Echocardiographic measurements of apparently Healthy Persian cats

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1. Abstract

Background: The objective of this study is to determine normal values for 2-Dimension (2D) and Motion-mode (M-mode) echocardiographic parameters in apparently healthy Persian cats. Apparently normal cats should be screened for hypertrophic cardiomyopathy.
Aim: This study has two aims, first, to determine the normal M-mode and 2D echocardiographic measurements in Persian cats obtained from right lateral recumbent position and express the relation of these measurements with gender, age and body weight. Second, to study the prevalence of hypertrophic cardiomyopathy in Persian cats.
Materials and Methods: Seventy eight (78) apparently healthy Persian cats, weighing between 2 and 5 kg, age range (2 to 14) years and of both sexes were enrolled in this study. Cats were subjected to M-mode echocardiography. Measurements from the right parasternal longitudinal axis left ventricular outflow tract view of the heart. Left ventricular internal dimension, interventricular septal thickness and left ventricular posterior wall thickness during diastole and systole, left atrial diameter, aortic root diameter, left ventricular systolic functional parameters, and indices were all measured. Left ventricular hypertrophy was identified when posterior wall during end of diastole ≥ 6 mm. So a separated group was made for Persian cats whose Posterior wall during diastole ≥ 6 mm to detect the apparently healthy Persian cats with Hypertrophic cardiomyopathy. Results: Gender showed statistically significant on heart rate (p=0.002). Age has statistical significant on left ventricle posterior wall during diastole. Body weight has statistical significance on left ventricle posterior wall during systole. Gender, age and weight have no effect on left ventricle internal diameter during systole and diastole, interventricular septum during systole and diastole, Left atrium and aorta. Hypertrophic cardiomyopathy is identified in 12 (15.3%) of the 78 examined cats. Conclusion: Gender has no effect on echocardiographic measurements except Heart rate is higher in females than in males, posterior wall during diastole increase by increasing age and posterior wall during systole increase by increasing body weight. Apparently normal cats should be screened for HCM.

Key words: Echocardiography, Hypertrophic cardiomyopathy, M-mode, 2D mode, Persian cat.

2. Introduction

Echocardiography is gold standard diagnostic method for cardiac structure and function evaluation as well as diagnosing of heart diseases. It is also use to determine cardiac performance in apparently healthy and diseased animal. [1]. Cardiac disorders of cats are a common finding in about 10%-15% of feline medicine. [1]. Cats suffering cardiac disorders are usually asymptomatic [1]. Echocardiographic studies have become routine for the diagnosis and evaluation of heart disease in veterinary medicine. Cardiac ultrasonography is an important noninvasive tool for imaging the heart and surrounding structures. Anatomic relationships and cardiac function can be

assessed by evaluating cardiac chamber size, wall thickness, wall motion, valve configuration and motion, and proximal great vessels and other parameters. Routine echocardiographic examination in cats and dogs obtained from the right thorax in recumbent position [2].

Occult heart disease is common in cats and currently, a veterinary cardiologist screens most cats using echocardiography. Echocardiography is the most important tool for the diagnosis of myocardial disease in cats, since it identifies structural changes and pathological dysfunction of the myocardium. It has been widely used in veterinary practice to provide a non-invasive assessment of cardiac function [3]. It is considered the gold standard exam for feline HCM [4]

Cardiomyopathies are the most common type of cardiac diseases in cats [3], affecting approximately 15% of the population, three recent studies of healthy cats where cardiomyopathy was identified by echocardiography reported remarkably consistent prevalence of 14.7% in 780 shelter cats [5] ; 15.6% in 199 healthy cats [6] and 15.5% in 103 healthy cats [7].

Primary cardiomyopathies are classified into five categories according to their morphologic appearance: hypertrophic cardiomyopathy (HCM), idiopathic dilated cardiomyopathy (DCM), restrictive cardiomyopathy (RCM), arrythmogenic right ventricular cardiomyopathy (ARVC) and unclassified cardiomyopathy (UCM). Hypertrophic cardiomyopathy is common in apparently healthy cats, in contrast with other cardiomyopathies. [5]

This study aimed to determine the normal M-mode and 2D echocardiographic measurements obtained from right lateral recumbent position and express the relation of these measurements with gender, age and body weight also screening the of hypertrophic cardiomyopathy in apparently healthy Persian cats.

3. Materials and Methods

Ethical approval

Cats were presented for routine clinical examination. Informed verbal consents were obtained from owners. All study procedure were performed in accordance to the animal use and ethical committee of Cairo University (Vet CU28/04/2021/308).

