Indian J. Vet. Med. Vol. 45, No. 1, 2025 pp. 13-20

Electrocardiographic Changes in Geriatric Dog with Congestive Heart Failure

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Abstract

Congestive heart failure (CHF) is a leading yet often unnoticed cause of canine deaths in India. The primary culprits behind CHF include dilated cardiomyopathy (DCM), mitral valve disease (MVD), hypertrophic cardiomyopathy (HCM), and pericardial effusion (PE). Sadly, the lack of advanced diagnostic facilities, such as radiography, echocardiography, and cardiac biomarker testing, often results in delayed diagnoses, robbing many pet owners of their cherished companions before timely intervention can be made. Electrocardiographic analysis uncovered a range of supraventricular, ventricular, and morphological abnormalities. In aged dogs affected by congestive heart failure (CHF), atrial fibrillation was the most common finding, observed in 7 dogs (29.17%). Among the other screened dogs (n=251), sinus arrhythmia (6.77%) was the most frequently detected arrhythmia, while deep Q-waves and wide QRS complexes were diagnosed in 3.10%, and 1.59% of cases, respectively. Early diagnosis and regular screening are crucial for identifying and managing cardiac disorders in dogs, enabling timely interventions to improve outcomes and quality of life.

Keywords: Geriatric dogs, Atrial Fibrillation, Dilated Cardiomyopathy, ECG

Introduction

Dogs are becoming more and more common as companion animals among urban populations these days. It had been estimated that around 10-15% of dogs taken to vets in North America are believed to have heart problems (Atkins *et al.,* 2009). In India, a study by Haritha *et al.* (2018) found that the overall prevalence of cardiac disorders among dogs was 1.77%, and it could vary as these diseases are not often properly diagnosed and treated, due to the lack of diagnostic facilities and expertise. Furthermore, Parker *et al.* (2006) emphasized that cardiac diseases in dogs often operate quietly, without showing obvious symptoms, and their sudden impact can leave owners and breeders grappling with feelings of loss and uncertainty. Boswood *et al.* (2016) reported that Congestive heart failure (CHF) CHF was a common outcome of various heart diseases and is particularly prevalent in geriatric dogs, with major causes including myxomatous mitral valve disease (MVD) and dilated cardiomyopathy (DCM). This study describes the electrocardiographic patterns associated with congestive heart failure in geriatric dogs.

Materials and Methods

The study was conducted from June 2023 to August 2024, at the Department of Veterinary Medicine, Dr. G.C. Negi College of Veterinary & Animal Sciences, CSKHPKV Palampur, Himachal Pradesh, in which 275 geriatric dogs were screened out of total 2,574 registered cases. Among them, 24 geriatric dogs were diagnosed with congestive heart failure (CHF) through electrocardiography (ECG), radiography, and echocardiography. ECG assessments were performed using the RMS Vesta 301i, a 12-lead system, following standard protocols (Tilley and Smith, 1997). Thermosensitive recording paper (80 mm width, 20 metres recording length) from Arrow Medical Recording, Chennai, was used for ECG recordings.

In dogs with respiratory distress, ECG was recorded in standing posture. The collected data was statistically analysed using Instat software from Graphpad (2008) and SPSS 12. Mean values of various parameters between control and diseased groups, as well as pre- and post-treatment data, were compared. Statistical significance at different levels was determined using the "t" test and ANOVA providing a thorough evaluation of the treatment effects.

Results and Discussion

The electrocardiographic findings in dogs with CHF due to DCM, MVD, HCM, and PE are summarized in Table I. In cases of DCM, our study revealed a significant reduction ($p<0.05$) in P wave amplitude. For dogs with MVD and HCM, no significant changes in ECG parameters were observed. In cases of DCM,

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https://doi.org/10.56093/ijvm.v45i1.160142

our study revealed a notably low P wave amplitude. The reduced P wave amplitude may be attributed to the high incidence of atrial fibrillation (AF) (Fig. 7) in dogs with DCM, where the P wave is absent, resulting in a P wave value of zero during AF episodes.

