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Electrocardiographic Interpretations of Cardiac Disorders in Dogs

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ABSTRACT

Background: Cardiac disorders are the second most common disorders after cancer in dogs. Cardiac disorders are often fatal and/or silent killers in canines. In our country, in the majority of cardiovascular disorders, there is a frequent omission by clinician and client due to lack of awareness. However, any cardiac abnormality requires to be dealt with top priority to avoid morbidity and mortality in the dog population. The present study was aimed to know the electrocardiographic interpretations of cardiac disorders in dogs.

Methods: For this purpose, a total of 5110 dogs presented at Veterinary Clinical Complex, College of Veterinary Science and Animal Husbandry, Nanaji Deshmukh Veterinary Science University, Jabalpur, Madhya Pradesh, from November 2019 to June 2020 were screened. Among them, 137 dogs had clinical signs about cardiac disorders were subjected to thorough electrocardiographic recordings for interpretations of various cardiac conduction anomalies.

Result: Electrocardiography revealed various types of supraventricular and ventricular abnormalities. Among supraventricular disorders maximally wandering pacemaker (30.60%) was recorded followed by atrial fibrillation (22.58%), left atrial enlargement (8.06%) and sinus arrest (4.84%) in dogs. Among ventricular abnormalities; left ventricular enlargement, right ventricular enlargement and biventricular enlargement (*i.e.* 41.67%, 37.49% and 8.33%, respectively) were commonly diagnosed.

Key words: Atrial fibrillation, Cardiac disorders, Electrocardiography, P-mitrale, Ventricular fibrillation, Ventricular premature complex, Wandering pacemaker.

INTRODUCTION

The dogs are one of the most trusted companion animals of human beings since ancient time and their health is one of the foremost concerns towards the pet owners. Dogs mostly share the same food which is being consumed by pet owners. This dietary shift may predispose the dogs to cardiac disorders in a similar fashion as it contributes to human cardiac diseases. Cardiac disorders are the second most common disorders after cancer in dogs. Cardiac disorders are often fatal and/or silent killers in dogs. In our country, in the majority of cardiovascular disorders, there is a frequent omission by clinician and client due to lack of awareness (Singh *et al.,* 2008). However, any cardiac abnormality requires to be dealt with top priority to avoid morbidity and mortality in the dog population (Kumar, 2012).

MATERIALS AND METHODS

The present study was conducted on 5110 dogs presented to Veterinary Clinical Complex, College of Veterinary Science and A.H., Nanaji Deshmukh Veterinary Science University, Jabalpur, Madhya Pradesh, from November 2019 to June 2020. Among them, 137 dogs had clinical signs suspected of cardiac disorders were subjected to thorough investigation for confirmation of the cardiac disorders. Evaluation of cardiac disorders was made based on history, clinical signs, physical examination, auscultation, electrocardiography, thoracic radiography, echocardiography, haemoglobin and serum electrolytes. However, thorough electrocardiographic recordings were done for interpretations of various cardiac conduction anomalies.

ECG procedure

Electrocardiographic tracing was recorded with Cardiart 8408 View (BPL Limited) machine by placing the dog in right lateral recumbency. Three bipolar limb leads (lead I, lead II and lead III) and three augmented unipolar limb leads (aVR, aVL and aVF) were used. ECG was recorded with a paper speed of 50 mm/sec. Before each recording, a one millivolt standardization pulse was made. A longer rhythm strip was run on lead II and four or five beats were recorded on each lead. Tilley's (1985) guidelines for measuring complexes and intervals were followed for the interpretation of electrocardiograms.

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RESULTS AND DISCUSSION

Supraventricular abnormalities in dogs with cardiac disorders

On electrocardiography various types of supraventricular abnormalities were observed and summarized in Fig 1, 2, 3, 4, 5 and 6. Supraventricular disorders documented as wandering pacemaker in 30.60%, followed by atrial fibrillation (fine AF and coarse AF) in 22.58%, sinus tachycardia in 12.90%, left atrial enlargement in 8.06%, sinus bradycardia in 8.06%, sinus arrhythmia in 6.45%, sinus arrest in 4.84%, atrial premature complexes in 3.22% and similar frequency *i.e.* 1.61% atrial standstill and right atrial enlargement in dogs.