Animals

Cats presented to Pets valley private pet clinic for examination were divided into both diseased and healthy cats according to inclusion and exclusion criteria. Out of 200 cats only 78 cats meet inclusion criteria and the rest were excluded. Inclusion criteria is normal physical examination findings, without a history of cardiac disease and with normal results of CBC. Exclusion criteria is abnormal cats in physical examination, abnormal CBC, cats suffering from renal or hepatic failure, abnormal radiographs as pneumothorax, pleural effusion, diaphragmatic hernia and pneumonia. They divided according to weight, age, gender and left ventricle posterior wall during diastole ≥ 6mm. Cats were included in the HCM group if the left ventricular posterior wall (LVPWd), obtained by 2D directed M-mode echocardiography, was ≥6 mm.

Total number of selected cats were seventy-eight (n=78; 24 males and 54 females). Physical examination, Auscultation was first performed when cats were at rest. Heart rate was recorded for all cats. Also mucus membrane were examined. A complete blood count (CBC) is a blood test used to evaluate overall health. Radiography is used to evaluate cardiac size and shape by applying vertebral heart score (VHS) [8], as shown in Fig. 1

Patient preparation and positioning

Cats getting an echocardiogram lie on a padded table on right lateral side with a cutout that allows the ultrasound probe to contact their chest wall. It is typically found near the strongest palpable right apical beat. A small amount of alcohol is used to separate the hair on the chest wall and

water-soluble ultrasound gel is used to provide contact with the ultrasound probe. The cats were conscious and no anesthetic drugs were used during the examination. From the right side, 3 probe positions are used to produce 4 basic views of the heart: Four chamber right-sided parasternal long-axis view, Five-chamber right-sided parasternal long-axis view, Right-sided short-axis view of the left ventricle at the level of the papillary muscles, Right-sided short-axis view at the level of the left atrium and aorta.

Echocardiography

Echocardiographic examinations were performed without chemical restraint. Ultrasound System (Chison Echo 2, china), using micro convex transducer was used to perform transthoracic echocardiography. Routine echocardiographic examination in cats included images obtained from the right thorax in right lateral recumbence according to published standards. Two-dimensional short-axis and long-axis right parasternal images of the left ventricle were used to measure end-diastolic thickness of the interventricular septum and posterior wall. In the short-axis plane, end of diastole was defined by the onset of the QRS complex in a simultaneously recorded. For those examinations, the maximal diastolic excursion of the ventricle was used to define end of diastole. M-mode echocardiographic evaluation of heart was guided by the simultaneous display of real-time two-dimensional echocardiographic images (fig. 2).

Aortic root diameter (AOD) was measured at end-diastole from the top of the anterior aortic wall to the top of the posterior aortic wall. Left atrial diameter (LAD) was measured at end-systole from the top of the posterior aortic wall to the top of the pericardium. LAD: AOD ratio was determined as an index to calculate the size of the left atrium. (fig.3)

Echocardiographic assessment of atrial size is an important element of the cardiovascular examination. [9]. It has been reported that LAD is considered as useful parameter in indicating the preload alteration which is used in early detection of hypertrophic cardiomyopathy. Left atrium size enlargement is characteristic sign for HCM. [10]

To calculate the fractional shortening (FS), Teichholz formula was used: Fractional shortening (FS) (%) = (LVIDd-LVIDs/LVIDd) ×100 [11]

Statistical analysis

Data are presented as mean values ± standard deviation (SD). Two way ANOVA was performed, and correlation coefficient (r) was calculated to determine the influence of body weight, age and gender on echocardiographic parameters. The correlation was considered positive and significant when the correlation coefficient was ≥0.05, and significance was ≤0.05. Computer software SPSS version 20 was used for statistical analysis. Value of $p<0.05$ and $p<0.01$ was considered significant at 5% and 1 %, respectively.

4. Results

Seventy-eight Persian cats (24 males and 54 females) that ranged in age from 2 to 14 years and weighed between 2 and 5 kg were examined echocardiographically. Echocardiographic measurements were obtained from Persian cats during right lateral position examination correlated with gender, age, weight. There are 66 cats with normal echocardiographic parameters summarize in (table 1).

All echocardiographic measurements were compared between male and female cats (Table 2). Statistical analysis showed that there is significance between gender and heart rate ($p=0.002$).The mean heart rate of all cats was 193.2 beats per min, which is higher in females compared to male (female 197.4 bpm and male 188 bpm).

Left ventricle internal diameter and interventricular septum in diastole and systole were found to be higher in male than

female, PW in diastole is higher in female than male, fractional shortening (FS) and left atrium (LA) were higher in males than females but failed to gain significance.

