



# Analysis of Base-Apex Lead Electrocardiogram in Clinically Healthy Kermani Sheep

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## Abstract

The normal electrocardiographic (ECG) parameters in the base-apex lead were evaluated in 40 clinically healthy Kermani sheep, and compared between sexes and three age groups. The heart rate varied from 83-192 beats/min with a mean of 128.9±4.7 beats/min (Mean±SEM). Sinus arrhythmia was the only observed cardiac dysrhythmia on the ECG traces diagnosed in 45% of animals. No significant difference was found in heart rate, amplitude, and duration of ECG waves and intervals between two sexes. Nevertheless, the heart rate, amplitude of ECG waves, duration of T waves and duration of P-R, Q-T and R-R intervals showed significant difference between the age groups. This study provides information on the cardiac rhythm, heart rate, duration, and amplitude of ECG deflections in Kermani sheep. We proposed the base-apex lead as a suitable lead for ECG evaluation in this species.

## Introduction

Cardiac dysrhythmias (arrhythmias) are defined as disturbances of impulse formation, disorders of impulse conduction, or both (Rezakhani et al., 2004a). In Veterinary medicine, electrocardiography (ECG) has been documented as a useful, accurate and non-invasive method for diagnosis of disturbances in the genesis and spread of the cardiac impulses, and cardiac arrhythmias (Escudero et al., 2009). ECG parameters and cardiac rhythms have been evaluated and published in different breeds of beef and dairy cattle (Rezakhani et al., 2004b), and in few breeds of sheep. Additionally, it has been documented that in small ruminant, ECG parameters may show high variability between diverse breeds (Tajik et al., 2013).

Twenty seven breeds and ecotypes of sheep have been recognized in Iran, and sheep has a high economic value as an important producer of meat, wool, and milk (Khaldari, 2003). The importance of obtaining normal values of ECG for specific breeds of animals as a useful and available method. It is especially recommended for small ruminants due to high variability in the ECG parameters (Escudero et al. 2009; Mohan et al., 2005), nevertheless, limited information exists regarding normal ECG parameters in healthy sheep. On the other

hand, the results of previous studies about the effects of age and sex on normal ECG parameters in ruminants are controversial.

Kermani sheep, as a highly adapted breed to arid and semi-arid conditions in Iran, is raised in large numbers in the Kerman province of Iran where sheep production contributes significantly to the agricultural economy. There is very little information about Kermani sheep and to authors' knowledge, there is no previous study regarding the normal ECG parameters in this valuable breed. The current study was done to provide ECG values and to evaluate the effects of age and sex on these parameters in this breed.

## Materials and Methods

In the current study, forty clinically healthy pure Kermani sheep were randomly selected from the research farm of the Agriculture School of Shahid Bahonar University of Kerman, Southeast of Iran. Four groups of the animals consisting of 10 male lambs (up to one year old, 15-20 kg body weight), 10 female lambs (up to one year old, 15-20 kg body weight), 10 non-pregnant female adult sheep (1-5 years old, 25-35 kg body weight) and 10 male adult sheep (1-4 years old, 20-40 kg body weight) were considered.

The animals were reared under the similar husbandry conditions in a same group pen. After clinical examinations, the ECG was obtained from each sheep using a single-channel ECG machine (Cardiomax FX-2111, Fukuda, Japan) on a bipolar base-apex lead with a paper speed of 25 mm/sec and calibration of 10 mm equal to 1 mV. Recording of ECG was done in a quiet standing position using an alligator-type electrode attached to the skin. The negative electrode (right arm) was attached over the jugular furrow about the lower 1/3 of the neck on the left side, the positive electrode of lead I (left arm) was placed on the skin of the fifth intercostal space just caudal to the olecranon, and the earth electrode was joint away from these two electrodes (Rezakhani et al., 2004b). Alligator clips were fixed on the skin after application of methyl alcohol.

