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Study Scope of Cardiographic Diagnosis of Myxomatous Mitral Valvular Disease and Sinus Arrhythmia in Dogs and Cats

[1]Intan Permatasari Hermawan, [2]Hana Cipka Pramuda Wardhani and [3]Palestin

[1]Department of Internal Medicine, Faculty of Veterinary Medicine,Universitas Wijaya Kusuma Surabaya, Indonesia
[2]Department of Phisiology, Faculty of Veterinary Medicine,Universitas Wijaya Kusuma Surabaya, Indonesia
[3]Department of Clinical Pathology, Faculty of Veterinary Medicine, Universitas Wijaya Kusuma Surabaya, Indonesia

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Corresponding Author:
Intan Permatasari Hermawan
Department of Internal Medicine, Faculty of Veterinary Medicine,Universitas Wijaya Kusuma Surabaya, Indonesia
Email: intanpermatasari@uwks.ac.id

Abstract: Myxomatous Mitral Valvular Disease (MMVD) is the most common cardiac problem in dogs, and sinus arrhythmia in cats is important to early diagnosis. This study aimed to diagnose Myxomatous Mitral Valvular Disease (MMVD) using echocardiography and sinus arrhythmia using electrocardiography in dogs and cats. This study evaluates two dogs, a male mix domestic, and two cats, a male mix domestic, with a range of 2-10 years old. This study was conducted at the Weka Animal Hospital, Faculty of Veterinary Medicine, Universitas Wijaya Kusuma Surabaya, utilizing sonography Edan Acclarix 3 (AX3) and Edan U60 curvilinear probe and electrocardiography five leads special for animals with the paper size 110 mm'30 m. For diagnosis of Myxomatous Mitral Valvular Disease (MMVD), the position of patients was right Parasternal Recumbency, and the Long Axis (RPLA) and short axis views were obtained. In the evaluation and diagnosis, B-mode and M-mode ultrasonography were performed. For diagnosis of sinus arrhythmia using electrocardiography, the patient's lateral right position was performed using five leads (Red, Yellow, Black, Green, and Red-White) with a paper speed of 50 mm/s with an amplitude of 10 mm/mV and paper speed of 50 mm/s with amplitude 20 mm/mV. The result is that dog 01 is diagnosed with MMVD stage B2, and cat 02 is sinus arrhythmia. Though the new method was not superior to objective assessment, it may facilitate learning and subjective interpretation.

Keywords: Arrhythmia, Cats, Dogs, Echo-/Electrocardiography, MMVD, Sinus

Introduction

Heart disease is common in dogs and cats with geriatric, breed predisposition, brachycephalic, obesity, or anorexia. Common symptoms in dogs with heart problems include exercise intolerance, panting, weakness, and dyspnoea. Common five arrhythmias in dogs like atrial fibrillation (33,68%), ventricular arrhythmia (28%), sinus pauses (27,58%), supraventricular arrhythmias (24%), and atrioventricular blocks (22.95%) (Noszczyk-Nowak *et al*., 2017). Incidence of heart problems in cats is rare, but in dogs, the incidence of heart problems is 6,8-8 cases per 1.000 dogs, but in cats, 0,2-1 cases per 1.000 cats (Côté *et al*., 2015).

Prevalence of Myxomatous Mitral Valve Disease (MMVD) is caused by mitral or bicuspid valve cases in geriatric dogs, about 30-70% commonly in small dogs like Miniature Schnauzers, Yorkshire Terriers, Miniature Poodle, Dachshunds, Chihuahua, Cavalier King Charles Spaniel and mixed breed dogs (Fox, 2012). Diagnosis of MMVD using auscultation and echocardiography. Furthermore, the procedure of physical examination to evaluate the symptoms of asymptomatic MMVD with Congestive Heart Failure (CHF). Echocardiography with color flow or color Doppler for visualized MMVD (Wah *et al*., 2024).

