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Research Article

Electrocardiographic changes vis a vis ageing in healthy Tharparkar and Vrindavani cattle

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Abstract

Electrocardiogram (ECG) was recorded among various age groups of healthy Tharparkar and Vrindavani cattle. Based on their age, cattle were assigned into four groups consisting of six animals (n=6) in each group. Group I comprised those under one-year-old, Group II was between one and eight years old, Group III was aged eight to ten, and Group IV included those aged ten and above (geriatric). Significant (P<0.05) decrease in amplitude of P wave and R wave was noticed with ageing in both Tharparkar and Vrindavani cattle. Significant (P<0.05) increase in PR and QT interval was noticed with ageing in both the cattle. There were no significant changing patterns of Q, S and T wave amplitude, P, QRS, T wave duration and in ST segment among all age groups. Certain ECG parameter amplitudes (P and R) and duration (PR and QT) are affected by age, with predominant changes seen in ECG morphology in both Tharparkar and Vrindavani cattle.

Keywords: Ageing, Electrocardiographic parameters, Tharparkar cattle, Vrindavani cattle

Highlights

- This study proposes the reference range of HR and, the amplitude and duration of ECG indices, analyzed for the base apex system in different age groups of Tharparkar and Vrindavani cattle.
- This study provides information on the age-wise correlation of electrocardiographic parameters in Tharparkar and Vrindavani cattle.

INTRODUCTION

Ageing is related to a reduction in cardiovascular reserve and adaptability. Cardiovascular disorders are one of the frequently occurring diseases in geriatric patients. During the middle to last one-third of life (i.e. transition period), the cardiac output drops by 30 per cent, and total oxygen intake decreases with age and increased peripheral resistance, leading to cardiac arrhythmias (Mosier, 1989). Only a few clinical studies of cattle with specific heart disease are available. Bacterial endocarditis, traumatic reticulopericarditis, lymphoma involving the myocardium, dilated cardiomyopathy, ventricular septal defect and other congenital heart diseases are most commonly reported (Buczinski *et al*., 2010). Congestive heart failure in cattle is thought to be mostly caused by traumatic pericarditis due to foreign bodies penetrating the reticulum. Extension of infection to the pericardium from pleural or lung infections, tumors such as lymphoma, or idiopathic pericarditis are also other possible causes (Abd El Raouf *et al*., 2020). Standard electrocardiographic measurements can be useful in determining cardiac status. By taking an electrocardiogram (ECG) and analyzing the amplitudes, durations and intervals in the recorded ECG, certain heart abnormalities and arrhythmias can be detected (Constable *et al*., 2016). As a result, the study of these parameters at various ages in animals or humans can aid clinicians in the diagnosis and prognosis of several cardiac disorders. Although the potential use of electrocardiography in cattle is well known, comprehensive studies on electrocardiographic parameters in Vrindavani and Tharparkar cattle of different age groups are lacking.

In contrast, numerous investigations on the impact of ageing on electrocardiographic parameters in

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humans have been conducted (Rijnbeek *et al*., 2014; Vicent and Martinez-Selles, 2017; Erelund *et al*., 2021) and few studies are also done in cattle (Rezakhani *et al*., 2004; Chalmeh, 2015) and in small ruminants (Reddy *et al*., 2014a; Reddy *et al*., 2014b) with ageing but age-related studies with respect to Tharparkar and Vrindavani cattle are lacking. The purpose of this study was to establish normal reference values for ECG indices in Tharparkar and Vrindavani cattle for clinical use, using the base apex lead system also aimed to explain changes occurring in electrocardiographic parameters in different age groups of Tharparkar and Vrindavani cattle.

MATERIALS AND METHODS

Experimental design: The study was carried out in the Indian Veterinary Research Institute's LPM department (cattle and buffalo farm), ICAR-IVRI, Izatnagar, Uttar Pradesh, India. The Tharparkar and Vrindavani cattle were randomly selected for the study from the organized farm of the institute, which are kept under common management and feeding practices. Animals were fed on a balanced diet developed at the Institute's Feed Technology Division. Based on their age, cattle were assigned into four groups consisting of six animals (n=6) in each group. Group I comprised those under one-year-old, Group II was between one and eight years old, Group III was aged eight to ten, and Group IV included those aged ten and above (geriatric). There were no clinical symptoms of respiratory, cardiac (jugular pulsation, oedema), or other systemic illnesses in any of the cattle involved in this study. Pregnant and animals in the early lactation stage were excluded from the study. Without causing any distress to the cattle and after allowing each animal to adapt for at least five to ten minutes in stocks, ECG was recorded during morning hours. The base apex bipolar lead was used for recording the ECG. All cows included in the study were apparently healthy.