Atrial fibrillations were recorded as coarse atrial fibrillation (large oscillations *i.e.* 'f' waves (Fig 2) of varying amplitude replace the normal sinus P waves) and fine atrial fibrillation, small f waves take the place of sinus P waves. Atrial fibrillation is characterized by complete electrical disorganization at the atrial level leading to the chaotic and rapid rise of depolarization (Ettinger *et al.,* 2000; Gugliemini *et al.,* 2000). The electrophysiological mechanism underlying AF is re-entry, which is characterized by multiple wavelets of depolarization. Multiple wavelets can cross the atria without fusing in one normal front of depolarization only when a large atrial mass is present (Zipes, 1997). Atrial fibrillation is a common arrhythmia in dogs (Meurs *et al.,* 2001; Noszczyk *et al.,* 2008). The results of the present study also suggested that AF is a common supraventricular disorder after the wandering pacemaker. Similar findings were also found by Varshney *et al.* (2011) who documented thirty cases of atrial fibrillation in dogs with unexplained illness and weakness. Atrial standstill is identified by the absence of P waves in any lead, heart rate is below 60 bpm and rhythm is regular. Atrial standstill is reported to be rare and often found associate with atrial parenchymal hypoplasia and severe hyperkalemia (Ettinger *et al.,* 2000). In this study, the atrial

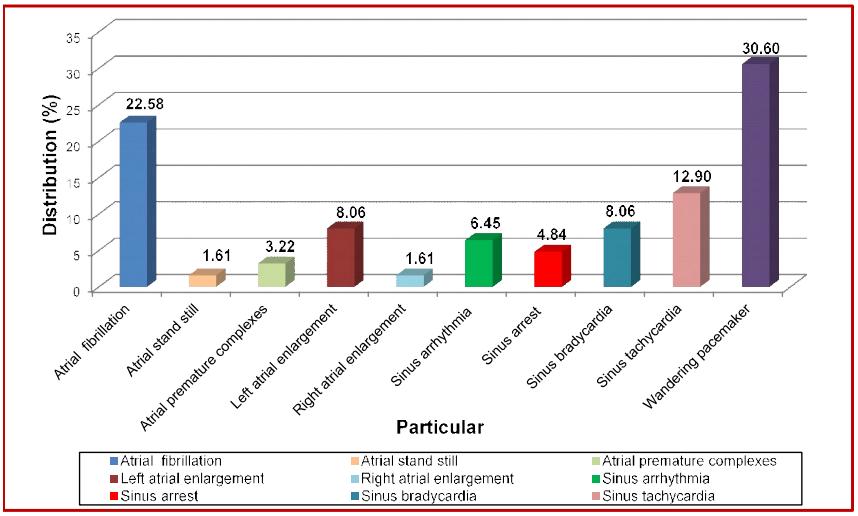

Fig 1: Supraventricular abnormalities in dogs with cardiac disorders.

