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Electrocardiographic Investigations of Anaemia in Domestic Cats of Kerala: A Prospective Study

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ABSTRACT: Anaemia is a frequently encountered hematologic disorder in felines, with potential systemic consequences that extend to cardiovascular function. Despite its occurrence, studies on the specific electrocardiographic (ECG) alterations associated with feline anaemia remain scarce. This study aims to investigate ECG changes in anaemic cats and to evaluate the relationship between the severity of anaemia and cardiac electrophysiological abnormalities. Sixteen anaemic cats were prospectively evaluated and classified based on volume of packed red cells (VPRC) into mild (VPRC 18-24 %) and severe (VPRC <18 %) anaemia groups. Standard six-lead ECGs were analysed for heart rate, P wave morphology, QRS complex amplitude and duration, QT interval, T wave and ST segment changes and arrhythmias. The most common abnormalities included ST segment depression (50 %), sinus tachycardia (>220 bpm, 37.50 %), increased R-wave amplitude (up to 1.0 mV) and T wave changes. ST segment changes and left ventricular hypertrophy-like (LVH) patterns were more prevalent in mildly anaemic cats, while severe anaemia was associated with more frequent T wave changes and tachycardia. Conduction intervals remained within reference limits. These findings suggest that anaemia causes subtle but consistent ECG alterations in cats, underscoring the value of ECG as a non-invasive tool for early detection of cardiac abnormalities in anaemic cats.

KEYWORDS: Cardiac remodelling, feline anaemia, ECG changes, electrophysiology

I. INTRODUCTION

Anaemia is a common haematologic disorder in cats, often resulting from infectious diseases, blood loss, haemolysis, chronic diseases or bone marrow suppression. While the systemic effects of anaemia are well-documented, its impact on cardiac electrophysiology in cats remains underexplored.

The primary effects of anaemia include a reduced ability of the blood to carry oxygen, resulting in tissue hypoxia and decreased blood viscosity due to drop in red cell mass (Fowler and Holmes, 1964). Most clinical symptoms arise from the attempts of body to compensate for this lack of oxygen, particularly through changes in cardiovascular and respiratory function. The mechanisms include increased heart rate, increased cardiac output and peripheral vasodilation.

However, these compensatory mechanisms can lead to cardiac overload and structural changes in the heart, particularly in severe or chronic cases.

The way anaemia presents can vary based on how quickly it develops, its severity, the patient's age and how well their cardiovascular system can adapt (Shashikala *et al.*, 2014). One of the most prominent effects of anaemia on the heart is a hyperdynamic state, even at rest. This may lead to a mismatch between the oxygen supply and demand in the heart muscle, resulting in ischaemia or even infarction in severe cases (Shander *et al.*, 2004). Fortunately, these cardiac changes can often reverse quickly once the anaemia is partially corrected (Kapil and Bhadoria, 2014).

Cardiovascular symptoms due to anaemia can sometimes resemble signs of an underlying heart disease. In patients with existing cardiac or coronary issues, severe anaemia may worsen heart failure or coronary insufficiency. That is why it is important to assess and correct anaemia well before fully evaluating the severity of any cardiac condition, where anaemia may be a major contributor to the clinical picture.

This study aims to characterise the ECG changes associated with varying degrees of anaemia in cats and to evaluate the correlation between anaemia severity and cardiac conduction abnormalities, if any.

II. MATERIALS AND METHODS

A prospective observational study was conducted on selected sixteen anaemic cats, aged between 8 months to 5 years, presented to the Teaching Veterinary Clinical Complex, College of Veterinary and Animal Sciences, Pookode, during the period of September 2024 to June 2025. The study included patients presented to the medicine out-patient unit who were clinically diagnosed with anaemia of any etiology, provided they met the inclusion criteria of haemoglobin (Hb) less than 8 g/dL and VPRC less than 24 per cent (Aiello *et al.*, 2016). Subjects were selected using a simple random sampling method. Cats were stratified based on the VPRC into mild (18-24%) and severe (less than 18%) anaemia groups. Standard six-lead ECG recordings were analysed for heart rate, P wave morphology, QRS complex duration, QT interval, ST segment deviations and arrhythmic events.

The exclusion criteria consisted of cats with pre-existing cardiac conditions, congenital heart defects, hypertension, thyrotoxicosis and systemic disorders known to influence cardiovascular function, such as renal diseases.

Electrocardiographic recordings were performed on the selected animals using standard bipolar limb leads, in accordance with the methodology outlined by Martin (2015) with a Welch-Allyn CP-150 machine. Flattened alligator clip surface electrodes were affixed to the skin at the caudal aspect of the forelimbs near the olecranon and at the cranial aspect of the hindlimbs over the patellar ligaments. Surgical spirit was used to ensure optimal electrical conductivity with the skin. Recordings were made in right lateral recumbency (Harvey *et al.*, 2005). Each cat was restrained with the forelimbs positioned perpendicular to the body's long axis, while the hindlimbs were maintained in a semi-flexed posture. All cats were fully conscious and not subjected to any chemical restraint. ECG recordings were obtained at a paper speed of 25 mm/s with a vertical calibration of 10 mm/mV. ECG trace analysis was performed for each recording by selecting multiple (typically five) representative complexes, measuring the relevant parameters and calculating the average for each (Varshney, 2020).