Posterior wall during diastole is statistically significant where ($p<0.05$) where PW during diastole increase by increasing age. Non significance increase in IVSd, LVIDd ,PWd ,IVSs ,LVIDs , PWs , LA , AO , LA:AO , HR and FS in regard to age as ($p>0.05$), but IVS during diastole , LVID during diastole and systole , PW during diastole and systole was found to be increase by aging while FS decrease by aging.

Statistical analysis express that there was significant between body weight and posterior wall during systole ($p<0.05$) but there was no significance on IVSd , LVIDd , PWd ,IVSs ,LVIDs , PWs , LA , AO ($p>0.05$) on other hand echocardiographic measurements increase by increasing weight.

All measurements were compared between normal cats and Hypertrophic cardiomyopathies cats which had left ventricular posterior wall during diastole ≥ 6(table 3). The mean left ventricle posterior wall during diastole of normal cats was (4.404 mm) and mean in HCM cats was (6.5mm) which was higher in HCM compared to normal cats (fig 4).

The mean of left ventricle internal diameter during diastole was higher in normal cats than in HCM cats where normal cats (12.15 mm) and (HCM 10.75 mm) with (p value 0.03) which is statistically significant.

While the mean of left ventricle posterior wall diameter during systole was higher in HCM cats (7.6mm) than in normal cats (6.15mm) with statistically significance ($p=0.001$).

Furthermore, mean left atrium to Aorta ratio in normal cats higher than in HCM cats (normal cats 1.31, HCM cats 2.09) with statistically significance ($p=0.023$)

The prevalence of hypertrophic cardiomyopathy in the examined cats were identified in 12 (15.3%; 95% CI) cats. Two cats were males 5 and 7 years old and 9 were females more than 7 years old.

5. Discussion

Since no study has been performed on Persian cats to determine normal echocardiographic parameters and screening HCM in Persian cats, this study reports these values in 78 apparently healthy Persian cats and compares the findings between males and females, also express the effect of weight and age on echocardiographic parameters and screening the prevalence of HCM on the examined cats.

In this study the mean heart rate of Persian cats in was 193.2 ± 11.67 bpm. Although it is in the normal range reported for cats in general (120 – 240 bpm) [12], it is relatively similar compared to most previous studies [13, 14, 15,16]We observed a higher heart rate within female cats compared to the males with statistically significant and These results conceded with (Wendy A. Ware) who express that female cats has a higher average heart rate (166.8 ± 5.8, range, 136–202 bpm) over the 24-hour period in male cats (147.1 ± 4.4, range, 114–161 bpm; P, .02). The overall range of heart rates for female cats is 95 to 292 bpm and for males is 68 to 294 bpm [17].

In study on Sphynx cats females have higher heart rate than males where mean HR in both females and males were respectively (mean females HR is 189.2 bpm) (mean males HR is 184.9 bpm) [10] and that conceded with this study.

On other hand in research on Turkish Van cat heart rate found to be higher in males than in females with no significance. Average HR in males were (183.55±9.21, range 127-213 bpm) while in females were (176.40±6.41, range 123-223 bpm) [18].

In study on Persian cats, gender found to have significance on heart rate where HR in females higher than in males which also conceded with this study [19].

In study on Maine coon cats, LAD and AOD has strong correlation with body weight and significant difference between males and females ($p<0.05$) [20] and this conceded in this study.

We documented that left ventricle internal diameter in both systole and diastole is higher in males than females, also FS are higher in males than in females. On other hand, PW in diastole is higher in females than males but these differences fail to gain significance ($p>0.05$) with respect to gender, In the same way, the LVID in systole and in diastole were not directly related to age, PW during diastole parameter was statistically significant with respect to age ($p<0.05$), PW during systole parameter was statistically significant with respect to BW ($p<0.05$).

In previous studies in other species it has been shown that Associations between BW and echocardiographic dimensions were best described by allometric scaling, and all dimensions increased with increasing BW (all $P<0.001$). Strongest associations were found between BW and AOD and LAD and weak linear associations were found between BW and HR for which HR decreased with increasing BW ($P<0.001$) which is consistent with this study [15,20,21].

Other clinical studies showed that body weight had a significant ($P<0.05$) independent effect on 2D variables whereas breed, sex and age did not. There were clinically relevant differences between reference intervals using mean ± 2SD of raw data and mean and 95% prediction interval of allometrically-scaled variables, most prominent in larger (>6 kg) and smaller (<3 kg) cats. A clinically relevant difference between thickness of the interventricular septum (IVS) and dimension of the LV posterior wall (LVPW) was identified [10, 22].

Regarding previous studies on sphynx cats there was non-existent or only a weak correlation between the measured echocardiographic parameters and the age with no significant difference between the 2D-echocardiographic values from obese cats and cats with standard body weights [10].