In cases of PE, a significantly reduction in QRS amplitude was noted, which is consistent with the findings of Lakshmi *et al.,* (2017). In our study a significant reduction in P wave amplitude was also found, in cases of pericardial effusions, which is similar to the findings of Habashy et al., (2004), they observed that low P-wave voltage occurred more often than low QRS voltage (Fig. 3). The low P wave amplitude indicate that some fluid from severe PE can collect around the right atrium, hence P-wave on an ECG gets smaller Madias (2008).

Table I: ECG parameters in CHF-affected dogs (n=24)

Parameter	Control (n=17)	DCM (n=9)	MVD (n=7)	HCM (n=3)	PE (n=5)
P-wave amplitude (mV)	0.26 ± 0.02^{b}	0.035 ± 0.02^{a}	0.13 ± 0.04^{ab}	0.11 ± 0.09^{ab}	0.06 ± 0.04^{b}
P-wave duration (sec)	0.03 ± 0.01	0.02 ± 0.01	0.03 ± 0.00	0.06 ± 0.02	0.03 ± 0.02
Q-wave amplitude (mV)	1.25 ± 0.06^{b}	1.26 ± 0.13^{ab}	0.86 ± 0.27^{ab}	1.03 ± 0.31^{ab}	0.48 ± 0.13^{a}
QRS (sec)	0.04 ± 0.01	0.06 ± 0.00	0.03 ± 0.00	0.05 ± 0.01	0.04 ± 0.00
T-wave amplitude (mV)	0.20 ± 0.02	0.18 ± 0.02	0.22 ± 0.06	0.3 ± 0.05	0.22 ± 0.04
T-wave duration (sec)	0.05 ± 0.01	0.04 ± 0.00	0.10 ± 0.00	0.06 ± 0.01	0.04 ± 0.06
PR interval (sec)	0.08 ± 0.01	0.05 ± 0.01	0.10 ± 0.01	0.09 ± 0.02	0.07 ± 0.02
QT interval (sec)	0.20 ± 0.01	0.17 ± 0.01	0.21 ± 0.02	0.19 ± 0.02	0.15 ± 0.01

Values with different upper-case alphabets in the same row are significant ($p \leq 0.05$)

In geriatric dogs with congestive heart failure (CHF), various ECG abnormalities were observed (Table II), with atrial fibrillation being the most prevalent, affecting 7 dogs (29.17%), consistent with the findings of Tejaswi (2022) and Noszczyk-Nowak et al. (2017). According to Lubitz *et al.,* (2010) higher prevalence of atrial fibrillation (AF) in congestive heart failure (CHF) can be attributed to various underlying mechanisms. Atrial fibrosis which disrupts cell-to-cell electrical coupling and impairs signal conduction thus creating an environment conducive to arrhythmias. Additionally, genetic predisposition may also contribute to the development of AF. Similarly, low QRS complexes were also seen in 7 dogs (29.17%). Other common arrhythmias included ST slurring or coving, R wave notching, wide QRS complexes, and electrical alternans, each present in 4 dogs (16.67%). Less frequent, but still notable, arrhythmias such as deep Q waves, prolonged PQ intervals (Fig. 13), first degree AV block, and sinus arrest/block were identified in 3 dogs (12.50%). The occurrence of sinus arrest (Fig. 14) is similar to that reported by Tejaswi (2022), while our findings of first-degree AV block align with Noszczyk-Nowak *et al.*, (2017), who noted a 12.63% prevalence of first-degree heart block in dogs with pathological arrhythmias and reported that high-grade atrioventricular blocks are usually claimed to be idiopathic and associated with fibrosis of the conduction system or myocarditis. Sinus pauses are typically observed in brachycephalic breeds. They may occur secondary to fluctuations in vagal tone associated with the respiratory cycle. Such fluctuations are particularly evident in dogs with brachycephalic syndrome due to their increased respiratory effort,

irritation of laryngeal region, and parasympathetic stimulation

Additional arrhythmias, including T(a) wave abnormalities (greater than ¼ of the R(a) wave), ST depression, prolonged QT intervals, supraventricular tachycardia, and ventricular premature complexes (VPCs) (Fig. 6), were each detected in 2 dogs (8.34%). Uncommon arrhythmias, such as deep S waves, right bundle branch block (RBBB) (Fig. 2), wandering pacemaker (WPM), and short PQ intervals, were observed in 1 dog each (4.17%). Satish (2009) recorded a lower incidence of RBBB (2.34%) in CHF dogs compared to our study. We also noted increased R wave amplitude in 2 cases (8.34%) (Fig. 12), closely matching the findings of Satish (2009), who reported an 8.60% occurrence in dogs with cardiac issues. Our study found higher incidences of deep Q waves and low QRS complexes compared to Tejaswi (2022), Satish (2009), and Haritha (2018). Additionally, the findings of ST coving aligned with Tejaswi (2022), and P mitrale was observed in only one case, similar to Satish (2009).