Fig. 1. As per base apex lead system, positive electrode (left arm) of lead I was connected to the fifth to sixth intercostal space, just caudal to olecranon

Fig. 2. As per base apex lead system, negative electrode (right arm) of lead I was connected to jugular furrow in the caudal third of the right neck

Electrocardiographic examination: ECG was recorded by bipolar base apex lead method in cattle using Lead I. ECG was recorded in a standing position, and a rubber mat was used as an insulating material with minimal restraining (Fig. 1 and Fig. 2). ECG was recorded in a quite environment. The area of the skin was sterilized with ethanol, and an alligator clip was applied after the ECG gel application. In bipolar base apex method, + ve electrode (left arm) of lead I was connected to the fifth to sixth intercostal space, just caudal to olecranon (Fig. 1) and -ve electrode (right arm) of lead I was connected to the jugular furrow (Fig. 2) in the caudal third of the right neck (Constable *et al*., 2016). The ECG was recorded by using single channel cardiart ® 6108 T BPL ECG machine at paper speed 50 mm/s and sensitivity of 10 mm/mV. Heart rate was calculated according to the RR interval in lead-1 and expressed in beats per minute (bpm). Various ECG complexes viz, P wave, QRS complex, R wave, S wave, T wave, ST segment, PR, QT and RR interval were recorded and analyzed appropriately.

Statistical analysis: To study the effect of groups for various parameters, one-way ANOVA (analysis of variance) was used. The multiple comparisons between the groups for various

parameters were done by using Tukey's test at 5% level of significance. The analysis was done using JMP 9.0 software. The results of the various parameters are expressed as Mean ± SE.

RESULTS

Electrocardiographic parameters in different age groups of Tharparkar and Vrindavani cattle were presented in Tables 1 and 2. Mean heart rate of the Tharparkar cattle in group I, group II, group III and group IV were 104.54, 85.71, 92.30 and 70.58 bmn. Mean heart rate of the Vrindavani cattle in group I, group II, group III and group IV were 133.33, 92.85, 109.12 and 82.97 bmn.

The amplitude of 'P' wave was positive in all the groups, and it was 0.23, 0.20, 0.18 and 0.13 millivolts in G-I, G-II, G-III and G-IV of Tharparkar cattle and 0.26, 0.23, 0.17 and 0.15 millivolts in G-I, G-II, G-III and G-IV of Vrindavani cattle, respectively. Significant ($P<0.05$) decrease in amplitude of P wave was noticed in group IV compared to group I of Tharparkar cattle. Significant ($P<0.05$) decrease in amplitude of P wave was noticed in groups III and IV compared to group I of Vrindavani cattle. The amplitude of 'Q' wave was positive in all the groups, and it was 0.10, 0.13, 0.11, 0.12 millivolts in G-I, G-II, G-III and G-IV of Tharparkar cattle and 0.12, 0.13, 0.14 and 0.16 millivolts in G-I, G-II, G-III and G-IV of Vrindavani cattle, respectively. The amplitude of 'R' wave was negative in all the groups, and it was 1.02, 0.71, 0.45 and 0.47 millivolts in G-I, G-II, G-III and G-IV of Tharparkar cattle and 0.89, 0.63, 0.43 and 0.44 millivolts in G-I, G-II, G-III and G-IV

Table 1. Electrocardiographic parameters in different age groups of Tharparkar cattle (Mean ± SE)