III. RESULTS

Out of the sixteen cases, seven (43.75 %) were males and nine (56.25 %) were females and the average age of the group was 3.07 years. The mean heart rate was 196 bpm (range 168-224 bpm), slightly above the reference mean of 190 bpm (Nelson and Couto, 2019), reflecting a compensatory tachycardic response. Changes observed in the ECG are shown in Table 1 and 2.

Table 1: Gender-wise data on ECG changes in anaemic cats

ECG Findings	Male	Female	Total
Sinus tachycardia (> 220 bpm)	2/7	4/9	6/16
T wave changes	1/7	2/9	3/16
ST segment changes	5/7	3/9	8/16
Left ventricular hypertrophy (LVH)	2/7	3/9	5/16

Table 2: Classification based on severity of anemia

Type of anaemia	Sinus tachycardia	T wave changes	ST segment changes	LVH
Mild (n = 10)	3/10	0/10	6/10	3/10
Severe (n = 6)	3/6	3/6	2/6	2/6

Table 1 presents the gender prevalence of ECG abnormalities observed in anaemic cats. ST segment depression was the most frequent finding (50 %), followed by sinus tachycardia (37.5 %) and signs suggestive of left ventricular hypertrophy (31.25 %). T wave changes were observed in 18.75 per cent of the cases.

Analysis based on anaemia severity (Table 2) revealed that the mildly anaemic group (n = 10) exhibited more frequent ST segment changes (60%) and LVH-like patterns (30%), while the severely anaemic group (n = 6) showed a greater proportion of T wave changes (50%) and sinus tachycardia (50%). This indicates a possible trend where chronicity in mild anaemia contributes to compensatory structural cardiac adaptations, while severe anaemia presents with more acute or severe myocardial hypoxia and electrophysiological stress markers (Wilson *et al.*, 2010).

A mild but consistent increase in R-wave amplitude (up to 1.0 mV) was noted in several cats. This may hint at early myocardial compensation or chamber enlargement, but it's subtle. PR, QT and QRS durations remained within reference limits for all cats, indicating no conduction delay or complex arrhythmias were identified.

IV. DISCUSSION

This study highlights that feline anaemia, even in the absence of overt clinical cardiac disease, can result in subtle but clinically relevant ECG changes, most importantly ST segment depression, mild increases in R-wave amplitude and occasional T wave abnormalities. These ECG changes can be patho-physiologically attributed to hypoxic myocardial stress and chronic volume overload, both of which are hallmarks of anaemia-induced cardiovascular compensation.

Sinus tachycardia is an expected physiological response to anaemia, as increased cardiac output is required to tackle the reduced oxygen-carrying capacity (Shashikala *et al.*, 2014). This mechanism, although effective in the short term, can contribute to myocardial stress if sustained, particularly in small animals. The higher occurrence of tachycardia in severely anaemic cats (50 %) supports this theory.

The ST segment depression observed in over half the cases aligns with literature in other species where ST changes are often associated with subendocardial ischemia (Biradar *et al.*, 2020). In the feline myocardium, where coronary reserve is already limited, even mild anaemia may reveal underlying ischemic susceptibility, especially under stress (Cofaru *et al.*, 2024).

T wave changes, limited to severely anaemic cats, may represent abnormal repolarisation dynamics secondary to acute hypoxia or electrolyte shifts, possibly mediated by changes in myocardial potassium channels (Shashikala *et al.*, 2014).

The observed increase in R-wave amplitude, although subtle, may reflect early myocardial hypertrophy or preload-induced chamber dilation, consistent with findings in volume-overload states (Santilli *et al.*, 2019). Notably, all cats retained normal PR, QRS, and QT intervals, indicating preserved conduction system function despite systemic anaemic stress (Champion *et al.*, 2011). This supports the idea that changes in ECG wave amplitudes are more likely the result of shifts in heart muscle excitability or changes in chamber dimensions, rather than a true delay in the heart's electrical conduction. However, this is in contrast to studies in dogs where anaemia has been shown to prolong P wave and QT intervals (Thakur and Thakur, 2018). The absence of such findings in this study may reflect species-specific differences, a relatively small sample size, or milder degrees of systemic compensation.

Another noteworthy point is that more ECG abnormalities were detected in the mildly anaemic group than in the severe group, possibly due to the chronicity of disease in mildly anaemic cats, allowing time for cardiac remodelling. In contrast, severe anaemia could represent more acute decompensation, with less time for overt ECG adaptations to manifest.

The limitations of current study include relatively small sample size, which may limit the generalisability of its findings. Echocardiographic study was not performed, which restricts the ability to correlate the ECG changes with structural or functional cardiac abnormalities; and the study included anaemia of mixed etiologies, which may have introduced variability in the degree and duration of myocardial involvement.

V. CONCLUSION

The findings of this study highlight the value of ECG as a non-invasive monitoring tool in anaemic cats, particularly to detect early cardiovascular stress. While echocardiography remains the gold standard for structural evaluation, routine ECG could offer early warning signs of myocardial involvement, especially in chronic anaemic cases or where echocardiography is not immediately available. Early detection of cardiac involvement can guide timely intervention and improve clinical outcomes.

Future studies should aim to correlate ECG changes with serum biomarkers (e.g., NT-proBNP, troponin I) and echocardiographic parameters to establish more robust clinical predictive models.

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