RESEARCH ARTICLE

M-Mode Echocardiographic Studies in Healthy Cats

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Abstract

M-mode echocardiography is a non-invasive and indispensible tool for the quantitative evaluation of the heart. Due to domestic cats' sedentary lifestyles, it has been difficult to diagnose heart disorders in cats since they frequently manifest and exhibit cardiac affections in novel ways. In order to help in the diagnosis of heart disorders in cats, this study was carried out to create baseline reference data in cats (n=12) with mean age of 3.43±1.28 years, weighing 4.43 ±0.45 kg, irrespective of breed and gender, having mean heart rate of 173.67±10.34 beats/min that are bred and fed in India. The M-mode parameters studied with their mean ±SD values were Interventricular septal thickness at diastole (IVSd, 3.50±1.15 mm) and systole (IVSs, 5.65±1.13 mm), Left ventricular internal diameter at diastole (LVIDd, 13.48±2.00 mm) and systole (LVIDs, 7.35±1.15 mm), Left ventricular posterior wall thickness at diastole (LVPWd, 4.53±0.74 mm) and systole (LVPWs, 6.58±0.82 mm), Ejection fraction (EF, 80.55±2.58%), Fractional shortening (FS, 45.50±2.69%), Left atrium (LA, 1.06±0.17 cm), Aorta (AO, 0.86±0.13 cm), LA/Ao ratio 1.25±0.09 and E point to septal separation (EPSS, 1.21±0.51 mm). These baseline values established will facilitate comparison and precise interpretation by the clinician.

Key words: Echocardiography, Feline, M-mode echocardiography, Reference values.

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Introduction

The specialty of Veterinary Cardiology now cannot function without echocardiography, which has been employed for experimental and clinical cardiac imaging and evaluation (Thomas *et al*., 1993). The M-mode is particularly beneficial for assessing echogenic tissues because it enables accurate measurements of the cardiac chambers, the thickness of the wall, and valvular motions, as well as estimates of functional indices like fractional shortening. The M-mode and two-dimensional echocardiogram (2DE) are likely the best diagnostic tools currently available for pericardial effusion, cardiac tumours, cardiomyopathy, and larger valvular vegetations as it can provide superior temporal resolution of recording cardiac walls and valves and volumetric blood flow analysis.

The basic principles of M-mode echocardiography including technical considerations were put forward by Bonagura and Pipers (1983), which stated that normal structures of heart can be scanned by changing the angle or location of the transducer. The phasic motion of cardiac structures can be captured if the transducer is held in place during the cardiac cycle. The most common domesticated animal worldwide is the cat. They have been employed for thousands of years to keep vermin under control and to provide people solace, joy, and a feeling of purpose. Cats are the most popular indoor animals in the world, and there is a growing need for specialist care of them. Due to their sedentary lifestyles, cats frequently develop and show cardiac diseases in distinctive ways, and the majority of cardiomyopathic cats go undetected for this reason. So, the purpose of this study was to understand the fundamental cardiac anatomy of the cat using M-mode echocardiography.

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Materials and Methods

The study was carried out on 12 clinically healthy cats brought to Department of Veterinary Clinical Medicine, Ethics and Jurisprudence, Mumbai Veterinary College, Parel, Mumbai (India). Adult cats older than one year irrespective of gender and breed which were found healthy upon anamnesis and

physical examination and cats whose vital signs fell within the predetermined range were regarded as clinically healthy and had their cardiac examination.

M-Mode Echocardiography Technique

GE Versana Premier Ultrasound machine with a phased array cardiac probe with a frequency ranging from 9-12 MHz were used for recording the echocardiographic studies. M-mode echocardiographic images were recorded and stored for further evaluation.

Cats were allowed to relax in the room before performing echocardiographic examination. The area between costochondral junction and sternum in the right parasternal window was clipped. From the long axis view of the heart, the transducer was rotated in 90° in clockwise direction and ultrasound beam was oriented perpendicular to the long axis of the left ventricle, *i.e.,* right short axis view. Proper alignment was achieved in order to visualise the left ventricle and aortic root as round structures. The examination began at the level of the apex of the heart followed by planes through the papillary muscles, mitral valve and aortic valve (Boon, 2011).