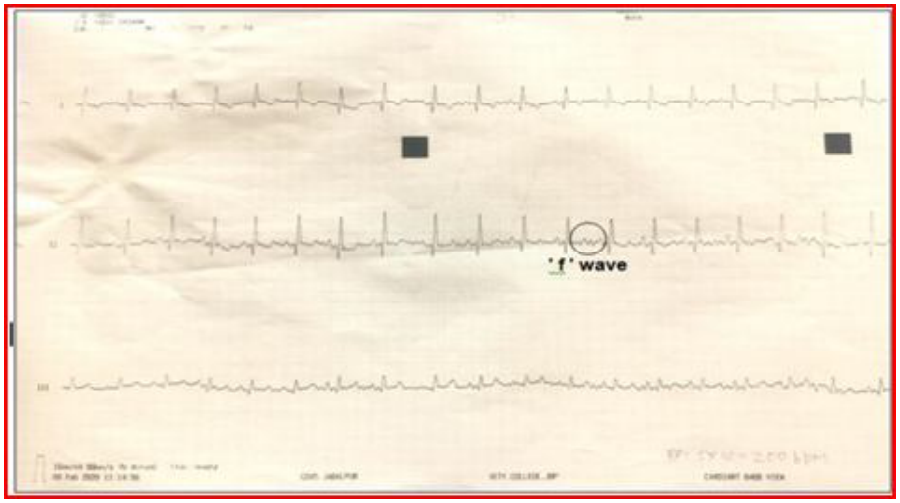

Fig 2: Electrocardiogram of a 6 year old male Beagle dog showing atrial fibrillation and sinus tachycardia with heart rate 250 bpm.

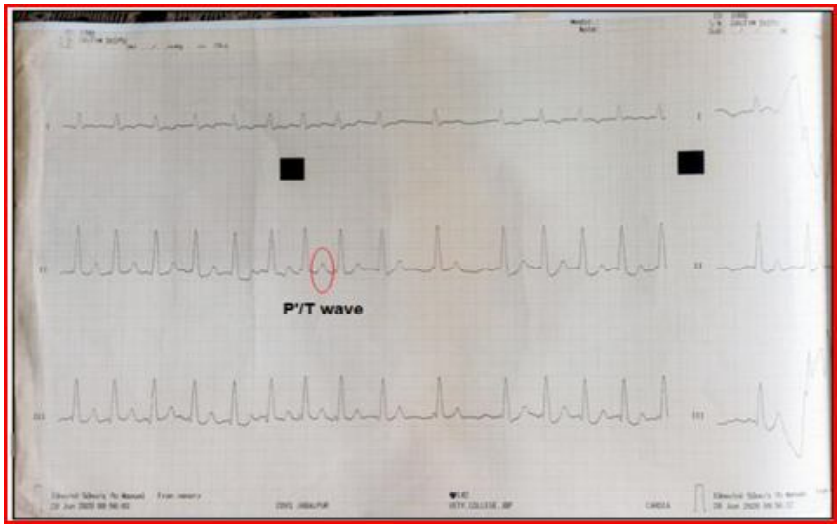

Fig 3: Electrocardiogram of a 3.5 year old male Labrador dog showing atrial premature complex (The upright P-wave is superimposed on the previous T-wave).

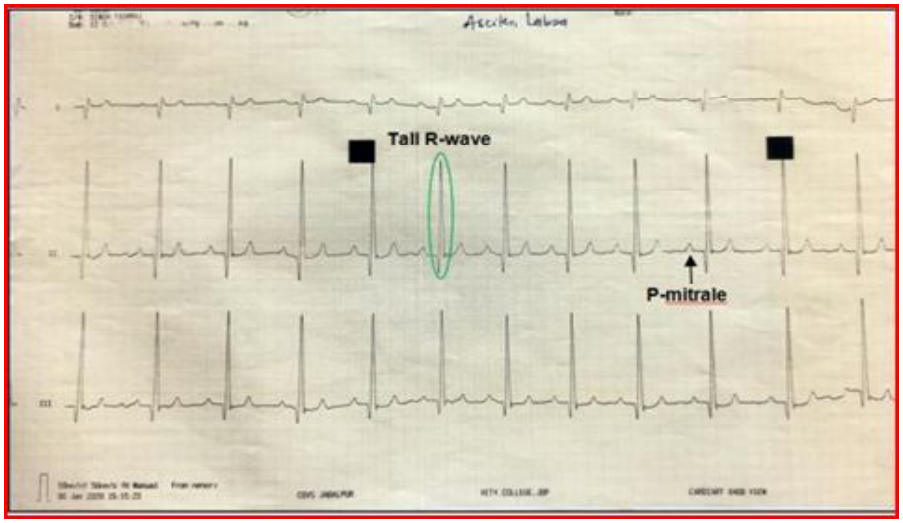

Fig 4: Electrocardiogram of a 9 year old female Labrador dog showing left atrial enlargement (P-mitrale; P_{dur} >0.04 sec) and left ventricular enlargement (Tall R-wave; R_{amp} 4.0 mV).