Echocardiography is a gold standard of evaluation of MMVD, assessing five chambers, cardiac muscle function, and cardiac valve. Based on the American College of Veterinary Medicine (ACVM), MMVD can be diagnosed by echocardiography (Keene *et al*., 2019). Left atrial enlargement is a critical point or risk of present or future Congestive Heart Failure (CHF). Classification MMVD include A, B1, B2, C1, C2, D1 and D2. For those in stages B1 and B2, monitoring of left atrial enlargement can be helpful (Vezzosi *et al*., 2021)

Sinus arrhythmia is an irregular rhythm like sinus bradycardia and sinus tachycardia. Sinus bradycardia has a slower heart rhythm than the normal range, but sinus

tachycardia has a faster heart rhythm than the normal range. Normal range heart rhythm in dogs and cats is 70-160 bpm. Sinus arrhythmia is further categorized into premature or escape types and is specified based on precise location (junctional vs. non-junctional) and behavior (re-entrant, etc.). Cardiac arrhythmias may arise from either cardiac or non-cardiac diseases. Cardiac causes of arrhythmia include cardiomyopathy, congenital heart defects, endocarditis, myocarditis, pericardial disease, Congestive Heart Failure (CHF), and cardiac neoplasia. Other problems caused by electrolyte imbalance include hyperthyroidism, Calcium disorder, Potassium disorder, Magnesium disorder, anemia, trauma, neoplasia, drug effects, anesthetic medications and arrythmia were common in older cats, male cats and presence of arrythmia not indicate heart disease (Szlosek *et al*., 2024)

Electrocardiography is a golden standard for sinus arrhythmia evaluation, heart rhythm, chamber size, cardiac conduction system, and myocardial ischemia. In evaluating ECG, it is important to develop a systematic approach to ensure that all the aspects of rate and rhythm are evaluated. Sinus arrhythmia with ECG results did not impact anesthesia or patient results. The Brody phenomenon must be taken into account when variable QRS complex amplitudes are identified alongside an irregular heart rate and, while not typical in cats, could be linked to respiratory sinus arrhythmia in this variety (Sugimoto & Mochizuki, 2022).

According to a case study conducted by Sheren *et al*. (2024), diagnosing MMVD in a Shih Tzu canine using Echocardiography, incorporating b-mode and m-mode assessment, indicated left atrial enlargement and issues with the mitral valve. Vomiting and a decrease in cardiac performance. Relying on Han *et al*. (2018) conducted a study with forty dogs; 22 females, and 18 males were included in that research for the identification of MMVD. Employing echocardiography, this study noted that the established traditional echocardiographic metrics, including EDV, LA/Ao ratio, LVIDd measurement, and the ratio of LVIDd to Ao was linked to the severity of MMVD in terms of notable distinctions and unique relationships.

Thus, we aimed to evaluate Myxomatous Mitral Valvular Disease (MMVD) using echocardiography and sinus arrhythmia using electrocardiography in dogs and cats because of a lack of minimal information and case reports. Early diagnosis of MMVD and sinus arrhythmia at Animal Hospital Weka Surabaya, Indonesia.

Materials and Methods

Study Overview and Case Selection

Study procedures were approved by the ethical clearance committee of the Faculty of Veterinary Medicine, Universitas Wijaya Kusuma Surabaya number 131B-KKE. Informed owner consent was obtained for each dog and cat before study enrollment.

This study uses a small sample size with two dogs (1 male, one female) and 2 cats (1 male, one female) with a range of 2-10 years old. This study was conducted at the Weka Animal Hospital, Faculty of Veterinary Medicine, Universitas Wijaya Kusuma Surabaya, Indonesia. The breed of dogs is golden mix domestic, and cats are mixed domestic.

Echocardiography for qualitative assessment involved the use of two positions for the Right Parasternal Short Axis (RPSA) and the Right Parasternal Long Axis (RPLA). Three successive systolic and diastolic heart cycles were obtained using B mode and M mode data to detect fetal heart defects. Transducer frequencies are between 8-12 MHz for dogs and cats that recommendation (Hammond, 2010).

