

## Analysis of normal electrocardiograms of Jamunapari goats

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In the present study, the normal electrocardiographic (ECG) values in the adult male Jamunapari breed of the goats were described. The mean heart rate in the goats was  $127 \pm 3.46$  per minute and ranged 107 and 168. The amplitudes and duration of various waveforms of ECG for six standard limb leads (I, II, III, aVL, aVR and aVF) were estimated. The overall P, QRS and T amplitudes (millivolts) were  $0.065 \pm 0.01$ ,  $0.47 \pm 0.06$  and  $0.20 \pm 0.014$  respectively. The duration (seconds) of these wave forms were  $0.042 \pm 0.005$ ,  $0.033 \pm 0.002$  and  $0.10 \pm 0.014$ , respectively. The P-R interval and R-R intervals ranged between 0.06–0.14 and 0.40–0.58 respectively. The average Q-T interval was  $0.24 \pm 0.01$  second, indicating the time for which the caprine ventricle remained depolarized. The corrected Q-T interval was also calculated which was found to vary from 0.24 to 0.57. The mean frontal plane vectors for the wave forms P, QRS and T wave forms were  $+49.99 \pm 6.02$ ,  $+37.34 \pm 4.05$  and  $+52.26 \pm 6.79$  degrees respectively.

**Key words:** electrocardiogram, frontal plane vectors, goat

### Introduction

The goat has advantages of small body size, easy availability and cheapness which make it more preferable over other ruminants for biological research. Most of the literature on the electrocardiogram (ECG) among domestic animals is confined to dogs and horses. Quite few studies describe the process of ventricular activation [4] and variability of QRS complex [12] or goats under experimental conditions [7] or values for few leads only [13]. The observations on the amplitude, duration and form of ECG waves (P, QRS and T), direction of cardiac vectors in goats are sparse. Upadhyay and Sud [13] described the high

variability in the wave forms of goat ECG. Besides this, the heart of the goat is reported to vary in size and form according to the breed [3] and this variation is expected to be reflected in the ECG. The present study was intended to describe the normal ECG values for six standard limb leads including the corrected QT interval in Indian breed of goat, Jamunapari which is known for the prolificacy.

### Materials and Methods

Apparently healthy Jamunapari male goats ( $n = 16$ ) aged between 1–3 years reared in the instructional goat farm of this University, attached to the College of Veterinary Science & Animal Husbandry, were used for the study. The ECG recordings were made in the standing position using single channel electrocardiograph (Cardiart 108T; BPL India, India). The three standard limb leads (Lead I, II and III) and augmented leads (aVR, aVL and aVF) were recorded by employing alligator clips electrodes on the anteriolateral aspect, just below the elbow and stifle joints in case of forelimb and hind limb respectively as per method described earlier [13]. All the recordings were made in the morning (8.00–11.00 AM). The sensitivity of the stylus was adjusted to give 10mm deflection/millivolt and the recordings were made at paper speeds of 25 mm/sec as well as 50 mm/sec. The descriptions of various wave s form of the electrocardiogram are as per Wagner [14].

The following parameters were measured from the ECG recordings:

1. Voltages (millivolts) of P, QRS complex and T wave forms in six leads (I, II, III, aVR, aVL and aVF).
2. Duration (seconds) of P, QRS complex and T wave forms and P-R, R-R and Q-T intervals in six leads (I, II, III, aVR, aVL and aVF). Corrected Q-T interval (Q-Tc) was calculated by Bazett's formula [6].
3. The mean QRS, P and T electrical axes were calculated using the formula  $\pm \arctan [(2II-I)/3 I]$  [9] from the voltages of corresponding wave forms.

The statistical analysis of data was done using Tukey-Kramer multiple comparisons test employing Graphpad Instat V2.05a (Graphpad Software, USA).

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## Results

The mean heart rate in the goats studied was  $127.0 \pm 3.46$  per minute and ranged between 107 and 168. The mean voltages and duration of the various wave forms is presented in table numbers 1, 2 and 3 respectively. Significant difference ( $p \leq 0.01$ ) was observed in QRS voltages between leads. The difference in voltage and duration of voltages and durations of P and T as well as P-R and Q-T segments were insignificant ( $p \leq 0.05$ ). There was significant difference between P, QRS and T waves in all the leads. The PR interval was significantly ( $p \leq 0.001$ ) higher than Q-T interval in all the leads among the goats studied. The S-T and P-R segments were isoelectric in the leads studied. The overall RR and corrected QT values were  $0.48 \pm 0.012$  and  $0.35 \pm 0.016$  seconds respectively.