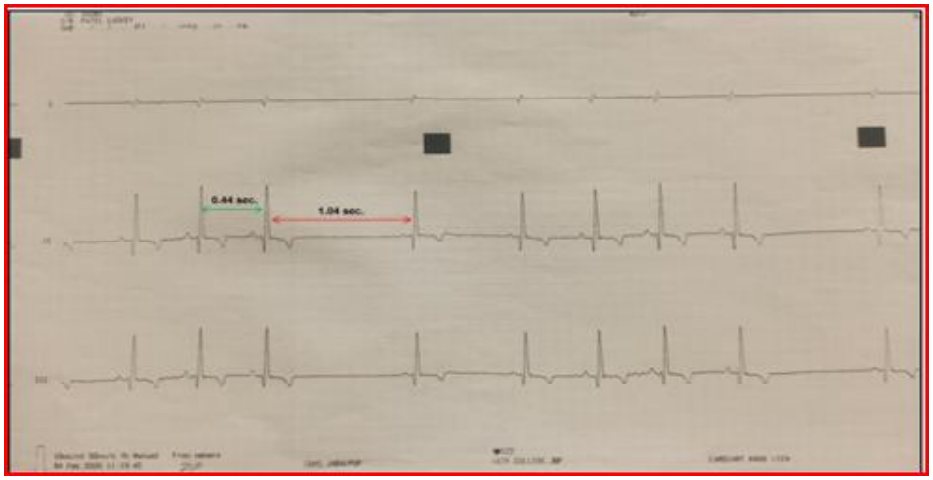

Fig 5: Electrocardiogram of a 5 year old male German Shepherd dog showing sinus arrest (pause > 2 normal R-R interval).

standstill may be due to hyperkalemia which is similar to the report of Jeyaraja *et al.* (2004).

Atrial premature complexes were diagnosed by ectopic premature P waves, which were superimposed on the previous T wave (Fig 3) and its configuration was different from normal sinus P waves. Atrial premature complexes arise from ectopic foci in the atria and may lead to atrial fibrillation/ tachycardia. These complexes can be of normal variation in geriatric dogs. The impulse that spread through the atrium to the atrioventricular node fails to reach to ventricles (Kumar, 2013). On examination of electrocardiogram, P wave was recorded as an abnormal shape *i.e.* premature and may be "buried" or superimposed on preceding T wave (Dhanapalan, 2003). Similar findings were also reported in other studies as 3.13% (Priyanka, 2012) and 8.69% (Singh, 2013).

Left atrial enlargement was recognized as P-mitrale by increasing the duration of P wave or wide P wave *i.e.* more than 0.04 second (Fig 4). Mitral valve disease leads to haemodynamic problems to the left atrium that injures and destroys some cells. The increased volume load and/ or pressure lead to cellular hypertrophy and atrial dilatation which results in the death of some atrial cells with replacement (fibrosis). P mitrale could be seen in chronic mitral valve insufficiency and DCM (McEwan, 2000). Right atrial enlargement was diagnosed as P- pulmonale by increase amplitude of P wave (more than 0.4 mV). Tall P waves are referred to as P- pulmonale (as right atrial enlargement may be associated with cor pulmonale; more than 0.4 mV) (Tilley, 1985 and Mike, 2007). The results similar to our study are also reported by Kumar (2012) as 3.03% in dogs.

