology analysis included packed cell volume and total protein concentration. Serum biochemistry test comprised of urea, creatinine, alanine transferase, total protein, albumin and globulin. All the blood parameters obtained must be within the normal range as determined by the Veterinary Hematology & Clinical Biochemistry Laboratory of Veterinary Laboratory Service Unit. A thick blood film was prepared for direct microscopic examination to visualize circulating microfilaria (positive). Commercial test kits (IDEXX SNAP 4Dx Plus, IDEXX Laboratories, United States) were used to detect for antigen of *Dirofilaria immitis* and the test was conducted according to manufacturer recommendation. All local dogs recruited must be free from heartworm disease with negative observation of microfilaria from thick blood film and negative results of the heart worm antigen test kit. As for urinalysis, approximately 5mL of urine was collected either via spontaneous micturition or ultrasound guided cystocentesis (using 23G needle and 5mL syringe). The urine specific gravity (USG) was examined using a refractometer and result of USG >1.030 was deemed normal. The urine's pH must be normal and free of leukocyte, nitrite, protein, glucose, ketone, urobilinogen, bilirubin and erythrocyte as determined visually using the commercially available urine dipstick test strips (Roche Combur-Test^{R}, Switzerland).

Screening for healthy heart based on radiography, electrocardiography and echocardiography

A right lateral and dorsoventral views of the thoracic radiographs were obtained to evaluate the structures of the heart and lungs. The normal heart size was measured using the vertebral heart score (VHS), ranged between 8.0-10.5 of the thoracic vertebrae length (Buchanan and Bucheler, 1995). Subjective assessment of cardiac silhouette, pulmonary parenchyma and pulmonary vasculature was made and must appear normal.

For electrocardiography (ECG), the local dogs were manually restrained on the right lateral recumbency on a table for the recording of electrocardiogram using an ECG machine (Model ECG-1950K, Nihon Kohden, Japan). A four limb leads were attached to the respective limbs and ECG tracing was printed on a paper speed of 25 and 50 mm/sec. All the recorded ECG traces were analyzed and must have a normal ECG tracing, without any conduction abnormalities.

Echocardiography examination (ESAOTE MyLab Class C VET, Italy) was performed on the local dogs to evaluate the structure and function of the heart. On the same right lateral recumbency, the local dogs were placed on a purpose-built foamed table, which allowed placement of the transducer (1-4 MHz) on the dependent side of the thorax. Electrodes were attached to the skin overlying the stifles and the right elbow allowed the simultaneous recording of a lead II electrocardiogram displayed on the ultrasound monitor. All echocardiographic procedures and measurements were performed by the same operator (LMY) and observed by an instructor (KKH). Prior to the conduct of echocardiographic measurement required for the study, a subjective assessment of the cardiac chamber and valves was made based on the real-time 2-D echocardiographic images to ensure that the dogs were free from the valvular degenerative lesion, myocardial abnormalities and outflow tract obstruction.

Echocardiographic measurements obtained using Two-Dimension (2-D) and Motion Mode (M-mode) echocardiography in local dogs

The transducer was placed perpendicular to the right parasternal of the cranial thoracic region at the area of strongest palpable apical beats. To improve the images, the ultrasonic gel was used for coupling purpose. The 2-D and M-mode echocardiograms images of both long and short axis of the left ventricle were obtained and analyzed in accordance to the recommendation by the American Society of Echocardiography (Thomas *et al.*, 1993). M-mode echocardiographic measurements were guided by a simultaneous display of real-time 2-D echocardiographic images. All data were obtained in an average of five measurements. For all the measurements, end-diastole was defined as the onset of QRS complex on ECG, coinciding with the largest dimension of left ventricular chamber; end-systole was defined as the end of T wave of ECG, coinciding with the smallest dimension of left ventricular chamber (Fig. 1).

Based on the images and the definition, the M-mode measurements established were as described in Fig. 1 and 2. The measurement of the left ventricular wall thickness was carried out (Fig. 1). The measurements of aortic root dimension (AOD) were obtained at end-diastole, while the left atrial dimension (LAD) obtained at end-systole (Fig. 2). Meanwhile, the left atrial to aortic root (LAD/AoD) ratio was calculated by dividing LAD with AoD (Fig. 2). Fractional shortening (FS) values were obtained from the following calculation:

$$FS = \frac{(LVIDd - LVIDs)}{LVIDd} \times 100\%$$

*Fraction shortening (FS), left ventricular internal dimension at end-diastole (LVIDd) and end-systole (LVIDs).