Cardiac rhythm, heart rate, and duration of P, QRS, T waves, PR interval, QT interval, and ST segment were measured in seconds in the base-apex lead. A magnifying glass was used to analyze and measure ECG parameters. Using this method of measurement, the precision of duration and amplitude was 0.02 sec. and 0.05 mV, respectively. The heart rate was calculated by calculating the average six R-R intervals of each trace. To describe the QRS complex, the first downward deflection was designated as Q, the first positive wave as R and the negative deflection after R was named as S. If the QRS complex was a single negative deflection, it was described as the QS pattern (Deroth, 1980; Rezakhani et al., 2004b). In the case of biphasic P or T waves (-/+ or +/-), the amplitude of two phases was summed.

Statistical analysis was performed using SPSS18 (Illinois, Chicago). Two-sample *t*-test was used for comparison of heart rate, amplitude, and duration of P-R, Q-T and R-R intervals between the two sexes. Analysis of variance (ANOVA) and Bonferroni tests as post hoc were used to compare of the parameters between different age groups. Comparison of wave conformation and cardiac arrhythmia prevalence between the two sexes and different age groups was done using Fisher's exact test, and Pearson's correlation test was used to evaluate any relationships. Results were considered statistically significant at  $P < 0.05$ .

## Results

The normal ECG parameters in the base-apex lead were evaluated in 40 clinically healthy Kermani sheep, and compared between sexes and three age groups in the present study. The average age of male and female sheep was  $1.63 \pm 0.17$  and  $2.1 \pm 0.33$  years (Mean  $\pm$  SEM), respectively, and there was no significant difference between two sexes. Values for ECG parameters,

including heart rate, amplitude and duration of ECG waves, and duration of P-R, Q-T and R-R intervals in different genders and age groups of Kermani sheep were summarized in Table 1.

The heart rate ranged from 83 to 192 beats/min with an average of  $128.9 \pm 4.7$ . There was a negative significant relationship between the heart rate and age ( $r = -0.536$ ,  $P = 0.001$ ). Comparison between the two sexes showed no significant difference in the heart rate, amplitude of ECG waves, duration of ECG waves, and duration of P-R, Q-T and R-R intervals.

The sheep were divided into three groups according to their age, as:  $G_1$ : up to 1 year old,  $G_2$ : higher than 1 year old and less than 3 years old, and  $G_3$ : higher than 3 years old. There was a significant difference between diverse age groups in the heart rate ( $P < 0.001$ ), P amplitude ( $P = 0.001$ ), QRS amplitude ( $P = 0.007$ ), T amplitude ( $P = 0.033$ ), T duration ( $P = 0.008$ ), P-R duration ( $P = 0.024$ ), Q-T duration ( $P < 0.001$ ) and R-R duration ( $P < 0.001$ ). Sheep up to one year old has higher heart rate and P amplitude, and less Q-T and R-R intervals in comparison to  $G_2$  and  $G_3$  groups. There were also higher QRS and T waves' amplitude, and less T duration and P-R intervals in  $G_1$  group than in  $G_3$  group (Table 1). The age had negative significant correlations with amplitudes of P ( $r = -0.465$ ,  $P = 0.004$ ), QRS ( $r = -0.402$ ,  $P = 0.012$ ) and T ( $r = -0.375$ ,  $P = 0.02$ ) waves.

Sinus arrhythmia, as the only observed irregularity on the ECG traces, was found in 18 sheep (45%). However, clinical signs of heart problem or cardiac insufficiency were not diagnosed in the animals. No dysrhythmia was detected in 22 out of 40 (55%) cases. The prevalence of cardiac arrhythmia had no significant difference between different sexes and age groups.

The configurations of ECG waves in different genders and age groups of Kermani sheep in the base-apex lead are shown in Table 2. Simple positive was the main configuration of P wave and a biphasic P wave (+/- and -/+) was observed in two animals. Additionally, a few notched P waves were evident on ECG traces of five sheep. QRS complex showed three different patterns in Kermani sheep; however, no statistically significant difference was found between QRS configurations of two sexes and three age groups.