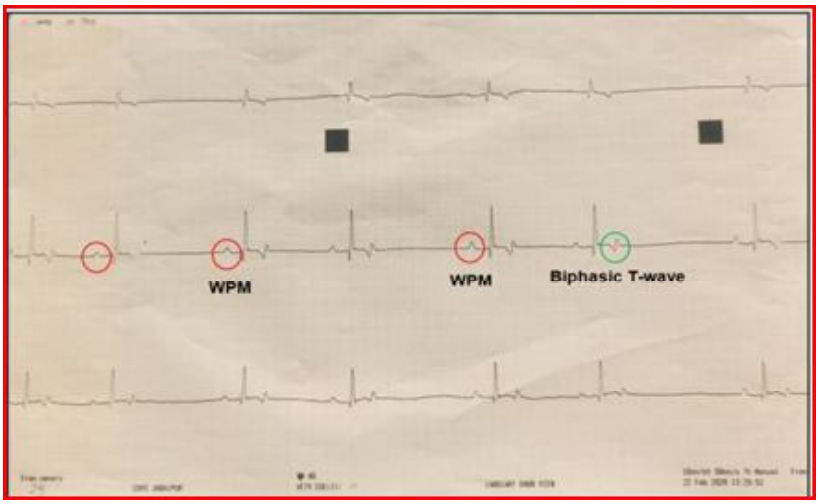

Fig 6: Electrocardiogram of a 4 year old female German Shepherd dog showing wandering pacemaker (gradual and temporary change in the configuration of P-wave) and biphasic T-wave.

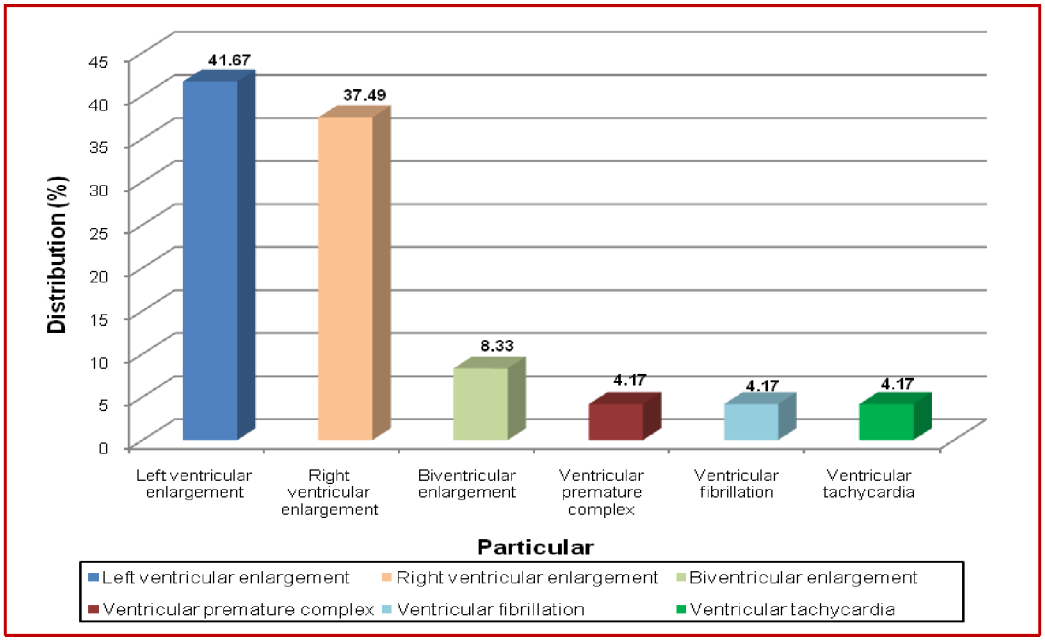

Fig 7: Ventricular abnormalities in dogs with cardiac disorders.