Parameters	Group I (n=6)	Group II (n=6)	Group III (n=6)	Group IV (n=6)
P ampl (mV)	0.23 ± 0.02^{a}	0.20 ± 0.03^{ab}	0.18 ± 0.02^{ab}	0.13 ± 0.02^{b}
Q ampl (mV)	0.10 ± 0.00^{a}	0.13 ± 0.02^{a}	0.11 ± 0.02^{a}	0.12 ± 0.04^{a}
R ampl (mV)	1.02 ± 0.13^{a}	0.71 ± 0.04^{b}	0.45 ± 0.04^{b}	0.47 ± 0.06^{b}
S ampl (mV)	0.02 ± 0.01^{a}	0.02 ± 0.01^{a}	0.02 ± 0.01^{a}	0.03 ± 0.01^{a}
T ampl (mV)	0.27 ± 0.02^{a}	0.27 ± 0.07^{a}	0.28 ± 0.02^{a}	0.22 ± 0.03^{a}
P dur (s)	0.057 ± 0.003^{a}	0.067 ± 0.004^{a}	0.050 ± 0.004^{a}	0.060 ± 0.005^{a}
QRS dur (s)	0.047 ± 0.004^{a}	0.050 ± 0.004^{a}	0.050 ± 0.004^{a}	0.057 ± 0.003^{a}
T dur (s)	0.057 ± 0.003^{a}	0.063 ± 0.006^{a}	0.053 ± 0.004^{a}	0.053 ± 0.004^{a}
PR Int (s)	0.133 ± 0.007^{c}	0.180 ± 0.015^{bc}	0.205 ± 0.017^{b}	0.268 ± 0.021^{a}
QT Int (s)	0.303 ± 0.020^{b}	0.330 ± 0.009^{b}	0.383 ± 0.028^{ab}	0.447 ± 0.027^{a}
RR Int(s)	0.633 ± 0.05^{a}	0.653 ± 0.02^{a}	0.793 ± 0.06^{a}	0.820 ± 0.05^{a}
ST Int (s)	0.060 ± 0.01^{a}	0.080 ± 0.01^{a}	0.080 ± 0.01^{a}	0.080 ± 0.01^{a}

Values within a row, having different superscripts, differ significantly ($P<0.05$) from each other

Table 2. Electrocardiographic parameters in different age groups of Vrindavani cattle (Mean ± SE)

Parameters	Group I (n=6)	Group II (n=6)	Group III (n=6)	Group IV (n=6)
P ampl (mV)	0.26 ± 0.02^{a}	0.23 ± 0.02^{ab}	0.17 ± 0.02^{b}	0.15 ± 0.02^{b}
Q ampl (mV)	0.12 ± 0.02^{a}	0.13 ± 0.02^{a}	0.14 ± 0.04^{a}	0.16 ± 0.05^{a}
R ampl (mV)	0.89 ± 0.07^{a}	0.63 ± 0.08^{b}	0.43 ± 0.03^{b}	0.44 ± 0.04^{b}
S ampl (mV)	0.02 ± 0.01^{a}	0.02 ± 0.01^{a}	0.02 ± 0.01^{a}	0.03 ± 0.01^{a}
T ampl (mV)	0.27 ± 0.04^{a}	0.23 ± 0.03^{a}	0.18 ± 0.02^{a}	0.17 ± 0.02^{a}
P dur (s)	0.06 ± 0.00^{a}	0.06 ± 0.01^{a}	0.06 ± 0.01^{a}	0.06 ± 0.00^{a}
QRS dur (s)	0.05 ± 0.00^{a}	0.05 ± 0.00^{a}	0.05 ± 0.01^{a}	0.05 ± 0.00^{a}
T dur (s)	0.06 ± 0.01^{a}	0.06 ± 0.01^{a}	0.05 ± 0.00^{a}	0.05 ± 0.00^{a}
PR Int (s)	0.14 ± 0.02^{a}	0.17 ± 0.01^{ab}	0.23 ± 0.02^{bc}	0.26 ± 0.02^{c}
QT Int (s)	0.30 ± 0.02^{a}	0.32 ± 0.02^{ab}	0.38 ± 0.01^{bc}	0.40 ± 0.02^{c}
RR Int(s)	0.60 ± 0.04^{a}	0.66 ± 0.02^{ab}	0.73 ± 0.05^{b}	0.88 ± 0.05^{b}
ST Int (s)	0.07 ± 0.01^{a}	0.08 ± 0.01^{a}	0.08 ± 0.01^{a}	0.08 ± 0.01^{a}

Values within a row, having different superscripts, differ significantly ($P<0.05$) from each other

of Vrindavani cattle, respectively. Significant (P<0.05) decrease was noticed in amplitude of R wave in groups II, III and IV compared to group I in both Tharparkar and Vrindavani cattle. The amplitude of 'S' wave was positive in all the groups, and it was 0.02, 0.02, 0.02 and 0.03 millivolts in G-I, G-II, G-III and G-IV of both Tharparkar and Vrindavani cattle. The amplitude of 'T' wave was positive in most of the animals, and few were biphasic. It was 0.27, 0.27, 0.28 and 0.22 millivolts in G-I, G-II, G-III and G-IV of Tharparkar cattle and 0.27, 0.23, 0.18 and 0.17 millivolts in G-I, G-II, G-III and G-IV of Vrindavani cattle, respectively. There were no significant (P<0.05) changing patterns of Q, S and T wave amplitude among all age groups.