Following parameters were determined to evaluate the size of cardiac chambers: Interventricular septal thickness at diastole (IVSd) and systole (IVSs), Left ventricular diameter at diastole (LVDd) and systole (LVDs), Left ventricular posterior wall thickness at diastole (LVPWd) and systole (LVPWs), Ejection fraction (EF), Fractional shortening (FS), Left atrium (LA), Aorta (AO), LA/Ao and E point to septal separation (EPSS). All data were collected on standard forms and analyzed. Continuous variables were described using mean and standard deviation.

Results and Discussion

A total of 12 adult cats irrespective of breed and gender underwent echocardiography. The cats were aged between 1.2-5.5 years, with a mean of 3.43 ± 1.28 years. The animals weighed 3.8 to 5.3 kg (mean, 4.43 ± 0.45 kg). M-mode echocardiographic images are shown in Fig. 1, 2 and 3.

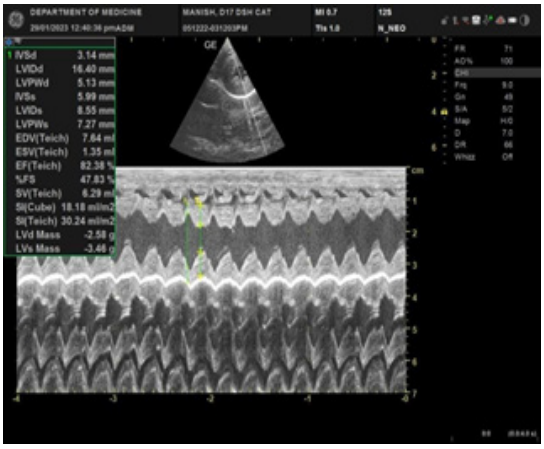

Fig. 1: M-mode right parasternal short axis view in apparently healthy cat

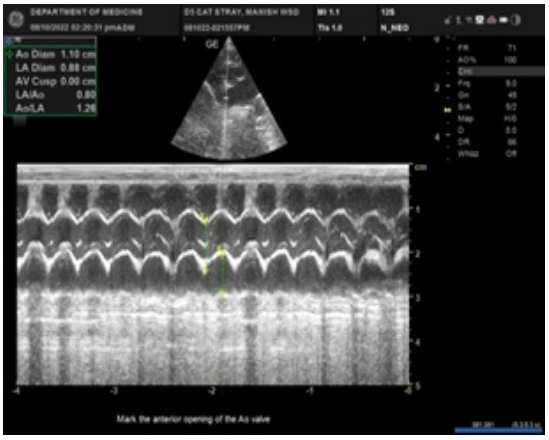

Fig. 2: M-mode right parasternal short-axis view at the level of aortic root in apparently healthy cat

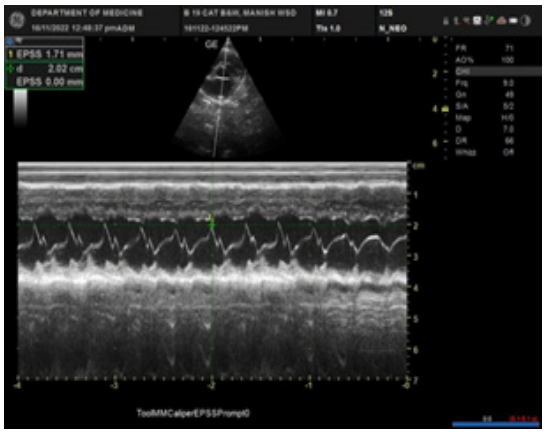

Fig. 3: E point to septal separation in apparently healthy cat

The mean heart rate of cats in this study was 173.67 ± 10.34 beats/min, which was in close agreement with Tamimi *et al.* (2020). Although, it was in the normal range reported for cats in general (120-240 beats/min, Nelson and Couto, 2019), it was relatively lower compared to most previous studies. For instance, Chetboul *et al.* (2006) reported a mean heart rate of 184 ± 33 beats/min in their study of 100 cats of different breeds. The lower values found in our study could be explained by the efforts taken in the current investigation to perform echocardiogram on the animals in a stress-free manner, as heart rate is directly related to environmental factors (specifically stress level) and is variable over time.

The inter ventricular septum in diastole (IVSd) in apparently healthy cats under study ranged from 1.57-5.46 mm with a mean of 3.50 ± 1.15 mm, and in systole (IVSs) it ranged from 3.91-7.58 mm with a mean of 5.65 ± 1.13 mm, which were in close agreement with Kayar *et al.* (2014) (IVSd 3.65 ± 0.09 mm; IVSs 5.81 ± 0.12 mm). The present mean values recorded were lower compared to the values reported by Chetboul *et al.* (2006). The left ventricular free wall and inter ventricular septum are thicker during systole when compared to diastole. This occurs as a result of the muscles relaxing during diastole to permit blood to fill and contract during systole (Nishimura and Tajik, 1997).

