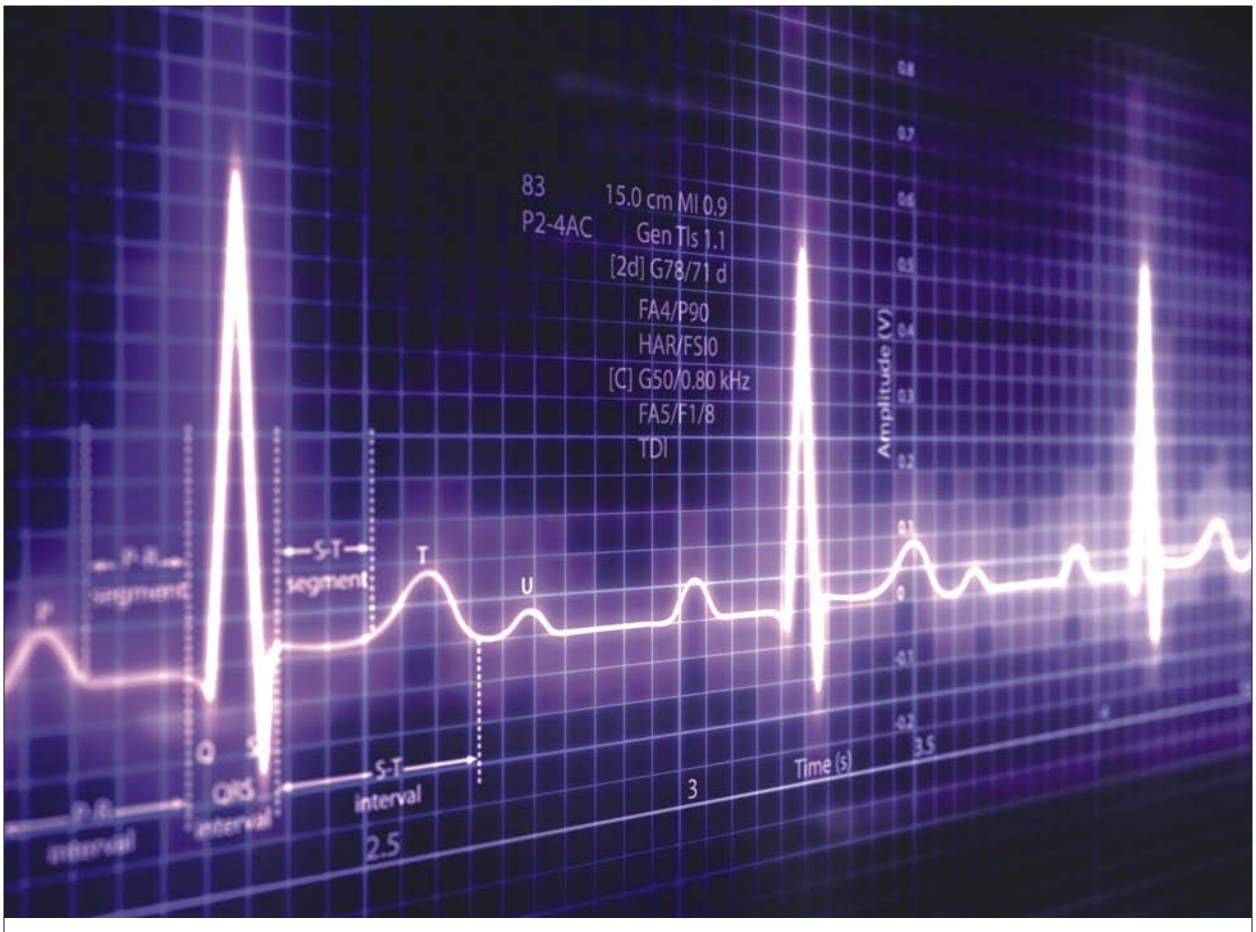

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Electrocardiographic Studies in Garol Sheep and Black Bengal Goats