The T wave showed a positive configuration in all Kermani sheep, except three female cases in  $G_3$  group that had a biphasic (+/-) T wave (Table 2). Statistical analysis showed no significant difference in T wave configuration between the two sexes; but, there was a significant difference between  $G_1$  and  $G_3$  groups ( $P = 0.023$ ).

**Table 1.** Heart rate, amplitude of ECG waves, duration of ECG waves, and duration of P-R, Q-T and R-R intervals in different genders and age groups of Kermani sheep recorded in the base-apex lead.

	n	Heart rate (Beats/min)	P amplitude (mv)	P duration (Millisec)	P-R interval (Millisec)	QRS amplitude (mv)	QRS duration (Millisec)	Q-T interval (Millisec)	T amplitude (mv)	T duration (Millisec)	R-R interval (Millisec)
All sheep	40 (18)	128.87±4.65	0.187±0.009	0.041±0.001	0.139±0.003	1.163±0.061	0.068±0.002	0.209±0.008	0.541±0.055	0.068±0.003	0.475±0.017
Female sheep	20 (11)	131.37±6.4	0.184±0.013	0.042±0.001	0.14±0.004	1.15±0.09	0.068±0.003	0.206±0.011	0.521±0.075	0.067±0.004	0.457±0.022
Male sheep	20 (7)	126.37±6.87	0.191±0.012	0.041±0.002	0.138±0.005	1.176±0.085	0.069±0.003	0.213±0.012	0.561±0.082	0.07±0.004	0.494±0.027
Female lambs	10 (5)	148.2±8.39	0.21±0.018	0.043±0.002	0.138±0.004	1.292±0.138	0.067±0.004	0.171±0.007	0.625±0.127	0.068±0.005	0.402±0.023
Male lambs	10 (3)	144.5±9.14	0.222±0.012	0.043±0.002	0.124±0.004	1.38±0.104	0.062±0.005	0.174±0.01	0.67±0.117	0.068±0.004	0.404±0.021
Female adults	10 (6)	112.67±4.88	0.156±0.0155	0.041±0.001	0.142±0.007	0.992±0.093	0.069±0.004	0.244±0.012	0.406±0.058	0.066±0.006	0.518±0.03
Male adults	10 (4)	106.2±4.8	0.156±0.013	0.038±0.002	0.153±0.007	0.95±0.092	0.077±0.002	0.256±0.011	0.439±0.107	0.072±0.008	0.593±0.026
G <sub>1</sub> (≤1 year)	21 (9)	146.4±6.1 <sup>a</sup>	0.216±0.011 <sup>a</sup>	0.043±0.002	0.131±0.003 <sup>a</sup>	1.336±0.085 <sup>a</sup>	0.065±0.003	0.172±0.006 <sup>a</sup>	0.648±0.084 <sup>a</sup>	0.068±0.003 <sup>a</sup>	0.403±0.015 <sup>a</sup>
G <sub>2</sub> (1 years≤ and <3 years)	9 (3)	110.7±4.7 <sup>b</sup>	0.15±0.014 <sup>b</sup>	0.038±0.002	0.147±0.006 <sup>ab</sup>	1.017±0.086 <sup>ab</sup>	0.076±0.003	0.24±0.008 <sup>b</sup>	0.539±0.086 <sup>ab</sup>	0.081±0.006 <sup>ab</sup>	0.551±0.029 <sup>b</sup>
G <sub>3</sub> (3 years≤)	10 (6)	108.2±5.2 <sup>b</sup>	0.161±0.014 <sup>b</sup>	0.041±0.001	0.149±0.008 <sup>b</sup>	0.926±0.096 <sup>b</sup>	0.07±0.003	0.26±0.014 <sup>b</sup>	0.306±0.064 <sup>b</sup>	0.057±0.006 <sup>b</sup>	0.56±0.029 <sup>b</sup>

<sup>ab</sup> Values with different letters in each part of columns are significantly different (P<0.05).

n: Number of Animals (Sinus Tachycardia Cases)