Electrocardiography using five leads or channels. Red lead on cranial extremities dexter, yellow lead on cranial extremities sinister, black lead on caudal extremities cranial, green lead on caudal extremities sinister, and red-white lead on a last-dexter costume with paper speed 50 mm/s and amplitude 10 mm/m; paper speed 50 mm/s and amplitude 20 mm/mV.

Statistical Analysis

The analysis employs the One-Sample Kolmogorov-Smirnov Test to evaluate the level of alignment between an observed distribution and a fully defined theoretical continuous distribution, while the paired-sample proportions offer tests and confidence intervals for the differences in two associated or paired binomial proportions. The images of the statistical analysis results utilized an error bar graph.

Results

Echocardiography Evaluation

Note: Figs. (1-2) Short axis view on B-mode and M-mode of left cardiac of dog one and dog 2. HR = heart rate, IVSd = interventricular septa-diastole, IVSs = interventricular septa-systole, LVIDd = left ventricle internal dimension-diastole, LVIDs = left ventricle internal dimension-systole, LVWd = left ventricle wall-diastole, LVWs = left ventricle wall-systole, EDV = end-diastolic volume, ESV = end sistolic volume, SV = stroke volume, EF = ejection fraction, FS = fraction shortening.

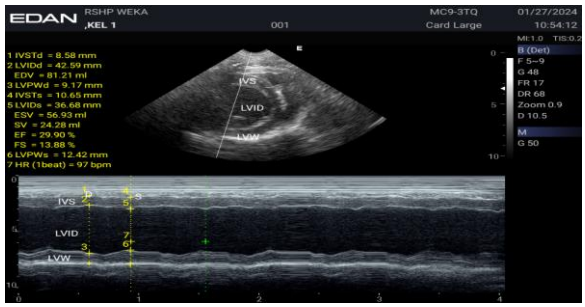

Fig. 1: Dog 01 using Edan Acclarix 3

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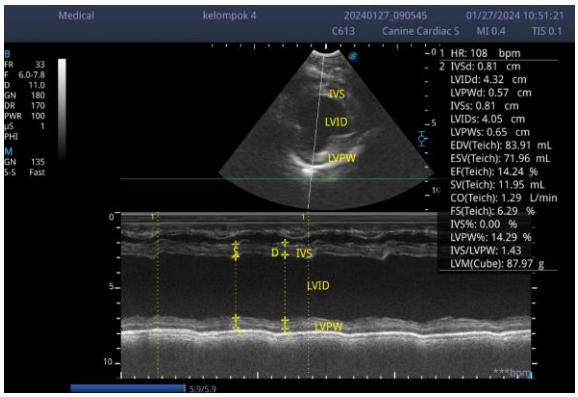

Fig. 2: Dog 02 using Edan U60

Electrocardiography Evaluation

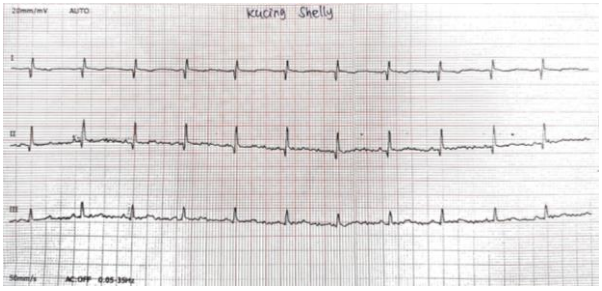

Fig. 3: ECG Cat 01 with paper speed 50 mm/s and amplitude 20 mm/mV (interpreted in Table 3)