In recent years, it is observed that there are moderate-to strong correlations between body weight and age with various echocardiographic parameters and allometric scaling was performed for body weight [23].

In a study on 150 healthy cat using 2D echocardiographic measurements found that body weight based references is preferred over conventional 2D echocardiographic reference ranges, while sex and breed hadn't any significant effect on echocardiographic measurements and mention that IVS and LVPW require dynamic reference ranges to facilitate screening examination for feline hypertrophic cardiomyopathy and this conceded with our study [21].

Published paper on Indian Spitz dogs showed that body weight has a significant influence on the majority of M-mode echocardiographic parameters and without any significant influence of gender [11].

Hypertrophic cardiomyopathy is the most common myocardial disease seen in cats, accounting for approximately two thirds of the cases [10]. Some cats with cardiomyopathy are clinically normal and, conversely, a large percentage (25– 69%) of cats with heart murmurs on physical examination have echocardiographic studies that are within normal limits [24].

In Maine Coon cats, familial HCM has been described with an autosomal dominant mode of inheritance [25]. A similar inheritance pattern has been described in Ragdolls [26], American shorthair cats and British shorthairs, In the Scottish fold and Norwegian Forest Cats, HCM was more frequently present than in the DSH [27], Sphynx cats similar to the Maine Coon [15].

Since HCM has been frequently observed in the Sphynx cat, a cardiac screening prior to breeding has been

declared mandatory by many breeding associations [10], and this agree with our study in screening HCM in Persian cats.

In this study we use to define left ventricular hypertrophy when posterior wall of left ventricle during diastole greater than or equal 6mm. Some clinicians use a more stringent classification and define left ventricular hypertrophy as being when the walls measure greater than 0.55 cm in thickness [6].some others said that diagnosis of HCM in cats is achieved using echocardiography measuring a maximum end-diastolic LV wall thickness (LVWd), where an LVWd ≥6mm is most commonly used to define HCM. Prevalence of HCM would increase using a lower cut-off value for LVWd [28].

Breed-specific differences do not appear to be significant in cats compared to dogs because there is much less body size variation between breeds; however, one group has reported several M-mode echocardiographic parameters for Maine coon cats [20].

Prevalence of HCM in apparently healthy Persian cats examined in this study is 15.3% while the prevalence of feline subclinical Cardiomyopathy in a sample of apparently healthy cats in Southwest Virginia is near 16%. In apparently healthy cats, a cardiac murmur has low sensitivity as a marker of the presence of Cardiomyopathy. [7].

Statistical analysis in this study showed that posterior wall thickness during diastole increase by increasing age and this agree with a recent study showed an overall prevalence of 14.7%, with an increased prevalence with increasing age [5].

Left atrium diameter failed to gain significance in this study increase as the examined cats were apparently healthy. Echocardiographic measurement of LA function, extreme LV hypertrophy, and LV systolic function provides important prognostic information in cats with HCM. [5], on other hand in research on van cats LAD higher in males than females but it gained significance [13] also in research on sphynx cats LAD higher in males than females with significance. [10].

6. Conclusion

There is no significant difference in echocardiographic measurements according to the gender except heart rate. Body weight and age had effect on some echocardiographic parameters. Prevalence of HCM in apparently healthy examined Persian cats use in research is 15.3 %.

7. References

1. Laudhittirut T, Rujivipat N, Saringkarisate K, Soponpattana P, Tunwichai T, Surachetpong SD (2020) Accuracy of methods for diagnosing heart diseases in cats, Vet. World, 13(5): 872-878
2. Boon, J. A. (2016). Two-dimensional and M-mode Echocardiography for the Small Animal Practitioner. John Wiley & Sons.
3. Ferasin, L. (2009). Feline myocardial disease: 1: classification, pathophysiology and clinical presentation. Journal of feline medicine and surgery, 11(1), 3-13.
4. Bonagura, J. D. (2000). Feline echocardiography. Journal of feline medicine and surgery, 2(3), 147-151.
5. Payne, J. R., Brodbelt, D. C., & Fuentes, V. L. (2015). Cardiomyopathy prevalence in 780 apparently healthy cats in rehoming centres (the CatScan study). Journal of Veterinary Cardiology, 17, S244-S257.
6. Wagner, T., Fuentes, V. L., Payne, J. R., McDermott, N., & Brodbelt, D. (2010). Comparison of auscultatory and echocardiographic findings in healthy adult cats. Journal of Veterinary Cardiology, 12(3), 171-182.
7. Paige, C. F., Abbott, J. A., Elvinger, F., & Pyle, R. L. (2009). Prevalence

