RESEARCH ARTICLE

Clinico-Haemato-Biochemical and Electrocardiographic Alterations in Gastro-Intestinal Tract Affections of Cats with Special Reference to Electrolyte Imbalance

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Abstract

Considering importance of electrolyte imbalance, the present study was carried out to report electrocardiographic changes and it's correlation with electrolyte imbalance in gastro-intestinal (GI) tract affections of cats from February to August, 2025. Of the 227 fresh cases, 27 were suspected for gastro-intestinal tract affections and 13 were confirmed with overall incidence of 5.73% (13/227). All haematological parameters showed non-significant variation between diseased and healthy cats. Among the biochemical parameters studied, the values of AST and ALT in affected cats were comparatively higher than the healthy cats, but within the normal range. Other parameters such as total protein, albumin, globulin and A: G ratio varied non-significantly. The values of BUN (33.58±5.45 mg/dL) and creatinine (1.19±0.09 mg/dL) were significantly higher in cases of GI tract affected than healthy cats. During the present study, the values of sodium (138.77±2.82 mEq/L) and calcium (8.68±0.32 mg/dL) in cats with GI tract affections were significantly lower than healthy cats (154.20±2.46 mEq/L & 9.98±0.37 mg/dL). Whereas, the values of potassium and chloride varied non-significantly in cats with GI tract affections compared to healthy cats. Among the electrocardiographic parameters, the values of P wave amplitude (mV), QRS duration (sec), T wave amplitude (mV) and QT Interval (sec) were significantly higher in cats with GI tract affected than the healthy cats. ECG changes reported were prolonged QT interval (6/13), normal sinus rhythm (6/13), prolonged PR interval (3/13), widened QRS complex (3/13), peak T wave (1/13) and ventricular premature complex (VPC) (1/13). Significant negative correlations between potassium and QRS duration, calcium and ST segment duration, and chloride and T wave amplitude were observed in cats with GI tract affections.

Key words: Cats, Electrocardiograph, Electrolyte imbalance, GIT affections.

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Introduction

With the first domestication of cats by the Egyptians around 5,000 years ago, the domestic cats with often unpredictable temperament have become the most popular pets worldwide, surpassing even dogs, traditionally regarded as man's best friend (Serpell, 2000). Domestic cats are frequently exposed to various stressors that can adversely affect their welfare and elicit a range of behavioural abnormalities related to gastrointestinal, hepatic and urinary tracts disorders (Buffington, 2002). While cardiac diseases are commonly associated with arrhythmias in cats, several non-cardiac factors may also precipitate ventricular arrhythmias, including electrolyte imbalances, hyperthyroidism, severe anaemia, hypovolaemia, hypoxia, intra-abdominal pathology and altered sympathetic nervous system activity (Bartoszuk *et al*., 2019). Electrolytes play a crucial role in numerous physiological processes, including cardiac and neural impulse conduction, regulation of fluid and acid-base balance, and skeletal muscle contraction. Disturbances in major electrolytes such as sodium, potassium, chloride and magnesium can result in serious and potentially fatal consequences in animals (Thorp and Liss, 2016). Early detection of severe arrhythmias, electrolyte disturbances and conduction defects facilitates accurate diagnosis of cardiac disorders and allows timely therapeutic intervention, thereby improving the quality of life in cats with cardiac disease. Electrocardiographic (ECG) evaluation can demonstrate characteristic changes that may suggest underlying electrolyte imbalances even prior to their confirmation by laboratory investigations (Varshney, 2020).

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Being a rapid and non-invasive procedure, an ECG is often used as an initial diagnostic tool for detecting cardiac arrhythmias. It can also provide information on the enlargement of the heart's chambers. It is now widely acknowledged as an essential component of a dog or cat's heart assessment. Specifically, the electrocardiogram can identify the origin of the rhythm and the frequency of impulse generation, making it effective for diagnosing most cardiac arrhythmias. ECG alterations often influenced by pathological or physiological conditions can offer critical information about the functional status of the myocardium. Considering the effects of electrolyte imbalance on ECG, the present studies on clinico-haemato-biochemical and electrocardiographic alterations in gastro-intestinal tract affections of cats were planned with special reference to electrolyte imbalance.

Materials and Methods

The present study was carried from February to August, 2025 in Department of Veterinary Medicine in collaboration with Veterinary Clinical Complex and Department of Veterinary Physiology and Biochemistry, College of Veterinary Science and Animal Husbandry, Kamdhenu University, Navsari (Gujarat, India). Initially, cats presented at Veterinary Clinical Complex (VCC) irrespective of age, breed and sex having signs of gastro-intestinal tract affections were included in the study. Further, detailed clinical examinations and other diagnostic procedures were performed in 13 cases and compared with the healthy (n=6) cats.