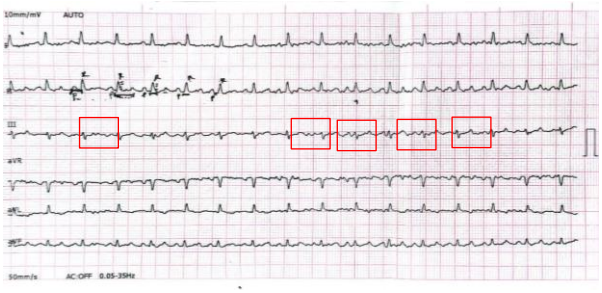

Fig. 4: ECG Cat 02 with paper speed 50 mm/s and amplitude 10 mm/mV, Atrial premature complex (red shapes) interpreted in Table 3)

Statistical Results

Using reported data of One-Sample Kolmogorov-Smirnov Test baseline descriptive statistics data reported as mean ± SD (normally distributed data) it is normal distribution, and the result of Paired-Samples Proportions showed that no significance from one-sided P (more than 0,05) and the distribution of residuals was assessed by visual inspection followed by the error bar.

Error bars focus on how much the bars overlap between different groups. If the error bars largely overlap, there is no significance. Based on Fig. (5), it is not significant because the bar is overlapping. Figures (6-8) are significant because the bar is not overlapping. Heart rate in dog 01 and dog 02, there is an overlapping bar, which means it is not significant, but LVIDd in dog 01 was very significant rather than the normal value (Fig. 5). LVIDd in dog 02 was slightly significant (Fig. 6) indication that dog 01 was MMVD stage B2. Meanwhile, the P wave height ECG in cat 01 was slightly significant compared to the normal value (Fig. 7), which was the same as in cat 02 (Fig. 8).