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Abstract: The study was attempted to describe the normal electrocardiographic pattern in Garol sheep and black Bengal goats using three bipolar standard limb leads (lead 1, 2 and 3) and three unipolar augmented limb leads (aVR, aVL and aVF). A total of 48 healthy black Bengal goats (*Capra hircus*) and 14 Garol sheep of both sexes, ranging in age from 1 to 3 years, were used in the study. The heart rate varied from 68 to 150 beats min^{-1} with a mean of 101±2.6 beats min^{-1} in goats and 75 to 115 beats min^{-1} with a mean of 85±2.8 beats min^{-1} in sheep. In certain cases the P wave in goats could not be measured in the ECG. While 9 goats were found with negative P, one goat showed a notched P wave. The QRS complexes in goat were variable and difficult to classify as a normal pattern. QRS was recorded negative in lead 1 and 2 and positive in lead 3. T waves were recorded to be positive in lead 1 and 2 and negative in lead 3 in goats. In all the experimental sheep, P waves were recorded to be positive and no negative P waves were observed. The QRS complex in sheep was found both monophasic and diphasic in different standard bipolar leads. All T waves were recorded to be negative in three standard bipolar leads in the case of sheep. The electrical cardiac axis in black Bengal goats ranged from −166 to +168°.

Key words: ECG, goat, sheep, heart rate, amplitude, duration, cardiac axis

INTRODUCTION

In animal practice, cardiac diseases retain an unjustified mystique. The correlation between cardiovascular pathology and pathophysiology and the resultant clinical signs are both logical and comprehendible. The sophistication of cardiac diagnosis has improved remarkably over the last few decades (Houghton and Gray, 1997) and the study of electrocardiogram (ECG) pattern is very useful in the detection of abnormal heart conditions (Venkateshwarlu *et al*., 1977). Although ECG is one of the most widely used and useful investigation in contemporary medicine, to the authors' knowledge, very few reports on the ECG in goats are available, while references on the normal electrocardiogram of sheep are scarce. The present study was therefore attempted to describe the normal electrocardiographic pattern in these animals with six standard limb leads.

MATERIALS AND METHODS

Forty eight healthy black Bengal goats (*Capra hircus*) from the University Goat farm, Mohanpur, Nadia district of West Bengal and 14 Garol sheep belonging to private farmers in the vicinity were used for the study during May, 2001. All the animals were of either sex in the age group of one to three years.

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Electrocardiography recordings of the animals were taken in the standing position as described by Schultz and Pretorius (1973). Care was taken to keep the animals as still as possible with manual restraint wearing rubber gloves, ensuring least electrical interference. The ECG tracings were made by a single channel electrocardiograph (CARDIART 108 T/ MK-VI, BPL India, India).

Site for attachment of electrodes were trimmed with scissors and three bipolar standard leads (Lead 1, 2 and 3) and three augmented unipolar limb leads (Lead aVR, aVL and aVF) were recorded with crocodile clips as electrodes in suitable position on the anterolateral aspect, just below the elbow and stifle joint with a little cardiac gel. Positioning was consistent to avoid QRS axis changes. All recordings were taken in the morning hours, when the animals were allowed to stand and acclimatize for 10-15 min before each recording. The ECG machine was calibrated with the vertical sensitivity of the stylus adjusted to give 10 mm deflection per mV of input and with a paper speed of 25 mm sec^{-1} recordings were traced.

The following parameters were evaluated after recording the ECG:

Heart Rate

Heart rate was calculated according to the P-P or R-R intervals in any standard bipolar lead in the sheep and goats and expressed in beats per minute (bpm). In arrhythmias, physical counting by auscultation was done to confirm the heart rate.

Amplitude of Waves

The amplitude of P, QRS and T waves was recorded for all three standard bipolar limb leads (lead 1, 2 and 3) and three unipolar augmented limb leads (Lead aVR, aVL and aVF) and expressed in millivolt (mV).

Duration of Waves

The duration in seconds, of the P waves, P to R interval, QRS, S to T interval and T waves were calculated from both the standard bipolar leads and unipolar leads.

Characteristics of the P and T Waves

These characteristics were studied in terms of the positive, negative or biphasic deflections in all the animals.