For haemato-biochemical evaluation, approximately 2-3 mL of whole blood was collected from suspected cases. Blood samples intended for haematological analysis were collected in vacutainers containing K_2EDTA and processed in fully automatic blood cell counter. For biochemical analysis, blood samples were collected in vacutainers with a serum clot activator and allowed to clot for 20-30 min, centrifuged for 10 min and harvested serum samples were stored at –20 °C until further the estimation of various biochemical parameters using commercially available diagnostic kits in semi-automatic biochemical analyzer.

All the suspected cats were subjected to routine electrocardiography using BPL Cardiart 6208 view plus ECG unit. The ECG recordings were obtained using standard limb leads at paper speeds of 50 mm/s and 25 mm/s and interpreted as per guidelines given by Tilley *et al*. (2008). Each recording was performed with the cat positioned in right lateral recumbency on a non-conductive surface with the leads being connected proximal to the olecranon process on the caudal aspect of both forelimbs and over the patellar ligament on the cranial aspect of both hind limbs, following the application of an adequate amount of conducting gel to enhance signal transmission. ECG was interpreted as per the standard interpretation protocols. Further, the faecal samples were screened for parasitic ova by direct smear method/ sedimentation technique (Soulsby, 1982).

Descriptive statistical analysis was applied to various parameters, calculating the mean ± Standard Error (SE). Vital parameters, haematological, biochemical and electrocardiographic parameters were compared with healthy cats using student T-test in IBM SPSS statistical software version 20.0 as per method described by Snedecor and Cochran (1994). Further, Bivariate Pearson's Correlation test was used to establish the correlation of various electrocardiographic parameters with important biochemical parameters at $p \leq 0.05$ in IBM SPSS statistical software version 20.0.

Results and Discussion

Incidence of GI Tract Affections

During the study period, total 426 cases of cats were registered at Veterinary Clinical Complex for medical treatment. Of which, 227 cases were fresh cases and the rest were as follow up cases. Among 227 fresh cases, 27 were suspected for gastro-intestinal tract affections. Out of which, 13 cases were identified as of GI tract affections with overall incidence of 5.73% (13/227). This is in partial accordance with results of Dokuzeylul *et al*. (2016) and Arsevska *et al*. (2017), who reported 5.0% and 2.2% overall incidences of digestive disorders, respectively. Still higher incidences of digestive disorders (12-28%) were reported by Sarker *et al*. (2015) and Nguyen and Nguyen (2025). During the study, the hospital based incidence of gastro-intestinal tract affections was 48.15% (13/27). Previously, Kouamo *et al*. (2021) and Indarjulianto *et al*. (2022) had reported 58.3% and 61.0% incidence of gastro-intestinal tract affections in cats, respectively. The disparity in incidences of gastro-intestinal tract affections might be due to differences in the geographic area, diet, popular breeds of cats in each country and duration of sample collection (Kouamo *et al*., 2021).

In the present study, higher incidence of gastro-intestinal tract affections was observed in age group 1 to 3 years (92.31%, 12/13) followed by 3 to 6 years (07.69%, 1/13). Earlier, Kouamo *et al*. (2021) reported higher incidence of diseases in young cats less than 1 year (75.5%) followed by adult cats 1 to 2 years (13.7%) and old cats greater than 2 years (10.9%). Sarker *et al*. (2015) also reported the highest incidence (42.67%) in young cats than old cats. Dokuzeylul *et al*. (2016) reported the age wise incidences of 24.1% in cats less than 1 year, 20.45% in cats between 1 to 3 years, 16.36% in cats between 3 to 6 years, 29.09% in cats between 6 to 10 years and 10% in cats between 10 to 15 years of age. The higher incidence in young cats is possibly related to lower immunity as compared to adult cats.

During the study, comparatively higher incidences of GI tract affections were noticed in males (53.84%, 7/13) than in females (46.16%, 6/13) cats. Previously, Dokuzeylul *et al*. (2016), Kouamo *et al*. (2021) and Indarjulianto *et al*. (2022) also reported higher incidence of GI affections in male cats than female cats, whereas Da Silva *et al*. (2018) reported higher incidence in female cats (57.5%) than in male cats (42.5%). The

higher incidence in male cats might be due to wider roaming area of male cats that makes male cat exposed to infectious agents easily (Hansen, 2010). The prevalence was identical in Persian and Domestic short hair cats (6 case each, 46.15%) with one case in Russian blue cat (7.70%).