**Table 2.** The configurations of ECG waves in different genders and age groups of Kermani sheep recorded in base-apex lead.

	n	P Wave		QRS Wave			T Wave*	
		+	+/-	QRS	RS	QS	+	+/-
All sheep	40	39	1	33	1	6	37	3
Female sheep	20	19	1	15	1	4	17	3
Male sheep	20	20	0	18	0	2	20	0
Female lambs	10	9	1	8	0	2	10	0
Male lambs	10	10	0	8	0	2	10	0
Female adults	10	10	10	7	1	2	7	3
Male adults	10	10	0	10	0	10	10	0
G <sub>1</sub> ( $\leq 1$ year)	21	20	1	16	0	4	21	0
G <sub>2</sub> (1 years $\leq$ and $< 3$ years)	9	9	0	8	0	1	9	0
G <sub>3</sub> (3 years $\leq$ )	10	10	0	9	1	1	7	3

\*Significant difference between G<sub>1</sub> and G<sub>3</sub> groups (P<0.05).

n: Number of Animals

### Discussion

The Kermani sheep is a medium-sized (mature weight ranging from 45 to 50 kg), fat-tailed and dual-purpose (meat and wool) breed, which is well adapted to the dry and hot climate conditions with low-quality pastures (Barazandeh et al., 2012).

Electrocardiography is a non-invasive diagnostic technique, which has been introduced as the method of choice for evaluation of electrical activity of heart and diagnosis of abnormalities in the cardiac rhythm. It is believed that the base-apex lead is the best and the most standard lead for monitoring cardiac arrhythmias; so, it is used routinely in large animal medicine (Rezakhani et al., 2004b). Previous studies about ECG parameters in healthy fat-tailed sheep were done seldomly. To the authors' knowledge, there is no research regarding the normal ECG values in Kermani sheep.

In the current study, sinus arrhythmia (45%) was the only observed abnormality in Kermani sheep. Sinus arrhythmia has been introduced as a normal physiological arrhythmia that occurs due to variation in vagal tone (Radostits et al., 2007). Rezakhani and Edjehadi (1980) reported that the sinus arrhythmia was common in fat-tailed sheep, and had the highest prevalence in sheep with lower heart rates. In the present study, animals with sinus arrhythmia had a lower heart rate (126.24 $\pm$ 6.3 vs. 131 $\pm$ 6.8, respectively); however, the difference was not statistically significant. Accordance with our finding, sinus arrhythmia has been reported as a common cardiac rhythm irregularity (with

a prevalence of 50-90%) in different breeds of goats too (Rezakhani and Khajedeji, 2001; Tajik et al., 2013). This arrhythmia has also been reported the most common dysrhythmia in cattle, with food deprivation or anorexia due to gastrointestinal problems (Rezakhani et al., 2004a). In contrary, none of the animals in the current study had the clinical sign of heart problem or cardiac insufficiency or had suffered from anorexia.

In the present study, mean heart rate in Kermani sheep was 128.87 $\pm$ 4.65 beats/min, which was slightly higher than other reports. Smith (2009) described 60-120 beats/min for adult sheep and 120-160 beats/min for lambs (Smith, 2009) while 70-90 beats/min for sheep and 102 beats/min in non-specified breed of the fat-tailed sheep reported by other researchers (Radostits et al., 2007; Rezakhani and Edjehadi 1980). However, it was relatively similar to Baluchi breed of fat-tailed sheep 120.4 beats/min (Shojaeian, 2012). In our study, regardless of insignificant differences between two sexes, the heart rate had a negative significant relationship with the age of animals. Our finding is in accordance with other studies in which influence of the age was described in Baluchi and Kordi breeds of fat-tailed sheep (Tajik, 2012), and cattle (Rezakhani et al., 2004b). However, higher heart rate in female sheep other than males was found in Baluchi breed (Shojaeian, 2012; Tajik, 2012), and reverse findings in Kordi breed of fat-tailed sheep were reported (Tajik, 2012).