Electrical Cardiac Axis

The cardiac axis only in goats was determined according to the method described by Houghton and Gray (1997) measuring the net amplitudes (algebraic sum) in Lead 1 (positive deflection minus negative deflection) and the net amplitudes in lead 3. When the tri-axial system is used, the point representing the net value obtained is marked off from the zero point on Lead 1; this procedure is repeated for the sum of the deflection in Lead 3. Perpendiculars are then followed from these two points to their intersection. A line drawn from the center to this intersection represents the QRS axis or electric cardiac axis.

RESULTS

The normal electrocardiogram of healthy black Bengal goat and sheep are represented in Fig. 1 and 2.

Heart Rate

The heart rate varied from 68 to 150 beats min^{-1} with a mean of 101±2.6 beats min^{-1} in goats and 75 to 115 beats min^{-1} with a mean of 85±2.8 beats min^{-1} in sheep.

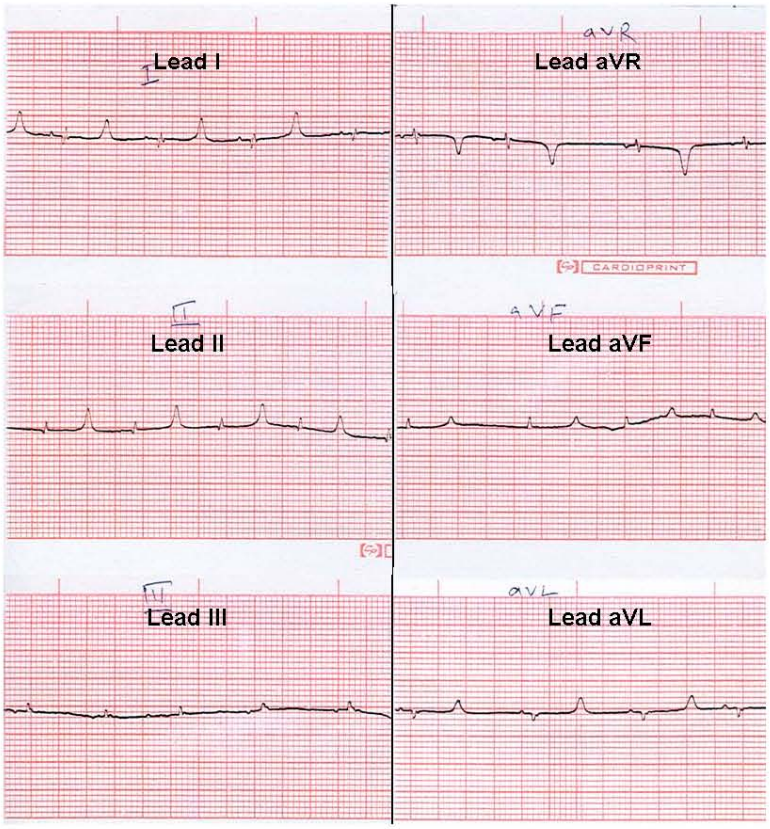

Fig. 1: Normal electrocardiogram of black Bengal goat

Amplitude of Waves

The amplitude of P wave, QRS and T waves for goats and sheep are presented in Table 1. In the present study, slight variations in the amplitudes values were recorded between animals both in sheep and between goats. Interpretatively, minor differences in amplitudes (<0.1 mV) was not considered clinically relevant. No alterations such as atrial or ventricular extra-systoles were observed. Amplitude values were different for sheep and goats examined during the study. The highest amplitude for P wave in goats was recorded in lead 1 and lowest in lead aVL, whereas in sheep the recordings for the P wave amplitude was highest in lead 2 and lowest in lead 3 and the voltage values were higher than those in the goats. Resultant amplitude of the QRS complex was negative in lead 1 and 2 in goats while QRS deflections in sheep were recorded to be higher than in the goats and were positive in all leads. T wave amplitudes were highest in lead 1 and least in lead 3 in goats and the T wave voltage value in sheep was highest in lead 2 and least in lead aVL.

Duration of Waves

The duration of P wave, P-R interval, QRS, S-T interval and T wave in lead 1, 2, 3, aVL, aVL and aVF of goats and sheep are presented in Table 2. Durations varied slightly among animals, but differences less than 0.02 sec was not considered clinically relevant. Differences in duration values were apparent between sheep and goats.