Clinical Signs and Vital Parameters in Cats with GIT Affections

The major clinical signs of gastro-intestinal tract affections in cats were inappetence/anorexia (76.92%), dehydration (69.23%), vomiting (61.54%), dullness and depression (53.85%), diarrhoea (38.46%), pyrexia (23.08%), constipation (23.08%) and cervical ventroflexion (7.70%), which concurred with Sobieh *et al*. (2024) and Nguyen and Nguyen (2025). Further, Da Silva *et al*. (2018) also reported vomiting (82.5%), diarrhea (35%) and constipation (10%) as important clinical signs in cats with GI tract affections.

The mean ± SE of rectal temperature and respiration rate in cats with GI tract affections varied non-significantly within the normal range as compared to healthy cats, whereas the heart rate was significantly higher in affected cats than the healthy cats (171.92±12.78 vs. 131.00±2.63 beats/min). Dishow *et al*. (2024) reported that increased temperature (40.20°C), respiratory rate (58.8 /min) and heart rate (154.7 /min) in cats infected with feline panleukopenia in early acute stage of disease, which were decreased in later stages (temperature 35.70°C; respiratory rate 23.5 /min; heart rate 67.9/min).

Haemato-Biochemical and Electrolytes Imbalance

All haematological parameters in cats with gastro-intestinal tract affections varied non-significantly within their normal ranges as compared to healthy cats (Table 1). Earlier, Kadam *et al*. (2022) reported non-significant decrease in Hb, RBC, PCV, MCV, MCH and MCHC in cats with feline panleukopenia, whereas, total leukocyte count, neutrophils and lymphocytes were significantly decreased and monocytes were relatively increased.

Among various biochemical parameters studied, the values of ALT, BUN and creatinine were significantly higher in cats with gastro-intestinal tract affections than healthy cats. Other parameters such as total protein, albumin, globulin and A: G ratio varied non-significantly (Table 1). Junckes *et al*. (2020) observed increased urea (100 mg/dL), creatine kinase level (280 U/L) and less consistently increased AST (47 U/L) in anorectic cats. While, studying clinical, haematological and biochemical changes in cats affected with infectious diseases such FPL/CPV and feline infectious peritonitis, various scientists found hypoproteinemia with a significant increase of AST, ALP, BUN and creatinine as compared to healthy cats (Singh *et al*., 2023; Al-Autaish *et al*., 2024; Dishow *et al*., 2024). Further, Sobeih *et al*. (2024) also found significantly elevated total protein, globulin, ALT, ALP, AST, urea and creatinine in viral, bacterial and parasitic enteritis.

During the study, the values of sodium and calcium were significantly lower in GIT affected cats than healthy cats, whereas the values of potassium and chloride varied non-significantly between them (Table 1). The finding of hyponatremia is in accordance with the results of Ueda *et al*. (2015), who reported hyponatremia in 8.7% and 30.4% of the cats with gastro-intestinal diseases and urological diseases, respectively. Similarly, Sobieh *et al*. (2024) reported decreased serum electrolytes (sodium, potassium, calcium, chloride) in cats with enteritis. The hyponatremia in gastro-intestinal diseases might be due to gastro-intestinal losses as a result of reduced intravascular volume, dehydration resulting from interstitial fluid loss or a combination of both conditions (Ueda *et al*., 2015; Kozat, 2020). Hoehne *et al*. (2019) reported that urinary tract diseases were strongly associated with moderate to severe hyperkalemia (97% of cats), whereas gastro-intestinal disorders were commonly linked to moderate to severe hypokalaemia (44% of cats). Hyperkalemia is mainly associated with impaired renal function and reduced potassium excretion, whereas, hypokalaemia primarily associated with decreased intake, transcellular shifts and excessive gastro-intestinal losses, with vomiting and diarrhoea being frequent causes (Hoehne *et al*., 2019).

Table 1: Haemat-Biochemical and eletrolyte parameters of cats with gastro-intestinal tract affections