According to our results, simple positive was the main configuration of P wave in the base-apex lead in Kermani breed in agreement with those previously

reported for Baluchi, Kordi and Galla sheep and goat (Mohan et al., 2005; Tajik, 2012). In contrary, Tovar et al. (1985) reported a biphasic P wave as the dominant shape in sheep, and believed that an increment in the heart rate shifts it to be simple.

In the present study, there was no significant difference between two sexes of Kermani sheep in the amplitude and duration of ECG waves. Same results have been found in Kordi and Baluchi sheep, and goat (Tajik, 2012; Tajik et al., 2013), although increased P amplitude in male animals than females have been reported in horses and donkeys (Escudero et al., 2009). On the other hand, there was an age-related decrease in amplitude of ECG waves in Kermani sheep similar to other breeds of sheep (Tajik, 2012; Tovar et al., 1985), while no significant difference has been found in goat (Tajik et al., 2013). Rezakhani et al. (2004a) also reported a positive correlation between amplitude of P wave and age in the base-apex lead in dairy cows. Difficulty in the waves reaching the body surface in adults due to gradual development of body mass has been proposed as the cause in sheep (Tajik, 2012).

Duration of ECG waves showed no significant difference between two sexes; however, the duration of T waves in G<sub>1</sub> group was significantly less than in G<sub>3</sub> group in the current study. Same results for the duration of P wave have been reported in Kordi and Baluchi fat-tailed sheep (Tajik, 2012) and goat (Tajik et al., 2013); even so, an age-related increment has been found in Merino sheep (Tovar et al., 1985). No significant difference between two sexes in QRS duration has been found in Baluchi sheep (Tajik, 2012) and goat (Tajik et al., 2013), but higher values in male animals other than females have been reported in Kordi sheep and donkey (Escudero et al., 2009; Tajik, 2012). Higher QRS complex duration in older animals compared with younger ones has been described in Baluchi sheep (Tajik, 2012), dairy cattle (Rezakhani et al., 2004b) and horses (Physick-Sheard and Hendren, 1983), and it is believed that may be due to the concurrent increment in myocardial mass relative to development of body mass (Physick-Sheard and Hendren, 1998). No relationship between the duration of T wave and age has been found in Kordi and Baluchi sheep (Tajik, 2012) and goat (Tajik et al., 2013); however, higher duration in male than in females has been reported in Kordi sheep and Horse (Tajik, 2012).

In Kermani sheep, the configuration and amplitude of T wave showed little variability. In comparison, different T wave has also been reported in donkey (Escudero et al., 2009) and cattle (Rezakhani et al., 2004b). Rezakhani et al. (2004b) believed that T wave is

variable in large animals and cannot be used in diagnosis of cardiac problems.

There are a few previous studies regarding the effects of age and sex on ECG intervals in animals. Regardless statistically insignificant differences, the durations of P-R, Q-T and R-R intervals were higher in males other than females in this study. However, our results showed a significant difference between three age groups. Same results about P-R and Q-T intervals have been found in Kordi and Baluchi sheep (Tajik, 2012) and goat (Tajik et al., 2013), although longer P-R and Q-T intervals in males other than females have been reported in horse (Alidadi et al., 2002), and higher body mass in male animals has been proposed as the cause (Tajik, 2012). Additionally, similar findings have been reported about lower P-R, R-R and Q-T intervals in young animals than older animals in Kordi and Baluchi sheep (Tajik, 2012) and horse (Alidadi et al., 2002). Larger myocardial mass in adults has been proposed as the cause (Tajik, 2012). Moreover, higher heart rate in the G<sub>1</sub> group may affect the R-R interval in this group. It seems that little difference between body mass of males, and females cause the results in two sexes.

In conclusion, determination of ECG parameters is essential for diagnosis of ECG abnormalities in Kermani sheep. This study provides baseline information on this breed, future studies must be performed with larger groups of animals to compare our study. Our results showed a little effect of sex on ECG parameters in the base-apex lead in Kermani sheep; however, the age of animals may affect the ECG parameters in this breed.

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