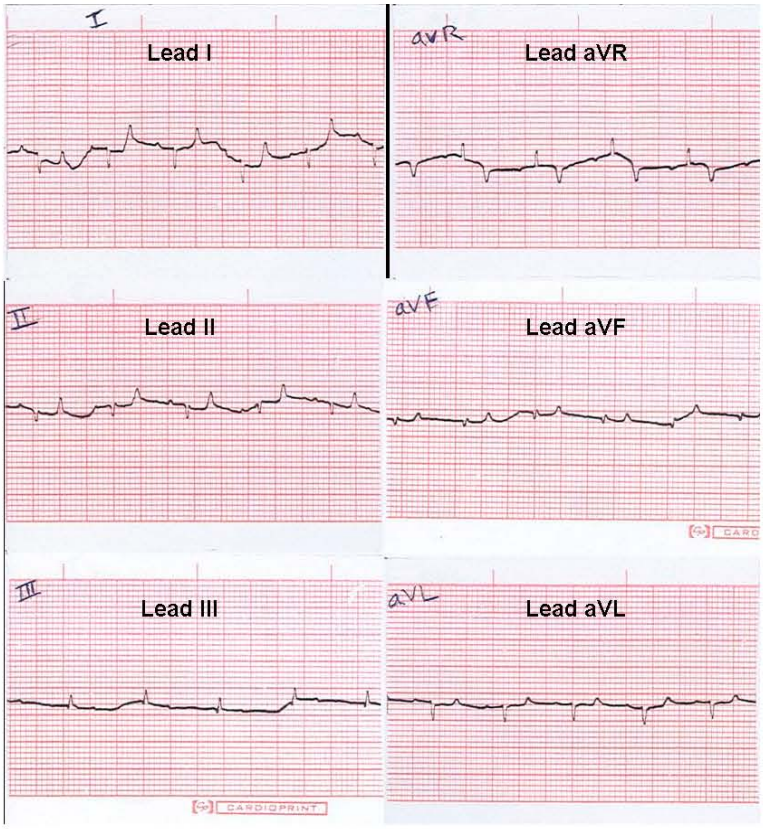

Fig. 2: Normal electrocardiogram of Garol sheep

Characteristics of P and T Waves

Different types of P and T waves were recorded in three standard leads and are presented in Table 3. Out of 48 goats only 9 goats were found with negative P and one goat with notched P wave. In certain cases the P wave could not be measured or discerned on the electrocardiograph. The P wave with net positive area was found in all three leads. The QRS complexes found negative in lead 1 and 2 and positive in lead 3 in goats are variable and difficult to describe as a normal pattern. Lead 1 had a predominance of R, RS in lead 2, while QR and R patterns in lead 3 were equally distributed. In lead 1 (in frontal plane), the ventricular activation was from left to right which produced a negative QRS complex. Even in lead 2 these types predominates. T waves were found positive in bipolar leads (lead 1 and 2) and negative in lead 3. The amplitudes of electrocardiographic deflections in goats were very small particularly P wave in standard limb leads. In the younger goats, P and T waves were more prominent and positive in three standard bipolar leads in comparison to QRS. In sheep, most P waves were nearer to the isoelectric line and therefore could not be measured; otherwise all measurable P waves were positive. The QRS complex were both monophasic and diphasic in different standard bipolar leads of sheep. All T waves were negative except in one sheep with a biphasic T wave pattern observed in lead 3, whereas recordings in the goat T waves were characteristically positive in lead 1 and 2 and negative only in lead 3.

Table 1: Amplitude in millivolts of the various electrocardiographic waves in goats and sheep (mean±SE)