The positive vector representing the QRS wave forces (the mean electrical axis of the heart) was found to be oriented in the frontal plane at  $+37.34 \pm 4.05$  degrees. There was a wide range ( $+7.5$  to  $+58.5$  degrees) in the orientation of the mean electrical axes among the goats. The P wave was oriented in the positive direction in all but one goat studied. The mean angle was  $+49.99 \pm 6.02$  (range,  $-6.60$  to  $+84.79$ ) degrees. All the T wave angles were in the positive direction of the frontal plane and ranged between  $+6.98$  and  $+87.69$  (mean,  $+52.26 \pm 6.79$ ) degrees.

## Discussion

The results of the present study supports the earlier studies conducted [12,13]. The P voltage in bipolar leads I, II and III were almost similar to those obtained by [12] but higher than observed in the study of Upadhyay and Sud [13]. The voltages in the augmented leads were higher than those reported in above two studies. This might be due to breed

difference in the goats studied.

The highest amplitude for P wave was recorded in lead II, and lowest in aVL. In this regard the P wave amplitudes in goat were similar to those values in horses but lower than observed for dog [2]. The QRS voltages were lower than those reported for horses and dogs [2]. The low amplitude QRS deflections might be due to high degree of synchronized ventricular depolarization, which results in canceling of various wave of depolarization passing in any given direction. The T voltage values were lower than those documented for both horses and dogs [2]. In the present study significant variation in voltages between animals was not observed. However, considerable variation from time to time in the same animal and between animals of the same and different species is reported especially for QRS complex [1,11]. Qs pattern of QRS complex predominated in I, II, aVL leads, R pattern in lead III and Qr in aVR and aVF among the goats studied (data not shown). The variability in the wave (form and amplitude) of the ECG may be attributed to determining factors like difference in the topographic anatomy of the heart within thorax, position of heart in relation to the limbs and mechanism of activation of ventricles as reported [2].

The P-R interval representing the time duration between atrial and ventricular depolarization (or the delay at AV node) observed in the study was in line with Swenson and Reece [11]. The RR interval representing the ventricular rate had a wide range (0.36 to 0.56 seconds), which might be due to its close relationship with autonomic nervous activity. The RR analysis is found to be suitable for non invasive assessment of autonomic nervous activity. The AV nodal delays in goats were intermediary to those for swine and dog. The caprine ventricles remained depolarized for about 0.24 seconds, as indicated by the Q-T interval. These values were slightly less than the value reported by Szabuniewicz

**Table 1.** Mean amplitude and range (millivolts) of various ECG wave forms in standard limb leads (I, II and III) and augmented leads (aVR, aVL and aVF) in Jamunapari goats (mean  $\pm$  SE)

Lead	P	QRS	T
I	$0.054 \pm 0.009$ (0.09~0.10) <sup>†</sup>	$0.45 \pm 0.075^{a,*}$ (0.1~1.0)	$0.18 \pm 0.03$ (0.01~0.4)
II	$0.096 \pm 0.015$ (0.01~0.22)	$0.51 \pm 0.064^a$ (0.2~1.0)	$0.19 \pm 0.032$ (0.01~0.5)
III	$0.05 \pm 0.007$ (0.01~0.09)	$0.60 \pm 0.062^b$ (0.2~0.9)	$0.25 \pm 0.064$ (0.15~0.38)
aVL	$0.041 \pm 0.007$ (0.01~0.09)	$0.45 \pm 0.05^a$ (0.1~0.7)	$0.13 \pm 0.013$ (0.03~0.2)
aVR	$0.065 \pm 0.009$ (0.01~0.12)	$0.69 \pm 0.062^c$ (0.16~0.9)	$0.25 \pm 0.016$ (0.15~0.38)
aVF	$0.084 \pm 0.008$ (0.04~0.16)	$0.41 \pm 0.034^a$ (0.16~0.75)	$0.20 \pm 0.022$ (0.08~0.3)
Overall	$0.065 \pm 0.01$	$0.47 \pm 0.06$	$0.20 \pm 0.017$

\*The values with same superscript or no superscript within a column does not differ significantly ( $p < 0.01$ ).

<sup>†</sup>The values in the parenthesis indicates range.