Statistical analyses

All the data obtained were analysed using SPSS© version 19.0 (IBM, United States) with the p-value < 0.05 indicating significant differences. All quantitative variables were assessed for the assumption of normality using the Shapiro-Wilk test. Descriptive statistics (mean±SD) and 95% confidence interval of each echocardiographic measurement were calculated. The effects of gender and body weight on echocardiographic measurements were evaluated using independent T-test and correlation coefficient test, respectively.

RESULTS

In this study, 20 out of the 24 (83%) client-owned healthy local dogs were recruited into the study based on the inclusion criteria. Among the 4 local dogs that were excluded; of which 2 dogs were un-cooperative for echocardiographic measurements; 1 dog might have underlying heart disease with observed poor cardiac contractility; and 1 dog has poor echocardiographic images for analysis.

Table 1: Distribution of the gender, age and body weight of the local dogs (n=20) recruited

Signalment of the local dogs		n	%
Gender	Male	9	45.0
	Female	11	55.0
Age (years)	1	5	25.0
	2	8	40.0
	3	3	15.0
	4	1	5.0
	5	3	15.0
Body weight (kg)	<15	6	30.0
	15-19.9	12	60.0
	>20	2	10.0

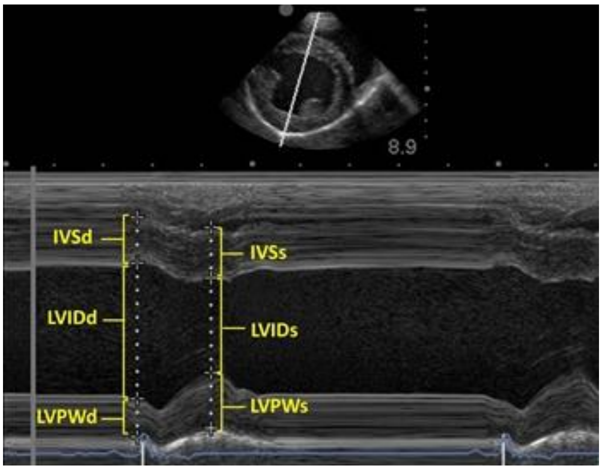

Fig. 1: M-mode echocardiographic measurements of intra-cardiac dimension and wall thickness: *Interventricular septal thickness at end-diastole (IVSd) and end-systole (IVSs), left ventricular free wall thickness at end-distole (LVPWd) and end-systole (LVPWs), left ventricular internal dimension at end-diastole (LVIDd) and end-systole (LVIDs).

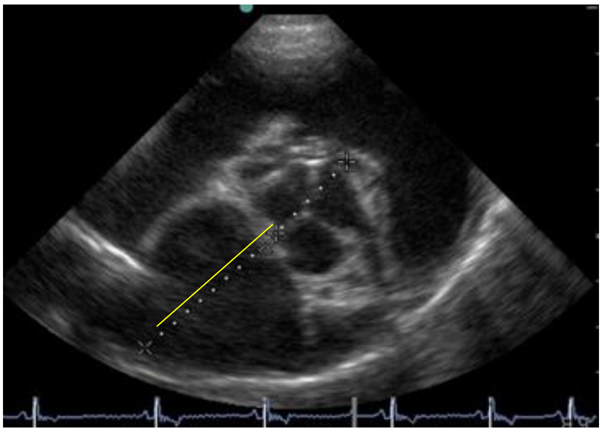

Fig. 2: M-mode echocardiographic measurement of left atrial dimension (LAD) (yellow line) and aortic root dimension (AoD) (white dotted line).

The local dogs recruited consisted of 11 female and 9 male dogs (Table 1). The bodyweight of the local dogs was 16.0±3.7kg (range: 10.4-25.0kg). However, 90.0% of the dogs' body weight ranged between 10.0 to 20.0kg. In this study, only two dogs were more than 20.0kg (21.6 and 25.0kg, respectively). All of the dogs aged between 1 to 5 years old (2.5±1.3 years old). The distribution of the local dogs' gender, age and body weight were as presented in Table 1.