Species	Lead	P	QRS (+) ve	QRS (-) ve	T
Goat (n = 48)					
	1	0.10±0.03	0.09±0.03	0.31±0.03	0.28±0.03
	2	0.04±0.01	0.08±0.009	0.15±0.02	0.23±0.03
	3	0.04±0.01	0.22±0.02	0.06±0.00	0.12±0.02
	aVR	0.04±0.004	0.21±0.03	0.07±0.01	0.20±0.03
	aVL	0.03±0.0001	0.46±0.00	0.24±0.02	0.16±0.02
	aVF	0.04±0.01	0.14±0.01	0.07±0.01	0.15±0.02
Sheep (n = 14)					
	1	0.10±0.00	0.55±0.05	0.20±0.00	0.18±0.06
	2	0.13±0.02	0.32±0.02	0.30±0.00	0.31±0.05
	3	0.08±0.012	0.24±0.04	0.20±0.03	0.24±0.05
	aVR	0.10±0.00	0.30±0.00	0.25±0.06	0.24±0.04
	aVL	0.10±0.00	0.32±0.06	0.15±0.02	0.10±0.01
	aVF	0.08±0.016	0.25±0.04	0.12±0.07	0.27±0.05

Table 2: Duration in seconds of different electrocardiographic waves in goats and sheep (mean±SE)

Species	Lead	P	P-R segment	QRS	ST	T
Goat (n = 48)						
	1	0.05±0.003	0.12±0.006	0.05±0.004	0.19±0.014	0.11±0.008
	2	0.06±0.004	0.12±0.006	0.05±0.004	0.20±0.010	0.11±0.006
	3	0.06±0.000	0.15±0.010	0.05±0.003	0.21±0.015	0.08±0.005
	aVR	0.06±0.006	0.12±0.008	0.04±0.003	0.21±0.012	0.11±0.009
	aVL	0.06±0.006	0.11±0.004	0.05±0.004	0.21±0.011	0.09±0.006
	aVF	0.06±0.006	0.12±0.008	0.05±0.004	0.20±0.018	0.09±0.004
Sheep (n = 14)						
	1	NM	NM	0.04±0.005	0.13±0.010	0.11±0.010
	2	0.04±0.004	0.14±0.012	0.06±0.010	0.12±0.010	0.14±0.010
	3	0.06±0.009	0.13±0.005	0.08±0.008	0.14±0.010	0.12±0.010
	aVR	0.05±0.006	0.16±0.006	0.06±0.008	0.13±0.009	0.10±0.009
	aVL	0.06±0.000	0.20±0.000	0.05±0.008	0.15±0.010	0.07±0.005
	aVF	0.06±0.006	0.16±0.020	0.05±0.006	0.13±0.009	0.00±0.007

Table 3: Patterns of electrocardiographic P and T waves in goats and sheep

Species		Lead Ω	Lead ℧	Lead 	Lead 
Goat	P waves	+	+	NF	NF
Sheep		+	NF	NF	NF
Goat	T waves	+++	+	NF	NF
Sheep		NF	++	NF	+

+ = 0.10 mV; ++ = 0.20 mV; +++ = > 0.20 mV; NF = Not Found; Ω = Positive P/T wave; ℧ = Negative P/T wave; = Biphasic P/T wave (+-); = Biphasic P/T wave (-+)

Electrical Cardiac Axis

There was a wide range (−166 to +168°) in the orientation of the mean electrical axes in goats ranging from 1 to 3 years.

DISCUSSION

Heart Rate

Heart rate of black Bengal goats aged between 1-3 years recorded in the study was 68-150 bpm with an average 101±2.6 bpm. Reportedly, mean rates has been found to be 258 bpm in day old and 176 bpm for month old goat kids (Montes *et al*., 1994) and as high as 94 to 270 bpm in 56 healthy goats between 15 days to 5 years (Upadhyay and Sud, 1977). Reports in Jamunapari goats between

1-3 years of age ranged from 107 to 168 bpm with a mean of 127±3.46 bpm (Montes *et al*., 1994). The heart rate recorded in the sheep (75 to 115 bpm; 85±2.8 bpm) was less than those described for the Gallega breed of sheep (Torio Alvarez *et al*., 1994), a possible variation due to breed differences. Variations in the heart rate may be expected with difference in age and size of animals. Moreover, variations according to breed may result in differences in the size and form of heart, that apparently reflects in the ECG.

Amplitude of Waves

The amplitude of P, QRS and T waves recorded in the black Bengal goats were similar to those described for the species (Upadhyay and Sud, 1977). The QRS deflections were lower than those reported in Jamunapari goats (Mohan *et al*., 2005) and presumably could be due to a high degree of synchronized ventricular polarization passing in any given direction. The configuration of the QRS complex varied widely as had also been reported by Upadhyay and Sud (1977).