Sinus arrest (sinoatrial block) was identified by the irregular rhythm with a pause or a lack of P-QRS-T complexes. The pause was double or greater than doubles of the normal R-R interval (Fig 5). The characteristics features of sinus arrest were variability of R-R interval that was twice of the normal preceding R-R interval as in this study, agreeing with the findings of Changkija (2007). A similar finding of sinus arrest was also reported by Singh (2013). Sinus arrhythmia was recognized by the normal P wave, QRS complex and PR interval whereas sinus bradycardia was diagnosed as a heart rate less than 70 bpm in small breeds or less than 60 bpm in giant breeds with regular sinus rhythm. Sinus tachycardia was recognized as a normal sinus rhythm with a heart rate above 160 bpm in giant breeds and above 180 bpm in toy breeds. The findings of present study are in agreement with the findings of Kumar *et al.* (2014) who reported sinus bradycardia and sinus tachycardia as 6.09% and 7.30%, respectively. Similar findings have also been recorded by various other workers as sinus arrhythmia is one of the most common forms of arrhythmia in young animals (Varshney and Tiwari, 2002; Changkija *et al.*, 2006).

A wandering pacemaker (WPM) was identified by gradual change in configuration of the P wave (Fig 6) without changing its polarity (due to shifting of pacemaker within the SA node). Shifting of the pacemaker causes a gradual change in the configuration of the P wave, which becomes positive, biphasic, isoelectric and negative. A wandering pacemaker was characterized by a 'P' wave of varying amplitude and morphology. It is a common non-pathological condition in dogs. The finding of Kumar (2012) is contrary to our findings who recorded wandering pacemaker in one dog (1.51%) and Jafari *et al.* (2011) reported 5.1%.

Ventricular abnormalities in dogs with cardiac disorders

On electrocardiographic examination of affected dogs, different types of ventricular alterations were recorded *i.e.* left ventricular enlargement, right ventricular enlargement and biventricular enlargement as 41.67%, 37.49% and 8.33%, respectively. However, ventricular premature complex (VPCs), ventricular fibrillation and ventricular tachycardia were recorded in the same frequency (4.17%) in dogs suffering from cardiac disorders. Results are summarized in Fig 7, 8, 9, 10 and 11.

Right ventricular enlargement was recognized by deep Q wave (amplitude; greater than 0.7 mV, Fig 8) and deep S wave (more than 0.35 mV) in lead II. Left ventricular enlargement was identified by ST coving (displacement of the ST segment in the opposite direction of QRS deflections, Fig 9). In volume overload both wall thickness and cavity size increases; wall thickness may be only moderately increased but the cavity size is the main dimension contributed to ventricular muscle mass. Due to increased muscle mass in hypertrophy or enlargement the height of the R wave is increased, the QRS complex is delayed or altered in conduction, the ST segment is depressed *i.e.* endocardial ischaemic change. These myocardial ischaemic changes may be due to neoplasia, renal disorders, blood parasites, immune mediated haemolytic anaemia, myocardial infarction and mitral valve insufficiency (Mahendran *et al*., 2021). Sarita (2008) and Kumar *et al.* (2011) also documented ST coving 8.3% and 3.91%, respectively. The findings of biventricular enlargement (Fig 11) of the present study are similar to Tilley (1985) and Kumar (2012) and characterized either by the presence of a tall 'R' wave (left ventricular enlargement; Fig 4) and deep 'Q' wave (right ventricular enlargement) or deep