Table 2: The mean and ±standard deviation of normal echocardiographic reference values for Malaysia local dogs (n=20) recruited in this study

Echocardiographic parameters	Unit	Measurements (mean±SD)	Range
Interventricular septal diameter in diastole (IVSd)	mm	8.46±1.43	6.4 – 11.2
Interventricular septal diameter in systole (IVSs)	mm	11.28±2.28	8.0 – 15.6
Left ventricular free wall diameter in diastole (LVPWd)	mm	9.56±1.85	7.0 – 12.9
Left ventricular free wall diameter in systole (LVPWs)	mm	12.95±2.60	8.2 – 19.1
Left ventricular internal dimension in diastole (LVIDd)	mm	32.0±3.34	27.8 – 41.7
Left ventricular internal dimension in systole (LVIDs)	mm	20.61±1.98	17.8 – 24.2
Fractional shortening (FS)	%	35.4±4.38	28.0 – 44.0
Left atrial dimension (LAD)	mm	19.62±1.95	15.7 – 22.7
Aortic root dimension (AoD)	mm	16.18±2.24	13.4 – 20.5
Left atrial dimension to Aortic root dimension ratio (LAD/AoD)		1.23±0.18	0.89 – 1.56

Table 3: Comparison of the echocardiographic measurements obtained in Malaysia local dogs to the Indonesian mongrel dogs (Noviana *et al.*, 2011) and pedigreed dogs (Bonagura *et al.*, 1985)

Data	Unit	Local dogs in Malaysia (n=20)	Indonesian mongrel dogs (n=9)	Pedigreed dogs (n=unknown)
Body weight	kg	16.0	12.5	15.0
IVSd	mm	8.5±1.4	6.4±0.3	7.6±0.8
IVSs	mm	11.3±2.3	8.7±0.5	11.5±1.2
LVPWd	mm	9.6±1.9	7.5±1.0	6.8±0.8
LVPWs	mm	12.9±2.6	10.8±2.0	10.2±1.1
LVIDd	mm	32.0±3.3	27.2±3.3	37.1±2.4
LVIDs	mm	20.6±2.0	16.3±2.8	24.3±2.1
FS	%	35.4±4.4	41±6.0	28 – 40*
LAD	mm	19.6±1.9	15.5±1.3	18.3±2.0
AoD	mm	16.2±2.2	13.2±1.3	20.4±1.4
LAD/AoD ratio		1.2±0.2	1.2±0.1	NA

*Bonagura (1985) – FS was given in range; NA – not provided: interventricular septal thickness at end-diastole, IVSd; interventricular septal thickness at end-systole, IVSs; left ventricular free wall thickness at end-distole, LVPWd; left ventricular free wall thickness at end-systole, LVPWs; left ventricular internal dimension at end-diastole, LVIDd; left ventricular internal dimension at end-systole, LVIDs; fraction shortening, FS; aortic root dimension, AOD; left atrial dimension, LAD; aortic root dimension to the left atrial dimension ratio, LAD/AoD ratio.

Fig. 3: Pictures of some of the client-owned local dog recruited in this study.

Table 2 represents all measurements of the left ventricular wall thickness and dimension, the left atrium and aorta diameter, and contractility. In this study, there was no significant association between gender and bodyweight on echocardiographic measurements (P>0.05) in the local dogs.

Comparison of echocardiographic measurements to other two studies

Table 3 represents the comparison of echocardio-graphic measurements obtained from local dogs in Malaysia to the pedigreed dogs (Table 2), the pedigreed dogs recruited with a mean body weight of 15kg found that the Malaysia local dogs were observed to have a slightly greater cardiac wall thickness (IVSd, IVSs, LVPWd and LVPWs) compared to the pedigreed dogs. Meanwhile, the chamber size was smaller in both diastole and systole phases. The FS was comparatively lower. Other than that, Malaysia local dogs have a bigger LAD and smaller AoD.

Table 4 represents the comparison of echocardio-graphic measurements obtained from local dogs in Malaysia to the Indonesian mongrel dogs. Six suitable Malaysia local dogs with the body weight ranged from 10.0 to 15.0 kg were identified. The comparison of the echocardiographic measurements obtained from the Malaysia local dogs were compared the observation in 9 Indonesian mongrel dogs, with an average body weight of 12.5kg found that the Malaysia local dogs shown to have slightly thicker cardiac wall (higher IVSd, IVSs, LVPWd and LVPWs values, respectively) and bigger chamber size (LVIDd and LVIDs, respectively). The calculated FS was smaller. Other than that, Malaysian local dogs also have bigger LAD and AOD but the LAD/AoD ration were similar.