Parameters	Healthy cats (n=6)	GIT affected cats (n=13)
Haemoglobin (g/dL)	10.72±0.46	12.04±0.85
TEC ($\times10^6$/µL)	09.75±0.79	08.59±0.57
TLC ($\times10^3$/µL)	09.40±1.19	11.05±2.46
Neutrophils (%)	69.17±2.44	65.69±4.48
Lymphocytes (%)	25.67±2.26	30.23±4.97
Eosinophils (%)	02.83±0.31	02.15±0.58
Monocytes (%)	02.33±0.33	01.85±0.45
Platelets (x10^5/µL)	03.06±0.61	02.96±0.53
MCV (fL)	37.53±2.51	42.42±1.22
MCH (pg)	13.25±0.54	14.07±0.53
MCHC (g/dL)	33.20±0.11	33.07±0.56
PCV (%)	33.18±1.26	36.49±2.44
ALT (IU/L)	31.70±3.29	56.32±6.95
AST (IU/L)	35.63±4.54	50.55±10.80
Total Protein (g/dL)	06.43±0.26	06.32±0.39
Albumin (g/dL)	03.16±0.17	02.72±0.10
Globulin (g/dL)	03.27±0.35	03.60±0.45
A:G ratio	01.08±0.21	00.87±0.09
BUN (mg/dL)	19.36^a±1.03	33.58^b±5.45
Creatinine (mg/dL)	00.83^a±0.07	01.19^b±0.09
Sodium (Na^+) (mEq/L)	154.20±2.46	138.77±2.82
Potassium (K^+) (mEq/L)	04.54±0.22	04.05±0.22
Calcium (Ca^{++}) (mg/dL)	09.98^a±0.37	08.69^b±0.326
Chloride (Cl^-) (mEq/L)	117.33±3.88	112.62±1.92

Means with different superscript (a, b) within a row differ significantly at p≤0.05.

Faecal Examination

Faecal examination was performed in cats with gastro-intestinal affections during the present study. Only single case

(1/13, 7.70%) was found positive for presence of *Anchylostoma* spp. eggs. Indarjulianto *et al*. (2022) also reported that 14% of the cats with digestive disorders had helminth infections that include *Ancylostoma* spp., *Toxocara* spp. and *Diphylidium* spp. Whereas, Vincy and Tresamol (2023) observed *Ancylostoma* spp. in 61% of the cats followed by *Toxocara cati* in 13.04%, *Isospora* spp. in 8.7%, *Diphyllobothrium latum* in 4.35% and mixed infection in 13% of the cats.

Electrocardiographic Changes

During the study, the values of P wave amplitude (mV), QRS duration (sec), T wave amplitude (mV) and QT Interval (sec) were significantly higher in cats with gastro-intestinal tract affections than the healthy cats (Table 2, Fig. 1a,b,c). Upegui

Table 2: Electrocardiographic parameters of cats with gastro-intestinal tract affections

Parameters	Healthy cats (n=6)	GIT affected cats (n=13)
P wave amplitude (mV)**	0.079^{a}±0.010	0.119^{b}±0.009
P wave duration (sec)	0.033±0.003	0.042±0.001
PR interval (sec)	0.068±0.003	0.076±0.003
R wave amplitude (mV)	0.417±0.038	0.402^{b}±0.061
QRS duration (sec)**	0.038^{a}±0.002	0.046^{b}±0.002
T wave amplitude (mV)*	0.071^{a}±0.010	0.113^{b}±0.015
QT Interval (sec)**	0.155^{a}±0.003	0.188^{b}±0.009
ST segment (sec)	0.063±0.004	0.068±0.004

Means with different superscript (a, b) within a row differ significantly at **p<0.01.

Fig. 1a: ECG of a cat representing prolonged QT interval

Fig. 1b: ECG showing widened QRS complex and prolonged QT interval

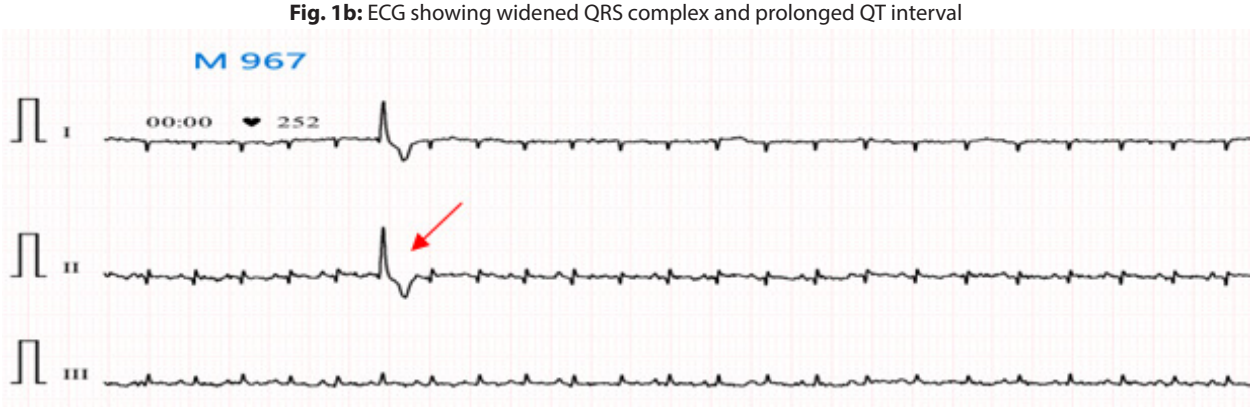

Fig. 1c: ECG showing ventricular premature complex in a cat

Table 3: Correlation of important biochemical parameters with electrocardiographic parameters in cats with gastro-intestinal tract affections