The study highlights distinct ECG patterns associated with mitral valve disease (MVD), hypertrophic cardiomyopathy (HCM), pericardial effusion, and dilated cardiomyopathy (DCM) that are associated with various forms of CHF. P wave, QRS duration, and T wave changes provided useful hints for the diagnosis of cardiac disorders.

Table II: Various ECG findings in CHF affected dogs (n=24)

Abnormal rhythm	Number of Dogs	Abnormal rhythm (%)
T wave (a) > ¼ R wave (a)	2	8.34%
ST slurring/coving	4	16.67%
R wave notching	4	16.67%
Deep S wave	1	4.17%
Right bundle branch block (RBBB)	1	4.17%
Low QRS Complexes	7	29.17%
Sinus arrest/block	3	12.50%
Wandering pacemaker (WPM)	1	4.17%
ST depression	2	8.34%
Wide QRS complex	4	16.67%
Atrial fibrillation	7	29.17%
Prolong QT interval (>0.25 sec)	2	8.34%
Electrical alterans	4	16.67%
Supraventricular tachycardia	2	8.34%
First degree AV block	3	12.50%
Ventricular premature complexes (VPCs)	2	8.34%
Prolong PQ/PR interval	3	12.50%
Short PQ interval	1	4.17%
Deep Q wave	3	12.50%
Increased R amplitude	2	8.34%
P-mitrale	1	4.17%
Total	58	100.00%

Table III: Various ECG abnormalities found during screening of geriatric dogs (n=251) excluding those diagnosed with CHF

Abnormal rhythm	Number of Dogs	Abnormal rhythm (%)
Sinus arrhythmia	17	6.77%
Deep Q-wave	8	3.10%
Wide-QRS complexes	4	1.59%
Notched R wave	7	2.78%
ST elevation	2	0.79%
Tall T-wave	6	2.39%
ST-coving	4	1.59%
Right bundle branch block	4	1.59%
VPCs	2	0.79%
Electrical alternans	7	2.78%
Atrial flutter	2	0.79%
Tall R wave	3	1.19%
Sinus arrest	2	0.79%
Sinus tachycardia	4	1.59%
Atrial fibrillation	4	1.59%
ST depression	2	0.79%
Sinus bradycardia	2	0.79%
Atrial standstill	3	1.19%
Asystole	3	1.19%
Low QRS complexes	5	1.99%
P- pulmonale	2	0.79%
P- mitrale	1	0.39%
First degree AV block	4	1.59%
Second degree AV block	2	0.79%
WPM	4	1.59%
Total	104	41.43%

Table III presents the types and frequency of arrhythmias identified during a screening of 275 geriatric dogs. The data includes the specific types of abnormal heart rhythms, the number of dogs affected by each, and the percentage of the total population (275) that each arrhythmia impacts. Out of these, 24 dogs were diagnosed with CHF and 104 dogs (41.43%) were identified with abnormal heart rhythms, indicating that over one-quarter of the elderly dogs exhibited some form of cardiac irregularity. The most common type of arrhythmia found was sinus arrhythmia, affecting 17 dogs (6.77%) (Fig. 1), followed by deep Q-wave abnormalities in 8 dogs (3.10%) and wide-QRS complexes, in 4 dogs (1.59%). Several other arrhythmias, including notched R-wave, ST elevation, tall T-wave, and ventricular premature complexes (VPCs), affected smaller proportion (1% to 3%) of the population. Severe conditions like atrial fibrillation, asystole (Fig. 10), and atrial flutter were rare, affecting nearly 1.59%, 1.19% and 0.79% of the dogs. Additionally, conditions such as AV blocks (first and second degree), electrical alternans and WPM syndrome were also found, though they were less frequent. Sinus arrhythmias are considered physiological in dogs due to their strong parasympathetic (vagal) influence on the heart. Physiological sinus tachycardia can occur as a transient response to catecholamine release, often triggered by the stress of an electrocardiographic examination. Conversely, sinus bradycardia is typically seen in athletic dogs of giant breeds. In smaller breeds, sinus bradycardia may result from elevated vagal tone, the presence of toxaemia, or as a secondary manifestation of sick sinus syndrome