The left ventricular internal diameter in diastole (LVIDd) ranged from 11.12-17.54 mm with a mean of 13.48 ± 2.00 mm, and in systole (LVIDs) it ranged from 6.03-9.41 mm with a mean of 7.35 ± 1.15 mm. These results were in close agreement with Kayar *et al.* (2014).

The left ventricular posterior wall thickness in diastole (LVPWd) in apparently healthy cats ranged from 3.54-5.85 mm with a mean of 4.53 ± 0.74 mm, and in systole (LVPWs) it ranged from 5.05-7.58 mm with a mean of 6.58 ± 0.82 mm. These observations were similar to those of Sisson *et al.* (1991) and Tamimi *et al.* (2020), but smaller compared to the findings of Chetboul *et al.* (2006).

The left ventricular dimension, Ejection fraction (EF), assessed using M-mode echocardiography, is another essential indicator of cardiac function. It displays the volume of blood that the left ventricle expels with each contraction. In our study, EF ranged from 77.27-86.02 % with a mean of 80.55 ± 2.58 %, which was consistent with Schille and Skrodzki (1999) and Kayar *et al.* (2014). EF was determined to be higher than values recorded for dogs, and it was discovered that functional echocardiographic indices like EF and FS are true regardless of the age and body size of cats (Schille and Skrodzki, 1999). The term "Fractional Shortening" (FS) refers to the left ventricle's size change from diastole to systole. It represents the shortening of left ventricle muscles and is expressed in percentage. FS is a measurement of cardiac function in addition to cardiac contractile force (Boon, 2011). In apparently healthy cats under study, the FS ranged from 42.00-51.32 % with a mean of 45.50 ± 2.69 %. Although our finding is consistent with most previous studies (Petric *et al.,* 2012; Kayar *et al.,* 2014), Lister and Buchanan (2000) reported higher FS values in their studies (59.8 ± 11.6%).

The mitral valve is generally and consistently measured by the E point to septal separation (EPSS), which measures the shortest distance between the mitral E point and the inter ventricular septum. In apparently healthy cats, EPSS ranged from 0.57-2.42 mm with a mean of 1.21 ± 0.51 mm and it was consistent with the findings reported by Tamimi *et al.* (2020). In cats, values smaller than 4 mm are considered normal (Nyland and Matton, 2002).

Left Atrium, Aorta (Ao), and LA: Ao ratio in apparently healthy cats under study ranged from 0.82-1.39 cm, 0.68-1.12 cm, and 1.05-1.44 with a mean of 1.06 ± 0.17 cm, 0.86 ± 0.13 cm, and 1.25 ± 0.09, respectively. These findings were comparable with the reports of Fox *et al.* (1985) and Tamimi *et al.* (2020), which were conducted on cats with mean body weights similar to our study population.

The mean left atrial diameter to the aortic diameter ratio in our study ranged from 1.05-1.44 with a mean of 1.25 ± 0.09, which was consistent with Fox *et al.* (1985), Sisson *et al.* (1991), Lister and Buchanan (2000), Alberigi *et al.* (2019) and Tamimi *et al.* (2020). This ratio aids in determining the size of the left atrium, with ratios above 1.5 indicating left atrial dilatation (Nelson and Couto, 2019), while other researchers have believed values as high as 1.7 to be normal (Boon, 2011).

Overall the values of M-mode echocardiographic parameters of cats in current study were in close agreement with Chetboul *et al.* (2006), Petric *et al.* (2012), Noviana and Kurniawan (2013), Kayar *et al.* (2014), Alberigi *et al.* (2019) and Tamimi *et al.*(2020), and provided a baseline data for use by the clinician in India.

Conclusions

In conclusion, only a small number of studies have attempted to explicitly determine the reference echocardiographic values for various cat breeds, and to the best of the author's knowledge, no study has been conducted so far to address this issue in cats in India. These echocardiographic indicators though differ significantly among reports, the present findings will serve as the reference values for cats in India. Furthermore, it is crucial to establish these indices for the various breeds bred and fed in India in order to facilitate comparison and precise interpretation by the clinician.

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