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Electrocardiographic findings associated with hypokalemic syndrome in dairy cows

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Abstract
Hypokalemia is one of the most common electrolyte imbalances in dairy cattle, characterised by a low potassium content in the blood. Potassium is the most abundant electrolyte in the body and is required for appropriate muscle and nerve function. The present study was conducted on normal dairy cows with no cardiac arrhythmias and dairy cows presented to the Veterinary Clinical Complex, Veterinary College and Research Institute, Namakkal, Tamil Nadu with the history of anorexia from last three days, unable to stand, tachycardia, administration of isoflupredone acetate for ketosis treatment, abdominal distension, reduced dung output were screened for hypokalemia and the electrocardiographic alterations were recorded. The electrocardiogram was obtained on a single channel ECG machine with paper speed of 25 mm/sec and calibration of 10mm. The significant increase in "P" wave duration and significant decrease in "T" wave amplitude were observed.

Keywords: Hypokalemia, cardiac arrhythmia, electrocardiogram, dairy cow

Introduction
Electrocardiography is a clinical method of choice for evaluating cardiac abnormalities involving the generation and conduction of electric impulses, as well as a valuable tool for assessing electrolyte disorders (Cedeno *et al.*, 2016) [2]. Electrocardiography is a non-invasive, low-cost technology that provide an important information in the categorization of arrhythmias and diagnosis of conduction abnormalities in cattle. It was also used as prognostic indicator and therapeutic management of hypokalemia. The base apex lead was most appropriate lead system for monitoring the heart rhythm in dairy cows (Areshkumar *et al.*, 2018) [1]. Potassium is 98 percent intracellular. An intracellular potassium shift, a decrease in potassium intake and an increase in potassium output could lead to hypokalemia (Rastegar, 2011) and hypokalemia in cattle occurred secondary to anorexia, diarrhoea, upper gastrointestinal tract obstruction, right side displacement, torsion and impaction of the abomasum (Radostits *et al*., 2007) [5]. Weaver and Burchell (1960) [8] reported increased P wave duration and inversion of the T waves or notches in the T wave in hypokalemia. The present study was undertaken to document the electrocardiographic abnormalities in association with hypokalemia in dairy cows.

Material and Methods
Cows with anorexia, tachycardia, emaciation, chronic diarrhoea, recumbency, ruminal atony, and abdominal distension presented to the large animal medicine unit of Veterinary Clinical Complex, Veterinary College and Research Institute, Namakkal, Tamil Nadu were screened. They were subjected to detailed clinical and haemato-biochemical examination. After confirmation of hypokalemic syndrome cows were examined for electrocardiographic analysis. ECG were recorded according to base apex lead system, the positive electrode of lead I (left arm) was attached to the skin of the fifth intercostals space just caudal to the olecranon (Fig. 1) and negative electrode (right arm) on the jugular furrow about lower 1/3 of the right side of neck (Fig. 2), and earth was attached away from these two electrodes (Fig.3). The data

obtained were statistically analyzed (Snedecor and Cochran, 1994) [7].

Results

A total of 3887 cows were presented to Veterinary Clinical Complex, Veterinary College and Research Institute, Namakkal during from March 2022 to May 2023. Out of 3887 cows, a total of 227 cows (5.83%) were found to be affected with hypokalemia based on clinical signs and serum biochemistry. Out of 227 dairy cows, 118 dairy cows were selected for the study based on the subsequent presentation of dairy cows to the unit for the follow up. Hypokalemic syndrome in dairy cows was occurred due to the various etiologies such as theileriosis, recumbency, traumatic reticuloperitonitis, over use of isoflupredone acetate in ketosis, excessive administration of sodium bicarbonate in the treatment of ruminal lactic acidosis, ileus, botulism and abomasal displacement. Anorexia, dehydration, sternal or lateral recumbency, unable to lift head, s-shaped kinking of neck, distention of abdomen, tachycardia were the prominent clinical signs of hypokalemic dairy cows. Serum biochemistry of diseased cows showed mostly hyperglycemia (more than 85 mg/dl) with low serum potassium levels (less than 3.9 mmol/L). The electrocardiographic value for normal healthy dairy cows (n=6) the mean (±SE) values of heart rate (beats/min.), P wave amplitude (mV) and duration (sec), QRS complex amplitude (mV) and duration (sec), PR interval, QT interval and amplitude of T wave (mV) were 84.67±1.74, 0.27±0.024, 0.039±0.008, 0.74±0.073, 0.04±0.008, 0.25±0.14, 0.55±0.02, and 0.53±0.08 respectively and for hypokalemia affected dairy cows (n=118) the values were 86.68±1.01, 0.26±0.004, 0.062±0.001, 0.72±0.19, 0.06±0.001, 0.27±0.003, 0.52±0.006 and 0.22±0.01 respectively that were presented in table no. 1. A significant (p<0.05) increase in "P" wave duration and highly significant (p<0.01) decrease in "T" wave amplitude were noticed in the dairy cows with hypokalemia (Fig. 4)