(Noszczyk-Nowak et al. 2017). The findings underscore the variety of arrhythmias present in geriatric dogs, with some being more prevalent than others. So, the routine screening for heart conditions in older dogs is essential for early detection and management of both common and rare arrhythmias.

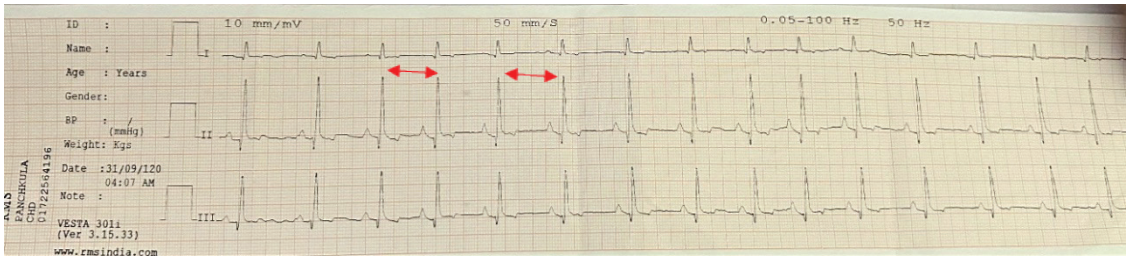

Fig. 1: Sinus arrhythmia (50 mm/s paper speed; 10 mm/mV gain)

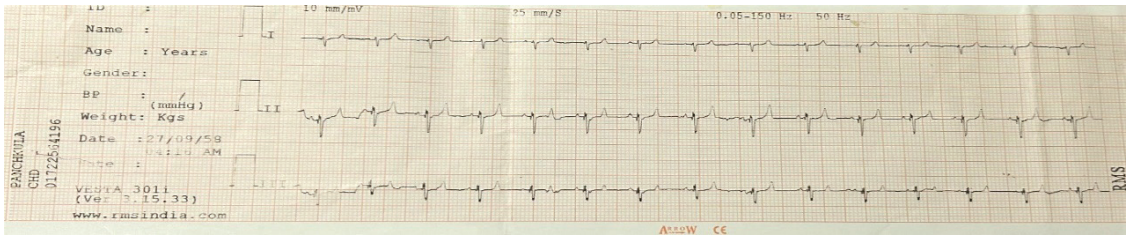

Fig. 2: Right bundle branch block (25 mm/s paper speed, gain 10 mV)

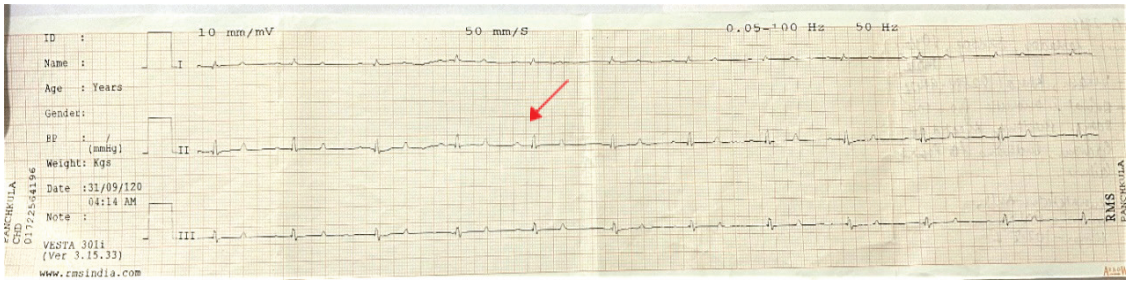

Fig. 3: Low QRS complex in a dog with pericardial effusion (50 mm/s paper speed; 10 mm/mV gain).