of cardiomyopathy in apparently healthy cats. Journal of the American Veterinary Medical Association, 234(11), 1398-1403.
8. Litster, A. L., & Buchanan, J. W. (2000). Vertebral scale system to measure heart size in radiographs of cats. Journal of the American Veterinary Medical Association, 216(2), 210-214.
9. Abbott, J. A., & Maclean, H. N. (2006). Two-dimensional echocardiographic assessment of the feline left atrium. Journal of veterinary internal medicine, 20(1), 111-119.
10. Mottet, E., Amberger, C., Doherr, M. G., & Lombard, C. (2012). Echocardiographic parameters in healthy young adult Sphynx cats. Schweizer Archiv fur Tierheilkunde, 154(2), 75.
11. Bodh D, Hoque M, Saxena AC (2019) Echocardiographic study of healthy Indian Spitz dogs with normal reference ranges for the breed, Vet. World, 12(6): 740-747
12. Nelson RW, Couto CG. Small animal internal medicine. 2014.
13. Chetboul V, Sampedrano CC, Tissier R, Gouni V, Saponaro V, Nicolle AP, et al. Quantitative assessment of velocities of the annulus of the left atrioventricular valve and left ventricular free wall in healthy cats by use of two-dimensional color tissue Doppler imaging. American journal of veterinary research. 2006;67(2):250-8.
14. Allen DG. Echocardiographic study of the anesthetized cat. Canadian Journal of comparative medicine: Revue Canadienne de Medecine comparee. 1982;46(2):115-22.
15. Jacobs, G., & Knight, D. H. (1985). M-mode echocardiographic measurements in nonanesthetized healthy cats: effects of body weight, heart rate, and other variables. American journal of veterinary research, 46(8), 1705-1711.
16. DeMadron E, Bonagura JD, Herring DS. TWO-DIMENSIONAL ECHOCARDIOGRAPHY IN THE NORMAL CAT. Veterinary Radiology. 1985;26(5):149-58
17. Ware, W. A. (1999). Twenty-four-hour ambulatory electrocardiography in normal cats. Journal of veterinary internal medicine, 13(3), 175-180.
18. Kayar, A., Ozkan, C., Iskefli, O., Kaya, A., Kozat, S., Akgul, Y., ... & Or, M. E. (2014). Measurement of M-mode echocardiographic parameters in healthy adult Van cats. Jpn. J. Vet. Res., 62(1&2), 5-15
19. Fatemeh et al.,(2020) Measurement of M-mode Echocardiographic Parameters in Healthy Adult Persian Cats International Journal of Pharmaceutical and Phytopharmacological Research (eIJPPR) | December 2020 | Volume 10 | Issue 6 | Page 167-173
20. Drourr, L., Lefbom, B. K., Rosenthal, S. L., & Tyrrell Jr, W. D. (2005). Measurement of M-mode echocardiographic parameters in healthy adult Maine Coon cats. Journal of the 1American Veterinary Medical Association, 226(5), 734-737
21. Häggström, J., Andersson, Å. O., Falk, T., Nilsfors, L., OIsson, U., Kresken, J. G., & Ljungvall, I. (2016). Effect of body weight on echocardiographic measurements in 19,866 pure-bred cats with or without heart disease. J. vet. Intern. Med., 30(5), 1601-1611.
22. Karsten, S., Stephanie, S., & Vedat, Y. (2017). Reference intervals and allometric scaling of two-dimensional echocardiographic measurements in 150 healthy cats. J Vet Med Sci, 79(11), 1764-1771

23. Gunther-Harrington, C. T., Sharpe, A. N., Vernau, K. M., Ueda, Y., Montgomery, E. A., Surmick, J. D., .& Stern, J. A. (2020). Reference intervals for radiographic, echocardiographic and N-terminal pro B-type natriuretic peptide values in healthy kittens. J Feline Med Surg, 1098612X20946461
24. Côté, E., MacDonald, K. A., Meurs, K. M., & Sleeper, M. M. (2011). Feline cardiology. John Wiley & Sons.
25. Kittleson, M. D., Meurs, K. M., Munro, M. J., Kittleson, J. A., Liu, S. K., Pion, P. D., & Towbin, J. A. (1999). Familial hypertrophic cardiomyopathy in maine coon cats: an animal model of human disease. Circulation, 99(24), 3172-3180.
26. Meurs, K. M., Norgard, M. M., Ederer, M. M., Hendrix, K. P., & Kittleson, M. D. (2007). A substitution mutation in the myosin binding protein C gene in ragdoll hypertrophic cardiomyopathy. Genomics, 90(2), 261-264.
27. Riesen, Kovacevic, Lombard, & Amberger. (2007). Echocardiographic screening of purebred cats: an overview from 2002 to 2005. Schweizer Archiv für Tierheilkunde, 149(2), 73-76.
28. Payne, J. R., Borgeat, K., Connolly, D. J., Boswood, A., Dennis, S., Wagner, T., ... & Luis Fuentes, V. (2013). Prognostic indicators in cats with hypertrophic cardiomyopathy. Journal of Veterinary Internal Medicine, 27(6), 1427-1436.