DISCUSSION

Echocardiography is often recommended by veterinary cardiologists as it provides a definitive diagnosis for canine patients suspected with heart disease (Bonagura *et al.,* 1985). To date, echocardiographic reference measurements for the general dog populations have been well established (Boon, 2011) and used as a guide. However, many studies had emphasized that there is a variation in the echocardiographic measurements between different breeds of dogs (Page *et al.,* 1993; Kayar *et al.,* 2006; Vörös, 2009; Jacobson *et al.,* 2013) and its importance on diagnostic accuracy (Boon *et al.,* 1983). Approximately, more than 37 studies have been reported describing breed-specific and generic echocardiographic measurements in dogs (Boon, 2011).

The local dogs in Malaysia, also known as mongrel dogs, are a mixed-breed dog with unknown interbreeding. The echocardiographic measurement obtained from a local dog was often compared to an established echocardiographic based on body weight or the breed-specific normal echocardiography studies in dogs (Boon, 2011). The other closer comparison that can be made for a better reference measurement guide used for local dogs in Malaysia was the studies conducted by Noviana *et al.* (2011) in Indonesian mongrel dogs. To improve the accuracy of diagnosis heart disease among the Malaysia local dogs, with this study, we successfully established the echocardiographic measurements for our Malaysia local dogs for reference. All 20 local dogs in this study were thoroughly screened to ensure that this group of local dogs recruited was healthy and free of any conditions or diseases that may contribute to underlying heart diseases.

Studies had suggested that gender did not have an important effect on echocardiographic measurements (Lombard, 1984; Crippa *et al.,* 1992). Similarly, in this present study, there was no association between gender and echocardiographic measurements in this group of recruited local dogs. In contrast, Kayar *et al.* (2006) found association between gender with left ventricular free wall thickness and fraction shortening in a study on German Shepherd; while in whippets, females have greater LVID (Bavegems *et al.,* 2007).

The effect of body weight on echocardiographic measurements had been reported in several studies, mainly on ventricular wall thickness (Lombard, 1984; Locatelli *et al.,* 2011). As for fraction shortening, Lombard (1984) found no effect of body weight, while others reported a negative correlation between body weight and fraction shortening (Kayar and Uysal, 2004). As for left atrial dimension and aortic root diemension, a positive correlation between body weight with left atrial dimension LAD and aortic root diemension measurements in dogs has been reported (Lombard, 1984). However, left atrial dimension to aortic root dimension ratio was not associated with body weight (Bavegems *et al.,* 2007). In the present study, there is no correlation between the body weight and selected echocardiographic measurements obtained in the local dogs in Malaysia. In a different breed, Vollmar (1999) found that several echocardiographic parameters from Irish Wolf Hound measured showed correlation with body weight, but the coefficient of determination was too low to contribute an effect.

A comparison was made between the echocardiographic measurements established in this study to the Indonesian mongrel dogs and the pedigreed breed dogs (Bonagura *et al.,* 1985; Noviana *et al.,* 2011). Despite geographical proximity, similar tropical climate and body conformation of the Indonesian mongrel dogs, this is a variation in echocardiographic measurements. In the present study, Malaysia local dogs have thicker left ventricular free wall and interventricular septum compared to Indonesian mongrel dogs probably due to the breed difference. As to wheather there is a genetic difference between local dogs from two different geographic locations could not be further investigated. Besides that, the Malaysia local dogs in the present study have a higher average body weight of 16.0kg and may contribute to the variation in the measurements obtained. According to Bayón *et al.* (1994) observation in growing Spanish Mastiff, the left ventricular wall thickness increases significantly in the adult dogs. However, this might not be the cause in this study as dogs were adults.

In comparison with the Indonesia mongrel dogs' reference measurements (Noviana *et al.,* 2011), the local Malaysia local dogs has greater left venticular wall internal dimension during systole and diastole, while the fraction shortening is considerably lower. Greater left ventricular internal dimension was associated with higher stroke volume and cardiac output during exercise. In an active condition, the body needs more blood supply to the other part of the body system. Meanwhile, fraction shortening was frequently used as an indicator of myocardial contractility or left ventricular systolic function. The normal values of fraction shortening in dogs ranged 28.0-50.0 (Goddard, 1995), and value of less than 25.0 usually is associated with heart disease (Cornell *et al.,* 2004). In previous studies, athletic breeds such as Greyhounds, Alaskan sled dogs and Border Collies have a larger heart and a lower FS value (Synder *et al.,* 1995; Stepien *et al.,* 1998). Majority of the local dogs in Malaysia were medium size with body weight range form 10.0 to 20.0 kg. In this study, these dogs had lower fraction shortening compared to the Indonesian dog and this may suggest that the local dogs in Malaysia could be less active in nature. Kayar *et al.* (2006) suggested that the number of dogs in a study should be noted because it may affect the precision of the fraction shortening, hence direct comparison with the pedigree dog was inapproriate. The comparison between of fraction shortening between the Malaysia and the Indonesion local dog, both a small sample size, hence may contributed to the differences observed and must be interprate with limitation. Besides that, other influencing factors have been reported that the measurement of FS is subjected to a number of variables, such as operator, position and interaction between dog and operator (Chetboul *et al.,* 2005). Genetic difference between local dogs in Malaysia and Indonesian mongrel dogs could be a factor but could not be further investigated in this study.