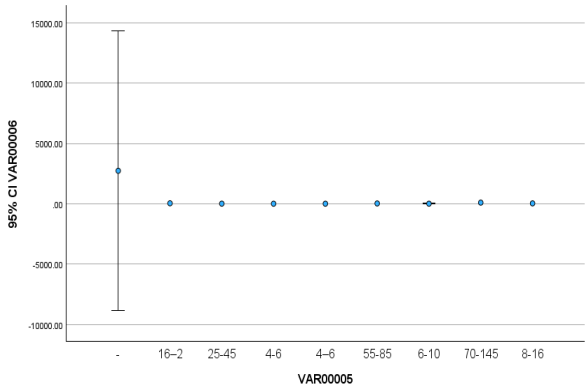

Fig. 5: Paired sample proportion between normal value and dog 01

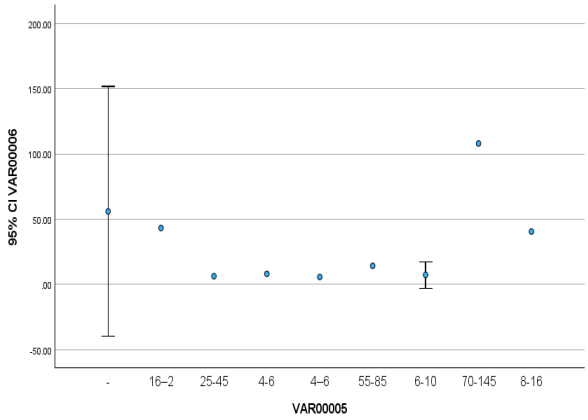

Fig. 6: Paired sample proportion between normal value and dog 02

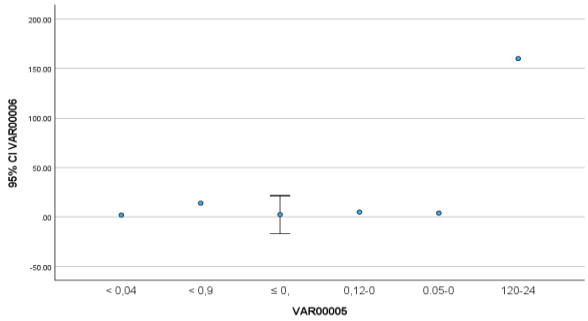

Fig. 7: Paired sample proportion between normal value and cat 01

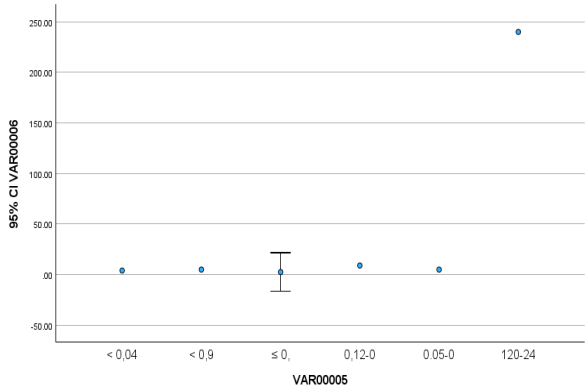

Fig. 8: Paired sample proportion between normal value and cat 02

Discussion

The history of dogs and cats of this model is senior to geriatric, and they were never examined by a vet to check for cardiac problems. Clinical signs of those models include dyspnea, coughing, and exercise intolerance. Based on the result, sinus arrhythmia in dogs is more normal than in cats; based on Table (1), dogs have normal heart rates and smooth and thin endocard layers. The valve structure and valve movement are normal, too. Based on Table (2), interventricular septa-diastole in Dogs 01 and 02 is higher than the normal value because sinus arrhythmia is a normal finding in dogs but unusual in cats, though it seems to be more prevalent in felines within their domestic surroundings. Respiratory sinus Arrhythmia is defined by a rise in heart rate with inhalation and a reduction during exhalation. Left Ventricle Internal Dimension-diastole (LVIDd) dog 01 is 42.59 mm, and dog 02 is 43.2 mm, which is higher than the normal value. Rather than the standard value of LVIDDN ≥1.7, suggest using a value of ≥1.6 in MMVD stage B2 (Isayama *et al*., 2022). LVPWd value Dog 01 is higher than normal; the LVPWd is increasing from the normal range, which indicates high pressure in the heart. A low heart rate supports MMVD-induced bradycardia. Left Ventricle Internal Dimension-systole (LVID) is greater than the normal value. The internal measurement of the LV was assessed utilizing 2DE at end-diastole (LVIDd) and end-systole (LVIDs) at the position of the chordae tendineae roughly at a right angle to the Lx of the ventricular septum and LV outer wall (Vezzosi *et al*., 2021). Departed Posterior Ventricular Wall end-diastole (LVPWs) in canine 01 is above the usual level (12.42), while dog 02 is within the normal range (6,5 mm). The posterior section of the Left Ventricle Wall During Diastole (LVPWd) experiences stretching of muscle cells in the heart chamber walls because of increased diastolic filling, thereby improving the Frank starling relationship.

Table 1: Two dimension Brightness mode (B-mode)

	Examination	
Parameter	Dog 1	Dog 2
Heart rhythm	97 bpm	108 bpm
Endocard layer	smooth and thin	smooth and thin
Valve structure	normal	normal
Valve movement	normal	normal

Table 2: Two dimension Motion mode (M-mode)

Parameter	Normal value (Isayama *et al*., 2022)	Dog 01	Dog 02
HR (bpm)	70-145	97	108
IVSd (mm)	4-6	8.58	8.1
LVIDd (mm)	16–28	42.59	43.2
EDV (ml)	-	81,21	83.91
LVPWd (mm)	4–6	9.17	5.7
IVSs (mm)	6-10	10.65	8.1
LVIDs (mm)	8-16	36.68	40.5
ESV (ml)	-	59.93	71.96
SV (ml)	-	24.28	11.95
EF (%)	55-85	29.9	14.24
FS (%)	25-45	13.88	6.29
LVPWs (mm)	6-10	12.42	6.5