Table 1: Echocardiographic indices in normal Persian cats (n = 66)

Variable	mean	SD	SE	Range	
				Min	Max
HR(bpm)	193.2	11.67	1.62	191.4	197.2
IVSd (mm)	3.87	0.69	0.1179	3.68	4.02
LVIDd(mm)	12.15	0.22	0.376	11.69	12.8
LVPWd(mm)	4.404	0.087	0.1559	4.23	4.66
IVSs(mm)	5.41	0.072	0.131	5.14	5.49
LVIDs(mm)	6.81	0.17	0.268	6.44	7.29
LVPWs(mm)	6.15	0.1	0.194	5.88	6.3
LA(mm)	9.309	0.16	0.277	9.2	9.9
AO(mm)	7.22	0.12	0.194	7.03	7.6
LA:AO(mm)	1.31	0.11	0.01	1.27	1.33
FS (%)	43.44	9.94	1.69	40.9	45.8

Table 2: Echocardiographic indices by sex in female (n = 44) and male (n = 22) Persian cats

variable	Female		Male		P value
	Mean ± SD	CI 95%	Mean ± SD	CI 95%	
HR(bpm)	197.4±12.33	194.1-200.7	188±7.1	183.5-192.8	0.002
IVSd (mm)	3.77±0.71	3.57-3.98	4.02±0.62	3.73-4.32	0.16
LVIDd(mm)	11.98±2.09	11.3-12.6	12.78±2.5	11.83-13.74	0.17
LVPWd(mm)	4.5±0.82	4.25-4.78	4.3±0.96	3.93-4.6	0.35
IVSs(mm)	5.19±0.6	4.98-5.41	5.56±0.74	5.26-5.87	0.054
LVIDs(mm)	6.8±0.16	6.32-7.38	6.9±0.18	6.16-7.66	0.9
LVPWs(mm)	6.09±0.1	5.78-6.4	6.23±0.1	5.79-6.68	0.6
LA(mm)	9.5±0.15	9.04-9.97	9.8±0.14	9.15-10.4	0.45
AO(mm)	7.3±0.1	6.9-7.69	7.2±0.1	6.7-7.7	0.8
LA:AO(mm)	1.2±0.1±	1.25-1.32	1.3±0.1	1.29-1.38	0.087
FS (%)	41.99±10.88	39-44.9	46.2±7.1	42.1-50.6	0.099

Table 3: Echocardiographic measurements comparing normal cats with HCM cats

Variable	Normal cats		HCM cats		P value
	Mean ± SD	CI 95%	Mean ± SD	CI 95%	
HR(bpm)	193.2 ±11.67	190-198.6	199.4±36.4	189-209	0.3
IVSd(mm)	3.87 ±0.69	3.66-4.05	3.74±1.23	3.29-4.2	0.66
LVIDd(mm)	12.15 ±0.22	11.7-12.7	10.75±1.47	9.5-11.9	0.03
LVPWd(mm)	4.404 ±0.87	4.23-4.66	6.5±0.9	6.06-7.07	0.000
IVSs(mm)	5.41 ±0.72	5.08-5.5	4.5±1.8	3.9-5.07	0.01
LVIDs(mm)	6.81 ±1.7	6.4-7.2	6.3±1.5	5.3-7.3	0.33
LVPWs(mm)	6.15 ±1.03	5.8-6.4	7.6±2.5	6.8-8.4	0.001
LA(mm)	9.309 ±1.6	9.1-9.8	9.6±1.4	8.75-10.5	0.74
(mm) AO	7.22 ±1.2	7.1-7.7	7.6±1.2	6.8-8.3	0.62
LA:AO(mm)	1.31 ±0.1	1.03-1.57	2.099±2.8	1.4-2.7	0.023
FS (%)	43.44 ±10.5	40.8-46.01	40.5±13.6	34.4-46.5	0.3