The duration of the mean 'P' wave was 0.057, 0.067, 0.050 and 0.060 sec in G-I, G-II, G-III and G-IV of Tharparkar cattle and 0.06 sec in all the groups of Vrindavani cattle. The mean duration of 'QRS' complex was 0.047, 0.050, 0.05 and 0.057 sec in G-I, G-II, G-III and G-IV of Tharparkar cattle and 0.05 sec in all the groups of Vrindavani cattle. The mean duration of 'T' wave was 0.057, 0.063, 0.053 and 0.53 sec in G-I, G-II, G-III and G-IV of Tharparkar cattle and 0.06, 0.06, 0.05 and 0.05 sec in G-I, G-II, G-III and G-IV of Vrindavani cattle. The time period between atrial and ventricular depolarization is known as the P-R interval, whereas the time period between the start of ventricular depolarization and the end of ventricular repolarization is the Q-T interval.

The mean P-R interval was 0.13, 0.18, 0.20 and 0.26 sec in G-I, G-II, G-III and G-IV of Tharparkar cattle and 0.14, 0.17, 0.23 and 0.26 sec in G-I, G-II, G-III and G-IV of Vrindavani cattle. Significant (P<0.05) increase in PR interval was noticed in groups III and IV animals compared to group I in both Tharparkar and Vrindavani cattle. The mean Q-T interval was 0.303, 0.330, 0.383 and 0.447sec in G-I, G-II, G-III and G-IV of Tharparkar cattle and 0.30, 0.32, 0.38 and 0.40sec in G-I, G-II, G-III and G-IV of Vrindavani cattle. Significant (P<0.05) increase in QT interval was noticed in group IV animals compared to groups I and II of Tharparkar cattle. Significant (P<0.05) increase in QT interval was noticed in groups III and IV animals compared to group I of Vrindavani cattle. The mean R-R interval was 0.63, 0.65, 0.79 and 0.82 sec in G-I, G-II, G-III and G-IV of Tharparkar cattle and 0.60, 0.66 0.73 and 0.88 sec in G-I, G-II, G-III and G-IV of Vrindavani cattle. In the present study, the recorded ST segment was 0.06 sec in G-I, 0.08 sec in G-II, G-III and G-IV of Tharparkar cattle and 0.07 sec in G-I, 0.08 sec in G-II, G-III and G-IV of Vrindavani cattle. There were no significant (P<0.05) changing patterns of P, QRS, T wave duration and in ST segment among all age groups.

In breed-wise comparison, no significant (P<0.05) difference was found in ECG parameters between both breeds (Table 3). A significant (P<0.01) negative correlation of P and R wave amplitude with ageing was noticed in both breeds (Table 4). Significant (P<0.01) positive correlation of PR interval, QT interval and RR interval was noticed with ageing in both the breeds (Table 4). Significant (P<0.05) negative correlation of T wave amplitude with ageing was observed only in Vrindavani cattle (Table 4).

Table 3. Breed-wise comparison of electrocardiographic parameters in Tharparkar and Vrindavani cattle (Mean ± SE)

Parameters	Tharparkar Cattle	Vrindavani cattle	P value
P ampl (mV)	0.19±0.01[a]	0.20±0.01[a]	0.316
Q ampl (mV)	0.11±0.01[a]	0.14±0.02[a]	0.270
R ampl (mV)	0.66±0.06[a]	0.60±0.05[a]	0.200
S ampl (mV)	0.02±0.00[a]	0.02±0.00[a]	0.734
T ampl (mV)	0.26±0.02[a]	0.21±0.02[a]	0.067
P dur (s)	0.06±0.00[a]	0.06±0.00[a]	1.000
QRS dur (s)	0.05±0.00[a]	0.05±0.00[a]	0.601
T dur (s)	0.06±0.00[a]	0.06±0.00[a]	1.000
PR Int (s)	0.20±0.01[a]	0.20±0.01[a]	0.729
QT Int (s)	0.37±0.02[a]	0.35±0.01[a]	0.331
RR Int(s)	0.73±0.03[a]	0.72±0.03[a]	0.855
ST Int (s)	0.08±0.00[a]	0.08±0.00[a]	0.521

Values within a row, having different superscripts, differ significantly (P<0.05) from each other

Table 4. Age-wise correlation of electrocardiographic parameters in Tharparkar and Vrindavani cattle

Parameters	Tharparkar cattle	Vrindavani cattle
P ampl (mV)	-0.577**	-0.693**
Q ampl (mV)	0.162	0.228
R ampl (mV)	-0.780**	-0.755**
S ampl (mV)	0.084	0.167
T ampl (mV)	-0.028	-0.480*
P dur (s)	-0.106	-0.152
QRS dur (s)	0.291	0.081
T dur (s)	-0.236	-0.338
PR Int (s)	0.742**	0.797**
QT Int (s)	0.713**	0.714**
RR Int(s)	0.544**	0.660**
ST Int (s)	0.385	0.107