Duration of Waves

Slight variations in the recorded duration of P waves in goats were found with those of earlier reports (Choi *et al*., 1997; Mohan *et al*., 2005; Upadhyay and Sud, 1977). The observed P-R segment in goats representing the time duration between atrial and ventricular depolarization (or the delay at AV node), the observed QRS duration, ST segment and T wave duration were similar to earlier reports (Choi *et al*., 1997; Miller, 1985; Upadhyay and Sud, 1977), but observed P-R interval was wider than those recorded in Jamunapari goats (Mohan *et al*., 2005). The P wave duration and P-R interval in sheep could not be measured in lead I. Duration for the P wave recorded in sheep were similar to, but differed in the P-R interval values for 32 2-tooth Romney rams (Smith, 1978). QRS duration in sheep was similar to previous findings Mohan *et al*. (2005) and Smith (1978) with the exception of the ST segment. T wave duration was within the earlier observations (Smith, 1978). Variations in the time durations from observed values and those recorded in earlier reports could be attributable to variation in size, age, sex and breed of animals.

Characteristics of P and T Waves

Out of 48 goats only 9 goats were found with negative P and one goat with notched P wave. Negative P implies that the impulse is generated from the AV junction (junctional premature complex). Also notched P wave is generally seen in animals with atrial enlargement. Since horse has a large heart, it is often found as normal ECG findings in this species and less commonly in cattle. Further investigation including Holter monitoring and diagnostic imaging studies (radiography and echocardiography), is required for clarification for possible atrial enlargement in animals showing this characteristics. In certain cases the P wave could not be measured or discerned on the electrocardiograph. This may be due to lack of coordinated atrial activity so that P waves are not being formed, or that P waves are present, but are just not obvious. The P wave with net positive area was found in all three leads. These observations were akin to earlier reports (Upadhyay and Sud, 1977) and were similar to human tracings; although there were differences like flat and round P, low potentials, etc. in humans. The QRS complexes found negative in lead 1 and 2 and positive in lead 3 in goats are variable and difficult to describe as a normal pattern. Lead 1 had a predominance of R, RS in lead 2, while QR and R patterns in lead 3 were equally distributed. Even when unipolar leads were used, a similar type of variability was recorded as has been previously observed by Upadhyay and Sud (1977). The amplitudes of electrocardiographic deflections in goats were very small particularly P wave in standard limb leads. This may be due to the presence of high degree of synchronization of depolarization of individual myocardial fibres. The QRS complex were both monophasic and diphasic

in different standard bipolar leads of sheep. Significantly, all T waves were negative except in one sheep with a biphasic T wave pattern observed in lead 3, whereas recordings in the goat T waves were characteristically positive in lead 1 and 2 and negative only in lead 3. This has been a significant observable difference in the ECG of the goat and sheep.

Electric Cardiac Axis

The cardiac axis conventionally referred to as the angle measured in degrees, is an indicator of the general direction that the wave of depolarization takes as it flows through the ventricles. In Jamunapari goats aged between 1-3 years, the mean electrical axes ranged between +7.5 to +58.5° similar to those in humans (Mohan *et al*., 2005). In day and month old goat kids, the electrical axis reportedly had a left rotation from −187 to +158° (Montes *et al*., 1994). Present observations in black Bengal goats also had a wide range of axis orientation (−166 to +168°). Marked variations in the cardiac electrical axis orientation in age and species are thus apparent.

The present study showed that there exists considerable variability in the electrocardiography parameters of goat and therefore difficult to describe a normal ECG in a conclusive manner. There also exist differences in values and wave characteristics between ECG of sheep and goat. Variations in T wave pattern in these two species were characteristic. In sheep, T waves were negative in all three bipolar standard leads, whereas, T waves in goat were positive in lead 1 and 2, but negative in Lead III. Further studies with a larger sample size in goats and sheep with appropriate categorization in age, sex, breed etc. is recommended for standardization of ECG parameters. Anomalies suspected if any should be confirmed by diagnostic imaging procedures.

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