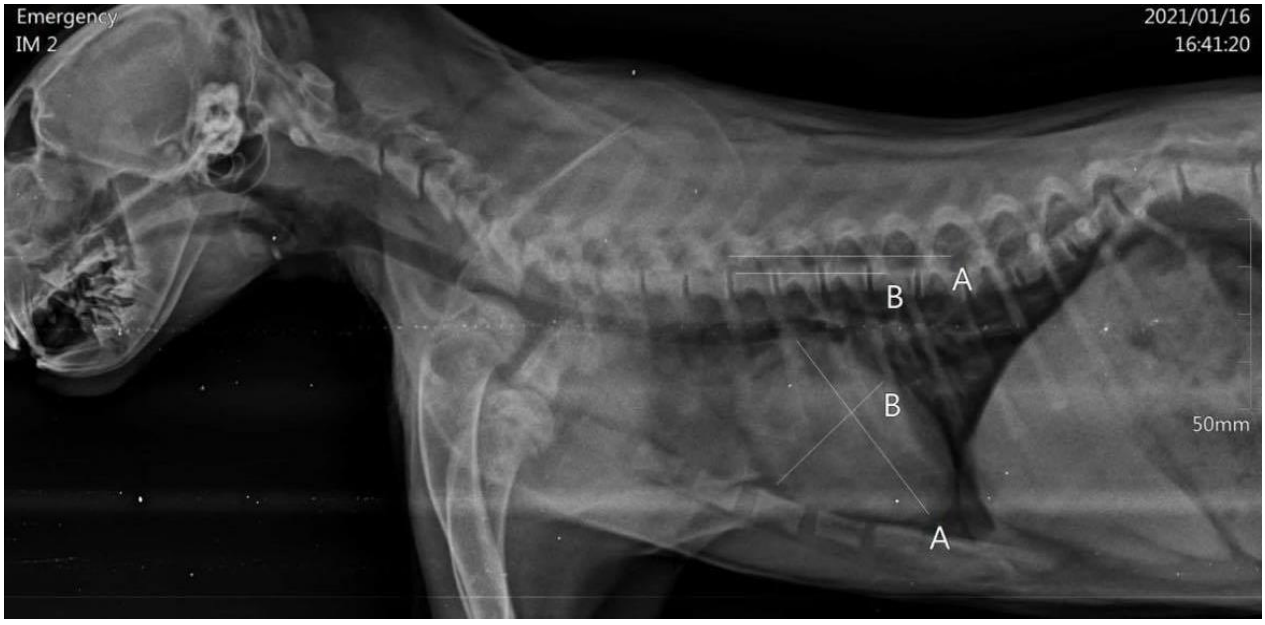

Fig .1: (Using the Right Lateral projection 1. Identify the long axis of the heart beginning at the point where the pulmonary vein crosses the trachea and end at the apex of the heart. 2. Place another line perpendicular to the long axis at the widest point of the cardiac silhouette, which would correlate with the short axis. 3. Identify the 4th thoracic vertebra (T4), and place 2 lines equal in length to the long and short axis lines at the cranial edge of T4. . 4. Determine the length of each line to the nearest thoracic vertebra and VHS is the sum of both measurements. 5. Normal right lateral VHS in a cat should be 6.9 to 8.1.vertbrea.