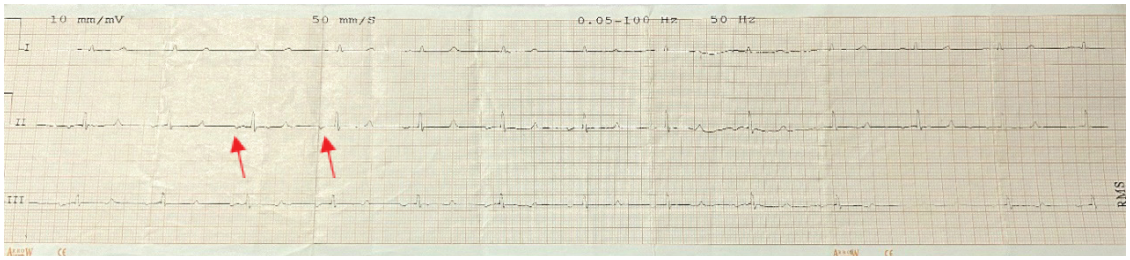

Fig. 4: Negative p wave and normal QRS complexes, suggestive of AV junctional premature complexes (50 mm/s paper speed; 10 mm/mV gain).

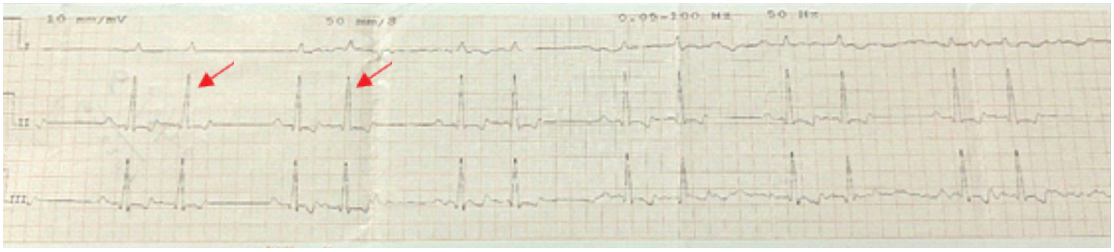

Fig. 5: Atrial premature complexes (APCs) in a dog with severe DCM and severe mitral valve regurgitation (50 mm/s paper speed; 10 mm/mV gain).

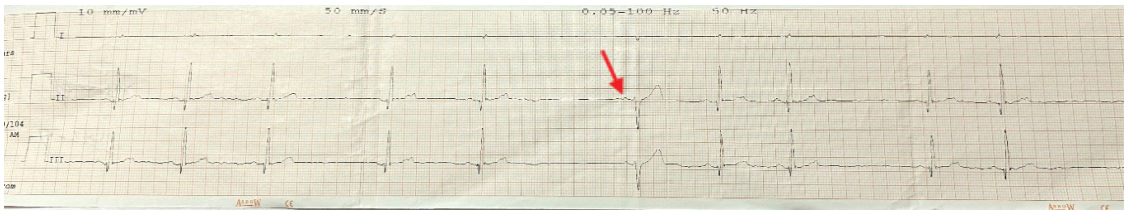

Fig. 6: Ventricular premature complex (VPC) in a dog affected with DCM (50 mm/s paper speed; 10 mm/mV gain).

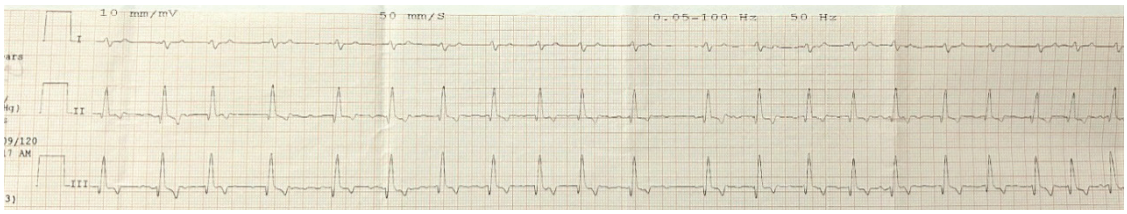

Fig. 7: Atrial fibrillation (AF) in a dog affected with DCM (50 mm/s paper speed; 10 mm/mV gain).