**Table 2.** Duration (seconds) of various ECG wave forms in standard limb leads (I, II and III) and augmented leads (aVR, aVL and aVF) in Jamunapari goats (mean  $\pm$  SE)

Lead	P	QRS	T
I	0.040 $\pm$ 0.004 (0.02~0.08)*	0.030 $\pm$ 0.008 (0.02~0.05)	0.096 $\pm$ 0.016 (0.03~0.24)
II	0.050 $\pm$ 0.007 (0.02~0.1)	0.03 $\pm$ 0.007 (0.02~0.08)	0.113 $\pm$ 0.012 (0.06~0.20)
III	0.044 $\pm$ 0.005 (0.02~0.08)	0.030 $\pm$ 0.002 (0.02~0.05)	0.093 $\pm$ 0.011 (0.03~0.20)
aVL	0.040 $\pm$ 0.004 (0.02~0.07)	0.030 $\pm$ 0.003 (0.02~0.06)	0.100 $\pm$ 0.011 (0.03~0.20)
aVR	0.044 $\pm$ 0.003 (0.03~0.08)	0.032 $\pm$ 0.003 (0.02~0.05)	0.120 $\pm$ 0.020 (0.04~0.28)
aVF	0.040 $\pm$ 0.004 (0.02~0.07)	0.033 $\pm$ 0.002 (0.02~0.05)	0.084 $\pm$ 0.030 (0.06~0.10)
Overall	0.042 $\pm$ 0.005	0.033 $\pm$ 0.002	0.10 $\pm$ 0.014

The values within a column does not differ significantly ( $p < 0.05$ ).

\*The values in the parenthesis indicates range.

**Table 3.** Duration (seconds) of various segments and intervals in standard limb leads (I, II and III) and augmented leads (aVR, aVL and aVF) in the ECG of Jamunapari goats (mean  $\pm$  SE)

Lead	P-R interval	R-R interval	Q-T interval	Corrected Q-T (QT <sub>c</sub> ) interval
I	0.084 $\pm$ 0.004 (0.06~0.12)*	0.46 $\pm$ 0.014 (0.36~0.56)	0.25 $\pm$ 0.01 (0.2~0.42)	0.36 $\pm$ 0.019 (0.29~0.57)
II	0.084 $\pm$ 0.005 (0.06~0.14)	0.48 $\pm$ 0.014 (0.36~0.56)	0.23 $\pm$ 0.01 (0.19~0.36)	0.34 $\pm$ 0.017 (0.27~0.52)
III	0.078 $\pm$ 0.003 (0.06~0.10)	0.49 $\pm$ 0.008 (0.44~0.56)	0.26 $\pm$ 0.01 (0.2~0.4)	0.36 $\pm$ 0.017 (0.29~0.54)
aVL	0.081 $\pm$ 0.005 (0.06~0.14)	0.46 $\pm$ 0.009 (0.40~0.52)	0.23 $\pm$ 0.01 (0.19~0.36)	0.36 $\pm$ 0.017 (0.29~0.55)
aVR	0.081 $\pm$ 0.005 (0.06~0.14)	0.50 $\pm$ 0.013 (0.42~0.58)	0.24 $\pm$ 0.01 (0.2~0.38)	0.33 $\pm$ 0.016 (0.25~0.48)
aVF	0.084 $\pm$ 0.003 (0.06~0.1)	0.47 $\pm$ 0.013 (0.38~0.56)	0.24 $\pm$ 0.01 (0.18~0.28)	0.35 $\pm$ 0.010 (0.24~0.40)
Overall	0.082 $\pm$ 0.004	0.48 $\pm$ 0.012	0.241 $\pm$ 0.011	0.35 $\pm$ 0.016

The values within a column does not differ significantly ( $p < 0.05$ ).

\*The values in the parenthesis indicates range.

and Clark [12], but were similar to Upadhyay and Sud [13]. The Q-T interval depends upon the heart rate, which is closely related to RR interval. The intervals Q-T and Q-Tc are reported to be of potential clinical value because of its association with ventricular arrhythmias [5].

The observations on P, QRS and T angles fall in line with earlier studies [13]. The normal mean electrical axes of the heart in the goats were within the range described for the human beings (0~90 degrees). The QRS angle was lower than those reported for roe deer (169.5 degrees), a small ruminant [10]. This might be due to species difference.

The results of the present study indicate that the ECG of goat differs from that of other species and existence of variability among goats. However, further studies are needed to understand the electrocardiogram of goat especially with

regards to its variability.

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