Other echocardiographic parameters such as left atrial dimension and aortic root dimension measurements were higher in local dogs from Malaysia, while the left atrial dimension and aortic root dimension ratio is almost similar to the Indonesian mongrel dogs. The greater left atrial dimension and aortic root dimension measurements again could be explained due to the possible effect of the genetic differences, the activity level, as well as heavier bodyweights of dogs in the present study. This is consistent with a previous study that the left atrial dimension and aortic root dimension ratio was independent of the bodyweight and have a constant value in healthy dogs (Lombard, 1984).

Variation in the echocardiographic measurement of our local dogs (average 16 kg) was apparent when compared to the general population of pedigreed dogs weighing 15 kg (Bonagura *et al.,* 1985), despite the attempt to minimise bodyweight effects. This observation was similar to the study by Morisson *et al.* (1992). Local dogs recruited in this study have higher values of left ventricular free wall and interventricular septum wall thickness, smaller chamber size , and lower faction shortening. It appears that local dogs in Malaysia may have a considerably thicker myocardium. Athletics dogs such as Greyhounds and whippets were reported to have thicker myocardium, possibly due to training-induced hypertrophy or genetic factors (Bavegems *et al.,* 2007). In this study, none of the Malaysia local dogs recruited in this study were subjected to any form of training as declared by their owners. Hence, the increased thickness of the myocardial wall would again be most likely resulted from genetic factors that warrant further investigation. This finding has important implications in the clinical assessment of cardiomyopathy in local dogs in Malaysia..

The left atrium dimension of Malaysia local dogs was bigger than that the pedigreed dogs population, while the AoD was smaller comparatively. Smaller aortic root dimension is an indication of lower stroke volume (Goddard, 1995) and has been reported that aortic root dimension regressed significantly with age. Instead of comparing absolute measurements of left atrial dimension and aortic root dimension LAD/AoD, the left atrial dimension and aortic root dimension LAD/AoD ratio is better for the assessment of left atrial enlargement (Vollmar, 1999). The LAD/AoD ratio of Malaysia local dogs was no different from the general pedigreed dogs population, and it was within the normal range of 1.0 to 1.4 (Nelson and Couto, 1998).

The study has several limitations that must be considered for data interpretation. Firstly, the small sample size could affect the precision of echocardiographic measurements. For example, a small sample size of certain body weight group could affect the association between body weight and echocardiographic measurements. The population of the local dogs recruited in this study was client-owned dogs presented in a referral hospital (UVH-UPM), and there is no control over the demographic characteristics of the dogs. Other than that, although the dogs are identified overtly healthy from based on the strict inclusion criteria and careful screening that was subjected, this study was unable to exclude the possibility of mild or subclinical heart diseases. No repeated follow up was conducted on all dogs after the study.

For future recommendation, a larger sample size is recommended to increase the reliability and accuracy of the study looking at body size. Body size of the local dogs in Malaysia varies and therefore by including dogs with a wider range of body weight would enable further investigation on the effect of body weight on the echocardiographic measurements of our local dogs. A big number of local dogs (unknown genetic lineage) in Malaysia has not been defined to characterize our local dog in Malaysia. The genetic information of the breed could further elucidate the differences of echocardiographic measurements reported.

Conclusion

This study established the echocardiographic reference measurements in the local dogs in Malaysia. The results of this study showed that the intracardiac dimension, wall thickness and contractility of local dogs in Malaysia varied from the Indonesian mongrel dogs, as well as general population of dogs that have the same average body weight. This is consistent with other studies and was supported by the fact that breed differences may play a major role. Observation from this preliminary study further emphasized the importance of breed-specific echocardiographic reference in the diagnosis of heart diseases. There is no association between echocardiographic measurements with gender and bodyweight of the Malaysia local dogs.

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Authors contribution

Both KKH and LMY has equal contributions in the planning and the conduct of the study, data collection, data analysis and writing of the manuscript. MW gave idea, motivated and was involved in manuscript writing. NAAR assisted and supported in the conduction of the study.

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