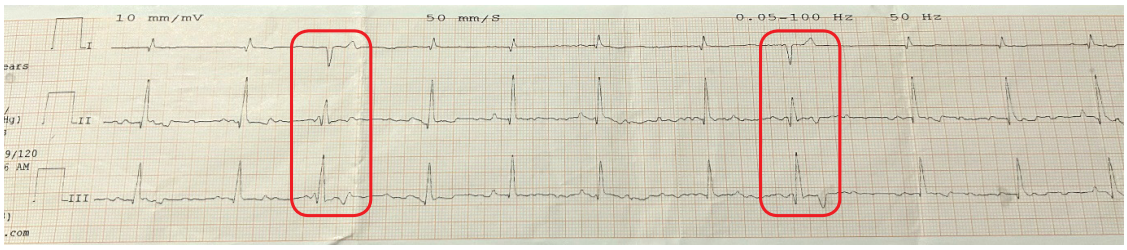

Fig. 8: Ventricular ectopic complex (square box) (50 mm/s paper speed; 10 mm/mV gain).

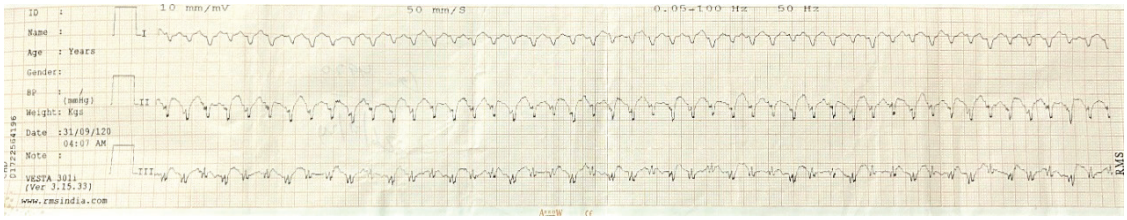

Fig. 9: Ventricular tachycardia (50 mm/s paper speed; 10 mm/mV gain).

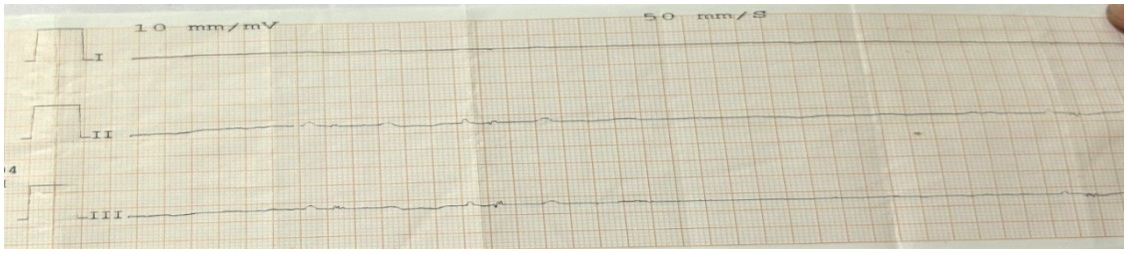

Fig. 10: Asystole (50 mm/s paper speed; 10 mm/mV gain).

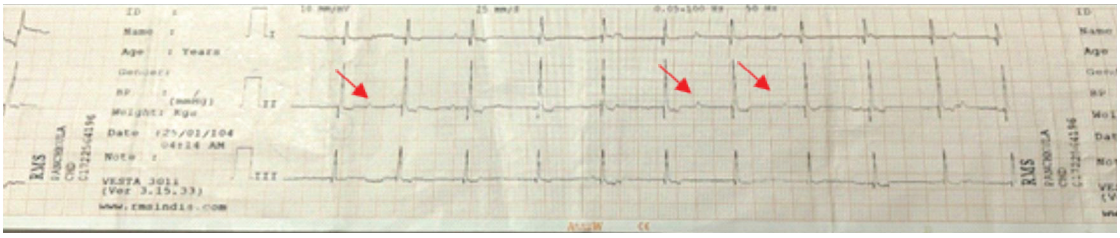

Fig. 11: Second Degree AV Block–Mobitz Type II (red arrows: represents P wave followed by no QRS complex) (50 mm/s paper speed; 10 mm/mV gain).