The Frank-Starling principle of the heart indicates that the stroke volume of the heart rises when the blood volume in the ventricles rises. The modulation of this connection is affected by numerous physiological factors and is often disrupted by episodes of heart failure (Hanft *et al*., 2021). The thickness of the interventricular septum during systole (IVSs) in dog 01 and the diastolic left ventricular wall (LVWd) can determine if LV hypertrophy exists. The LVPWd is the maximum threshold of the typical range; it might indicate elevated stress within the heart of dog 01. Internal Measurements of the Left Ventricle in Diastole (LVIDd) and systole (LVIDs) are both experiencing an increase compared to the normal range for both (dogs 01 and 02). Canine 01 that interpretation using MMVD. In phase B1, a patient demonstrating myxomatous changes in valves, usually identified by the existence of a murmur, indicates no to mild cardiac renovation. It is unlikely to see clinical symptoms within a year, and no therapies or drugs have shown effectiveness at this point. However, this research has no Color flow Doppler (CFD). CFD can evaluate blood circulation and backflow in the valve.

Based on Table (3), cat 01 and cat 02 have a regular rhythm, with p wave duration of 0,04 seconds, ds, and p wave height of 0,1 Mv. PR interval cat 01 is 0,04 sec lower than normal, but cat 02 is 0,04 on normal range. QRS complex cat 01 under value 0,02 is normal, and cat 02 is 0,04 shows that normal value. R wave height cat 01 is higher than the normal range (0,14 Mv), but cat 02 is normal (0,05 Mv). ST segment both cats normally show no depression or deletion.

Table 3: ECG examination report

Parameters	Normal Value Cat	Cat 01	Cat 02
Heart rate	120-240 bpm	160	240
Heart rhythm	Regular	Regular	Irregular
P wave duration	≤0,035-0,04 sec	0,04	0,04
P wave height	≤0,2 mV	0,1	0,1
PR Interval	0.05-0,09 sec	0,04	0,05
QRS complex	<0,04 sec	0,02	0,04
R wave height	<0,9 mV	0,14	0,05
ST segment	No depression/ deletion	No depression/ deletion	No depression/ deletion
QT interval	0,12-0,18 sec	0,05	0,09

The ST segment includes the area between the conclusion of ventricular depolarization and the start of ventricular repolarization on the ECG. In simpler terms, it refers to the region between the conclusion of the QRS complex and the start of the T wave. The ST Segment denotes the period between ventricular depolarization and repolarization. The primary significance of ST segment irregularities such as elevation or depression is myocardial ischemia or infarction. The QT interval is reduced compared to the normal value on Cat 01 (0.05 sec) and Cat 02 (0.09 sec). A diagnostic ECG can be used to assess patterns suggestive of chamber enlargement, such as wide P waves or high R waves that relate to left atrial and left ventricular enlargement.

A rhythm ECG will evaluate for arryhtmia. Supraventricular arrhythmias like atrial premature complexes (APCs) and or atrial fibrillation (AF) are generally more prevalent than ventricular arrhythmias in MMVD. However, both types can occur and can be differentiated using a rhythm or single lead II ECG. The pattern of complex QRS wave cats 02 shows abnormality because of complex QRS.

The lack of this study is due to the small sample size and the lack of statistical results, but for diagnosis, MMVD in dogs has the gold standard using echocardiography.

Conclusion

This research summary utilizes Echocardiography to visualize the heart's abnormality, particularly in this instance, the identification of MMVD using B mode and M mode. Canine 01 was diagnosed with MMVD stage B2. A diagnostic ECG may be utilized to evaluate chamber function enlargement patterns (for example, broad P waves or high R waves in agreement with the enlargement of the left atrium and left ventricle, correspondingly). A rhythm ECG will evaluate for abnormal heartbeats. Moreover, the diagnosis of MMVD using the X-ray method VHS, THIS, VLAS, mVLAS, and RLAD, although the new approach was not better than objective evaluation, could promote understanding and personal interpretation.

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Author's Contributions

Intan Permatasari Hermawan: Drafted, revised, and edited the manuscript.

Hana Cipka Pramuda Wardhani and Palestin prepared the data.

Ethics

The author(s) declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

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