Values within a row, having different superscripts, differ significantly (P<0.05) from each other

DISCUSSION

ECG parameters with ageing in cattle were within the standard reference range as indicated by earlier workers (Rezakhani *et al*., 2004; Chalmeh, 2015; Reddy and Sivajothi, 2016). However, significant changes in the amplitude of P and R wave, PR, QT and RR interval were noticed with ageing. In our findings, a significant ($P<0.05$) decrease in the amplitude of P and R waves was noticed with ageing in both Tharparkar and Vrindavani cattle. One cattle each in >10 year age group and one cattle each in 8-10 year age group of both Tharparkar and Vrindavani cattle exhibited low QRS voltage complexes which may be attributed to a decrease in R wave amplitude; similar observations were noticed by Chalmeh (2015) and Reddy and Sivajothi (2016) the thinner chest walls in young animals compared to adults may facilitate the rapid transmission of cardiac electrical waves to the ECG equipment, resulting in higher amplitudes in the recordings.

The distribution of body surface potentials in the ECG is also influenced by the conductive properties of ruminant body mass, which is due to the volume of the GI tract (Santamarina *et al*., 2001). It's likely that gradual increases in body mass will make it more difficult to reach the waves at the body surface due to relative electrical insulation and cause a change in ECG amplitude. The duration of cardiac electrical activity transfer increases as the volume of the heart becomes larger during the course of development in large animals. Because of the existence of a deep Purkinje system in ruminants, depolarization from the ventricular endocardium to the epicardium occurs rapidly in several directions at once (Pennisi *et al*., 2002).

From current findings, P-R, Q-T and R-R intervals were significantly ($P<0.05$) increased in old animals than young; similar changes were noticed by Chalmeh (2015), likely due to the large size of the heart in older cows. Histological variations in the conduction system are quite common with ageing. These changes may impact the orientation of the electrical axis, as well as the PR and QT intervals, and the morphology of atrial and ventricular complexes (Jones *et al*., 1990). Atrioventricular conduction is determined using the P-R interval. Conduction delay within the atrioventricular node is indicated by physiologically prolonged P-R intervals. Delays in the conduction system are probably due to massive cardiac musculature in adult cattle (Constable *et al*., 2016). An increase in vagal tone also causes prolonged P-R intervals (Pessoa *et al*., 2014). Macfarlane *et al*. (1994) also studied that Q-T interval increased with ageing in human beings, P-R intervals in children are shorter than adult because of lower cardiac muscle mass, which is also seen with ageing in cattle according to the present results. Young animals are anxious during ECG acquisition, which may result in an artifactual decrease in the R-R interval (O'Connor *et al*., 2008). Degenerative changes occur in the heart muscle and its conduction system with ageing. Fibrous tissue and fat deposition may take place in few of the pathways of pacemaker system with ageing (O'Connor *et al*., 2008).

From the present ECG findings, no significant variation in T wave (duration and amplitude), S wave, and Q wave amplitude was noticed with ageing. A similar finding has been reported by Chalmeh (2015). No significant changes in the ST segment are observed with ageing. A similar observation was made by Pourjafar *et al*. (2012), who reported that except in newborn calves (64.2% of newborn calves have elevated ST segment), all the age group animals have isoelectric horizontal ST segment. Variations in vagal tone during ageing, size and volume of heart, properties of Purkinje fibers in the cardiovascular conductive system and conductive characteristics of the body, all these factors influence the changing patterns of electrocardiographic parameters in different age groups in cattle (Chalmeh, 2015).

The study contributes to the bovine electrocardiography by providing normal reference values of HR and different ECG components as a reference value for clinical evaluations of cardiac conduction abnormalities as well as cardiovascular soundness of Vrindavani and Tharparkar cattle. It could be stated that ageing can affect electrocardiographic findings, but a wide range of data covering different ages still needs to be collected to propose a reference value.

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

Author's contribution: DU, KM: Designed the present study; KK, CAK, PM, ACS: Executed the work; KK, MV, YSR: Prepared the manuscript with inputs.

Data availability statement: Raw data of this study are available from the corresponding author.

Ethical statement: This study was approved by the Institute Animal Ethics Committee (IAEC) of ICAR-IVRI, vide order No. F. 26-2/2019/JD(R) dated: 6/01/2020.

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