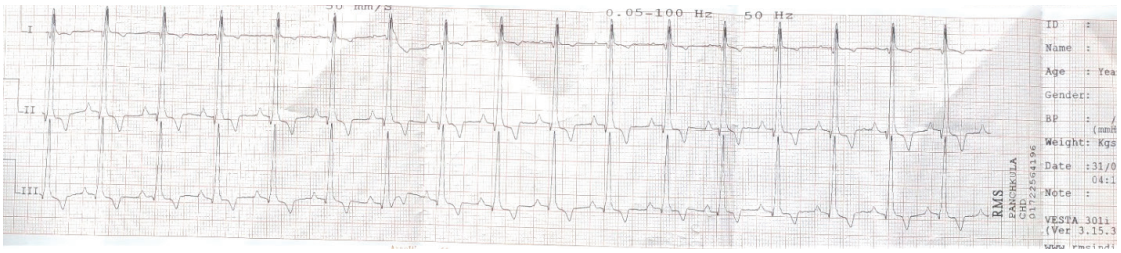

Fig. 12: Spiked R wave with amplitude >3mV, suggestive of left ventricular enlargement (50 mm/s paper speed; 10 mm/mV gain).

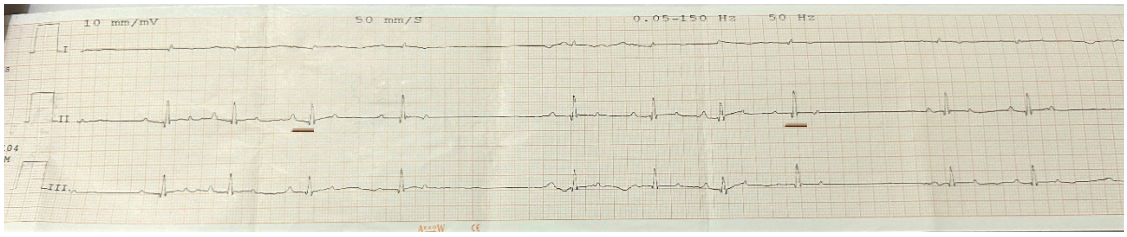

Fig. 13: Second-degree AV block–Mobitz Type I, with prolong PQ interval and with escape of a beat (50 mm/s paper speed and 10 mm/mV gain).

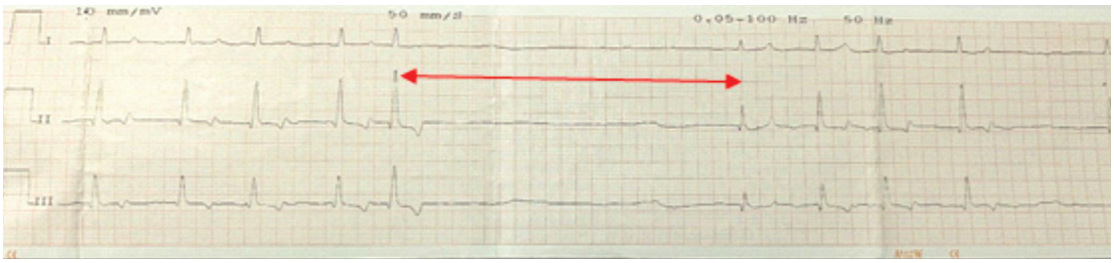

Fig. 14: Atrial standstill and sinus block (50 mm/s paper speed; 10 mm/mV gain).

Conclusion

This study highlights the timely detection and treatment of congestive heart failure (CHF) in geriatric dogs can be facilitated by routine electrocardiogram (ECG) examinations. The most frequent arrhythmia, occurring in 29.17% of cases of CHF, was atrial fibrillation and low QRS amplitude. In DCM, atrial fibrillation was prevalent, along with low P wave amplitude, whereas in PE patients, low QRS amplitude and low P wave amplitudes were typical.

Conflict of interest: Authors have no conflict of interest in this study.

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Received : 18.11.2024 **Accepted : 11.06.2025** **Published : 30.06.2025**