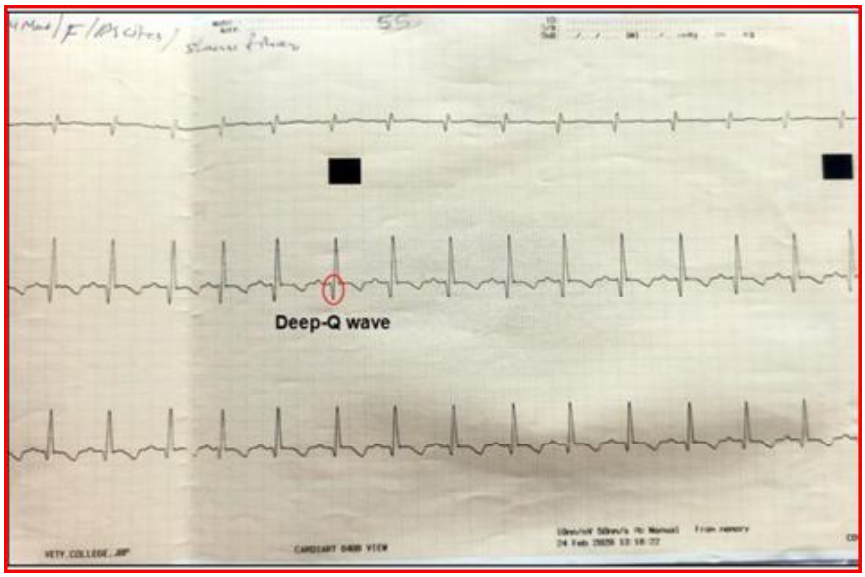

Fig 8: Electrocardiogram of a 1.5 year old female Great Dane cross dog showing deep Q-wave (0.7 mV amplitude; suggestive of right ventricular enlargement).

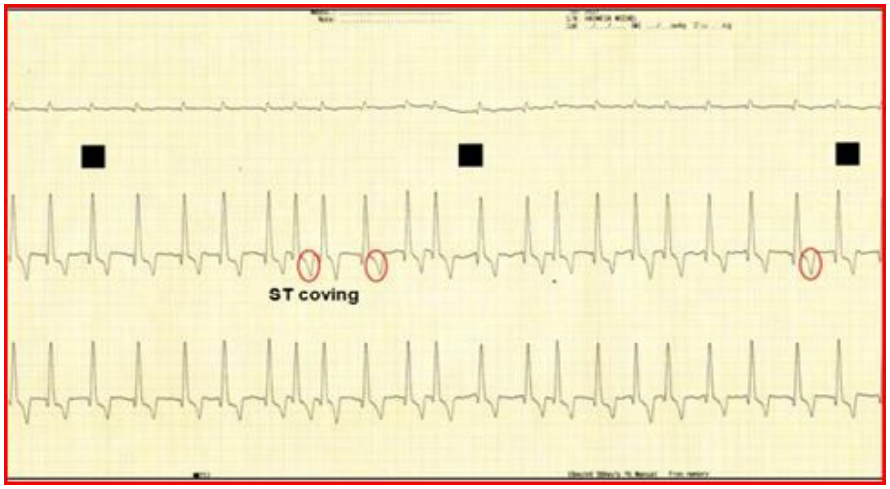

Fig 9: Electrocardiogram of a 2 year old male Boxer dog showing ST coving suggestive of left ventricular enlargement (A case of Dilatedcardiomyopathy).

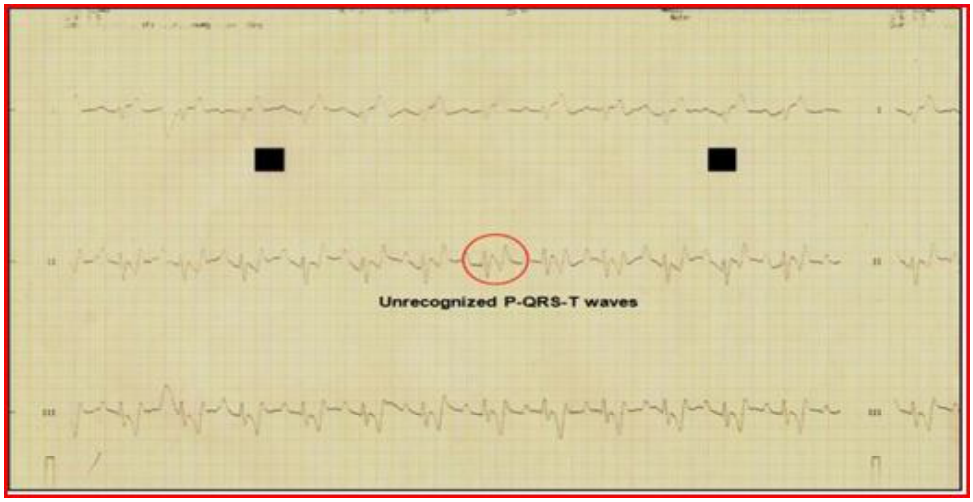

Fig 10: Electrocardiogram of a 9 year old female French Mastiff dog showing ventricular fibrillation (P-wave, QRS complex and T-deflection cannot be recognised; A case of DCM).