Parameters	P wave amplitude (mV)	P wave duration (sec)	PR interval (sec)	R wave amplitude (mV)	QRS duration (sec)	T wave amplitude (mV)	QT Interval (sec)	ST segment (sec)
BUN	0.184	0.535	-0.007	0.056	0.358	0.446	0.223	-0.212
Creatinine	-0.176	0.297	0.202	0.205	0.176	0.166	-0.077	-0.486
Sodium (Na^+)	0.172	-0.111	0.161	-0.189	-0.053	-0.203	0.347	0.174
Potassium (K^+)	0.105	-0.095	-0.169	0.175	**-0.611***	0.407	-0.386	-0.048
Calcium (Ca^{++})	-0.003	0.188	0.116	0.183	-0.306	0.097	-0.316	**-0.590***
Chloride (Cl^-)	-0.074	-0.287	-0.139	-0.263	-0.403	**-0.590***	0.076	0.097

*Indicates significant at p≤0.05, ** Indicates significance at p≤0.01

and Gómez, (2015) also reported QT interval prolongation in human patients with anorexia nervosa. They further stated QT interval serves as a measure of ventricular repolarization quality and any prolongation or increased dispersion of this interval is strongly associated with an elevated risk of ventricular arrhythmias and sudden cardiac death.

Among 13 cases, cats with gastro-intestinal tract affections showed prolonged QT interval (n=6), normal sinus rhythm (n=6), prolonged PR interval (n=3), widened QRS complex (n=3), peak T wave (n=1) and ventricular premature complex (VPC) (n=1) (Fig.1a,b,c). While studying electrocardiographic alterations in anorexic cats, Junckes *et al*. (2020) reported sinus rhythm, extended QT interval, increased T-wave sinus arrhythmia, VPC and increased R-wave amplitude.

Correlation of Electrolytes with ECG Parameters

In the present study, the values of serum electrolytes and important biochemical parameters were correlated with electrocardiographic parameters in cats with gastro-intestinal affections (Table 3). All positive and negative correlations between electrolytes, BUN & creatinine and electrographic parameters were having non-significant effects, except that the potassium level and QRS duration (r= -0.611), calcium with ST segment (r= -0.590) and chloride with T wave amplitude (r= -0.590) were significant and negative.

The significant negative correlation of potassium with QRS duration might be due to hypokalaemia. On negative correlation between potassium & QRS duration, Schaer (2008) stated that ECG changes noticed in hypokalaemic animals are prolonged QRS interval along ST segment depression; reduced, flattened or inverted T waves; the appearance of an elevated U wave (noted in human cases); increased amplitude of the P wave and prolonged PR which indirectly indicates negative correlation between potassium & QRS duration. Similarly, El-Sherif and Turitto (2011) mentioned decrease in conduction velocity, shortening of the effective refractory period, prolongation of the relative refractory period, increased automaticity, and early after depolarizations are electrophysiological effects of hypokalaemia. Further, they reported various ECG changes such as atrio-ventricular block; cardiac arrest; increase in P wave amplitude and duration; and slight prolongation of the PR interval along with increase in QRS duration without change in QRS configuration due to conduction abnormalities in advanced stages of hypokalaemia. The significant negative correlation of calcium with ST segment duration might be due to hypocalcaemia. This finding is in accordance with previous reports in which it was mentioned that hypocalcaemia can cause prolonged QT interval which is predominantly caused by ST segment elongation as calcium plays important role in excitation–contraction coupling that enables the function of cardiac myocyte (Dusky, 2001; Holowaychuk and Martin, 2007).

Conclusions

Cats with gastro-intestinal tract affections had significantly lower sodium and calcium values indicated loss of electrolytes in gastro-intestinal tract affections. Cats with gastro-intestinal tract affections showed prolonged QT interval, prolonged PR interval and widened QRS complex with occasional peak T wave and ventricular premature complex. The correlation of electrolytes, BUN, creatinine with ECG parameters in cats with gastro-intestinal tract affections showed significant negative correlations between serum potassium & QRS duration, calcium & ST segment duration and chloride & T wave amplitude.

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