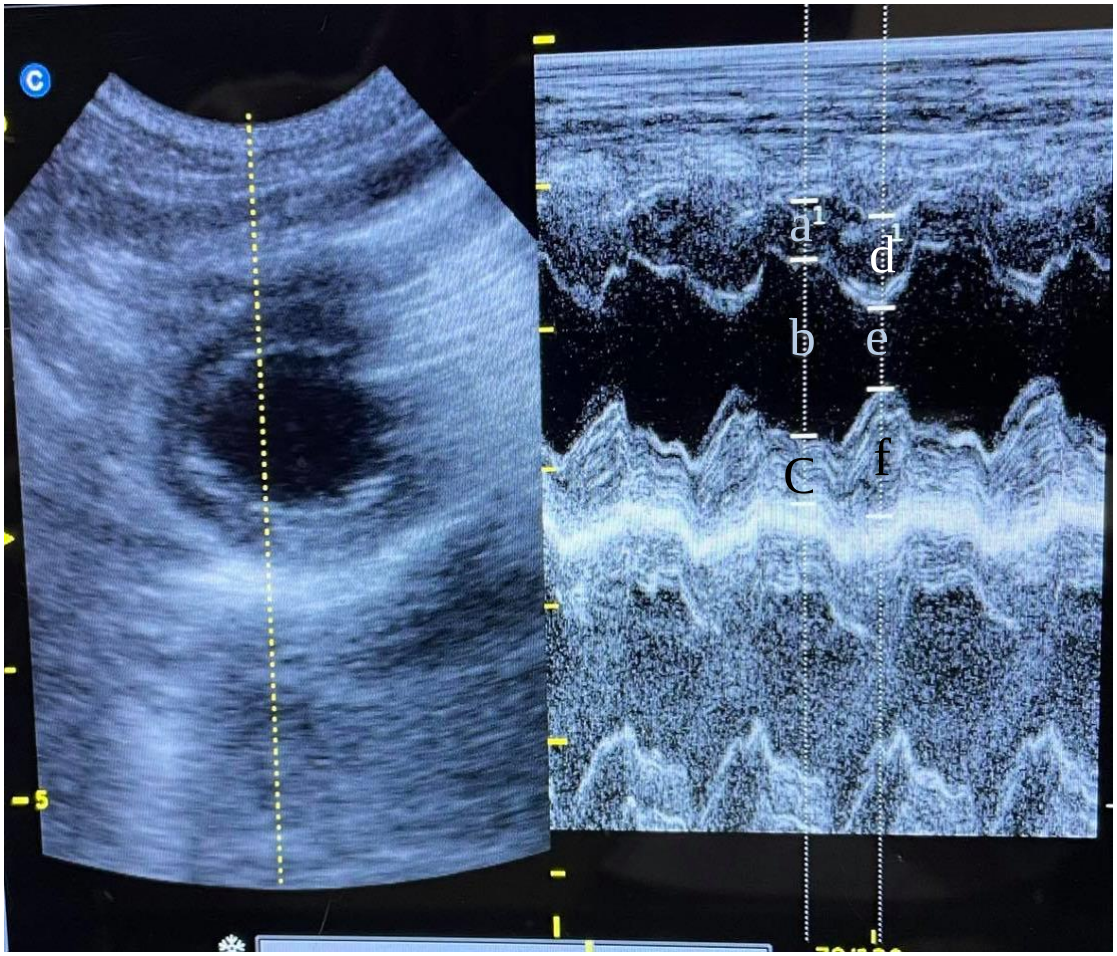

Fig .2: (M-mode Left ventricle short axis at papillary muscle level
a) IVSd, b) LVIDd, c) LVPWd, d) IVSs, e) LVIDs, f) LVPWs)

Fig .3: (Short-axis two-dimensional (2D) image of the aorta and left atrium. a) AO (Aorta) 1.65 cm
b) LA (Left atrium) 2.07 cm . Ratio of the atrial and aortic root dimensions LA:AO 1.25 cm

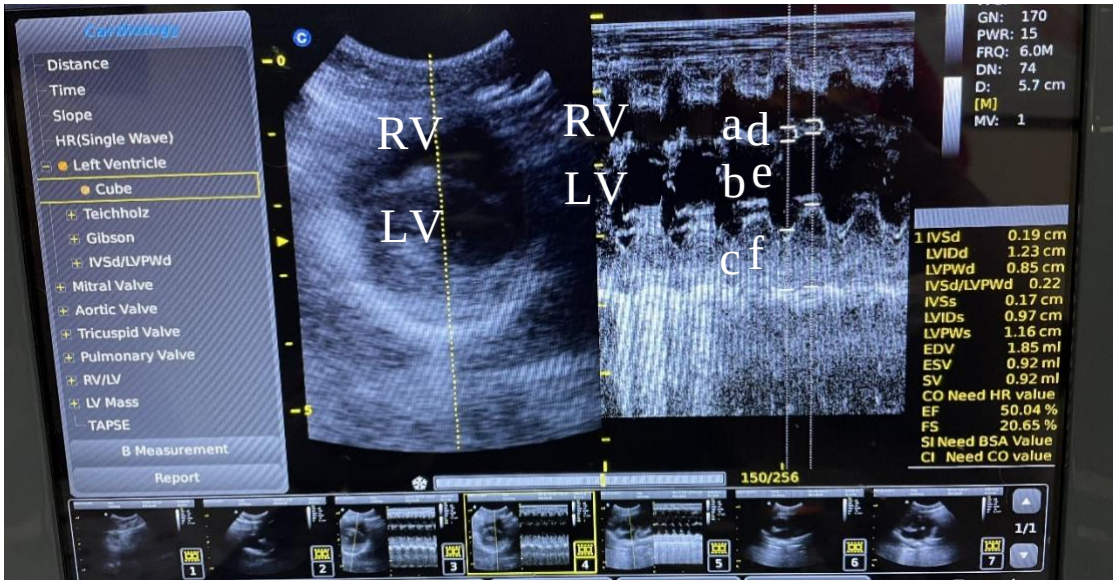

Fig .4: (Right para sternal short axis at level of papillary muscle left image side indicate 2-D mode and right image side indicate m-mode
a) IVSd, b) LVIDd, c) LVPWd, d) IVSs, e) LVIDs, f) LVPWs. LVPWd 8.5mm which represent HCM. LV (left ventricle) RV (right ventricle)