Discussion

Hypokalemia (serum potassium value less than 3.9 mmol/L) is one of the major electrolyte imbalances in dairy cows that could be occurring secondary to anorexia, diarrhoea, upper gastrointestinal obstruction, right side displacement and torsion of abomasum and impaction of abomasum. It could be due to excessive loss of electrolytes in diarrhoea, sequestration of ingesta and abomasal refluxin pyloric obstruction. Muscular weakness and recumbency were the major clinical findings seenin most of the dairy cows with hypokalemia (Johns *et al.*, 2004) [3]. There was a correlation between hyperglycemia and hypokalemia which might be due to shift of potassium from extracellular to intracellular space during hyperglycemia (Peek *et al.*, 2000) [4]. In the present study, the significant (p<0.05) increase in "P" wave duration and highly significant (p<0.01) decrease in "T" wave amplitude were noticed in the dairy cows with hypokalemia. It could be due to less contraction of atrial muscles and stretching of ventricular muscles during the stage of rapid filling or longer duration of action- potentials in sections of the ventricles (Weaver and Burchell, 1960) [8].

Conclusion

Electrocardiography was a helpful tool for diagnosing electrolyte problems as well as a clinical method of choice for evaluating cardiac abnormalities affecting the production and conduction of electric impulses in the large animal practice. The base apex lead system was the most appropriate lead system for recording cardiac rhythm alterations with hypokalemia in dairy cows. In the present study electrocardiogram complemented the serum potassium value for the confirmatory diagnosis of hypokalemia in dairy cows.

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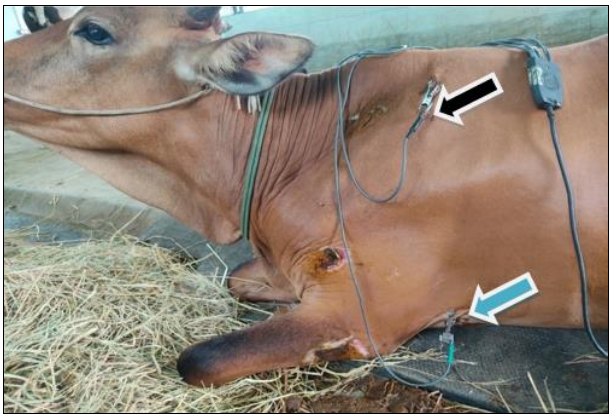

Fig 1: Electrocardiography- electrode placement in recumbent dairy cow (left arm at 5th intercostal space on left side and ground electrode at wither)

Fig 2: Electrocardiography- electrode placement in recumbent dairy cow (right arm at lower 1/3rd of jugular on right side)

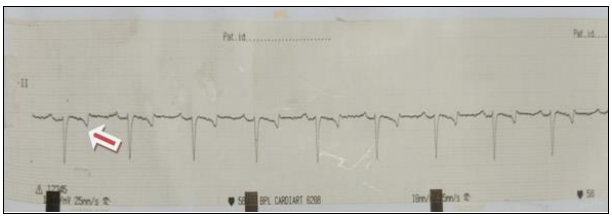

Fig 3: Electrocardiogram of hypokalemic dairy cow showed reduced T wave amplitude

Table 1: Electrocardiographic parameters of apparently healthy and hypokalemic dairy cows (Mean ± SE)

Parameter	Apparently healthy dairy cows (n=6)	Hypokalemic dairy cows (n=118)	P- value
Heart rate (beats/min.)	84.67±1.74	86.68±1.01	0.34
P amplitude (mV)	0.27±0.024	0.26±0.004	0.57

P duration (sec.)	0.039±0.008	0.062±0.001	0.05*
QRS amplitude (mV)	0.74±0.073	0.72±0.19	0.89
QRS duration (sec.)	0.04±0.008	0.06±0.001	0.11
PR interval (sec.)	0.25±0.14	0.27±0.003	0.29
QT interval (sec.)	0.55±0.02	0.52±0.006	0.31
T amplitude (mV)	0.53±0.08	0.22±0.01	0.01**

* Significant (p<0.05)
**Highly significant (p<0.01)

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