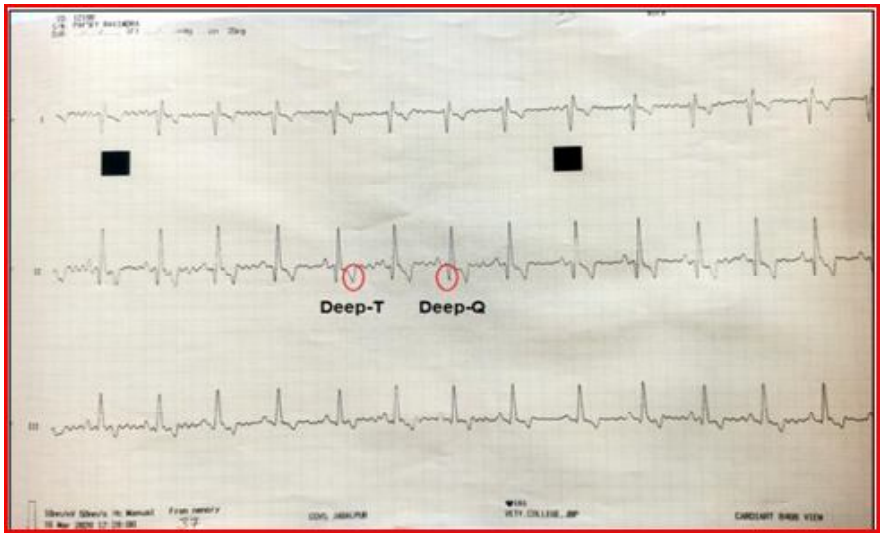

Fig 11: Electrocardiogram of a 2.5 year old female German Shepherd dog showing biventricular enlargement deep Q-wave (right ventricular enlargement) and deep-T wave (left ventricular enlargement).

Q-wave (right ventricular enlargement) and deep-T wave (left ventricular enlargement).

Ventricular premature complexes (VPCs) were recognized by the premature, bizarre and large amplitude of the QRS complex with irregular rhythm and the T wave is directed opposite to the QRS complex. Gupta *et al.* (2005) documented ventricular premature complexes with bizarre QRS complexes in dogs suffering from congestive heart failure. Similar findings of VPCs 2.08% and 6.41% were reported by Kumar *et al.* (2011) and Varshney *et al.* (2013), respectively. Our findings are contrary to Knight (1999); who found that the VPCs were ubiquitous; however, Tilley (1985) reported incidence of VPCs as high as 26% to 45%. Ventricular premature complexes originate from the ventricles and are commonly seen in chronic mitral valve insufficiency and dilated cardiomyopathy.

Ventricular fibrillation was diagnosed by rapid heart rate with irregular, chaotic and bizarre waves. The P waves, QRS and T deflections were unrecognized (Fig 10). Varshney *et al.* (2013) documented the prevalence rate of ventricular fibrillation (0.98%) and ventricular tachycardia (2.76%) similar to our study. Ventricular tachycardia was recognized by a wide and bizarre pattern of QRS complex with a rate more than 120 bpm, however, the normal configuration of P waves.

CONCLUSION

Cardiac disorders are often fatal and/or silent killers in dogs. In our country, in the majority of cardiovascular disorders, there is a frequent omission by clinician and client due to lack of awareness. However, any cardiac abnormality requires to be dealt with top priority to avoid morbidity and mortality in the dog population. Electrocardiography is a useful non-invasive tool for the diagnosis of various cardiac conduction anomalies.

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