http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet

Asian Network for Scientific Information

308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 17 (5): 689-695, 2014
ISSN 1028-8880 / DOI: 10.3923/pjbs.2014.689.695

Reference Values of Six-limb-lead Electrocardiogram in Conscious Labrador Retriever Dogs

Mudasir Bashir Gugjoo, Mozammel Hoque, Abhishek Chander Saxena and
Malik Mohamed Sham-Suz Zama
Division of Surgery, Indian Veterinary Research Institute-Izatnagar,
Bareilly, U.P-243122, India

Abstract: Breed-wise standard electrocardiographic values in dogs have been reported as there is variation in body and chest conformation, which limits the application of data of one breed for other breed. Labrador retrievers being originated from hunting dogs, their electrocardiogram (ECG) values might be different from standard normal range of other dog breeds. So, the purpose of the present study was to determine the standard ECG of Labrador retrievers and to check effect of body weight, gender and breed upon different ECG parameters. Six-lead ECGs, three bipolar standard limb leads (I, II and III) and three augmented unipolar limb leads (aVR, aVL and aVF), were taken from 24 Labrador retrievers positioned in right lateral recumbency without any chemical restraint. Amplitude and duration of P wave and QRS complex, PR interval, QT interval and mean electrical axis and heart rate were measured in each recording. Non-significant effect of gender and body weight was seen on all the ECG waves. Deep Q waves in Leads I, II and aVF and variation in relation to QRS pattern were noted. It was concluded that retrievers had a specific shape of QRS complex which must be considered when evaluating a patient suspected of having cardiac disease. However, amplitude and durations of different ECG waves in all the six leads were statistically not affected by gender or body weight.

Key words: Breed, electrocardiogram, labrador retrievers, six limb lead values

INTRODUCTION

The cardia is an electrically charged organ (an electrical generator) in the thoracic cavity. Thus, information such as heart rate (HR), cardiac rhythm, conduction integrity and the theoretical axis can be detected through an electrocardiogram (ECG) (De Caterina *et al*., 2012). ECGs of healthy dogs have been reported mainly by using standard bipolar limb lead II. The individual ECG records forces in only one direction whilst the situations occurring in clinical practice are three-dimensional and correspondingly more complicated. The multiple electrocardiographic leads are obviously necessary to indicate the variations of distribution of heart within the thorax (Hsieh and Hsu, 2012). Significant breed differences in ECG parameters in healthy dogs have been reported which may be due to variations in thoracic cavity shape or due to genetic differences (Avizeh *et al*., 2010; Vailati *et al*., 2009). The purpose of this study was to provide and establish a more comprehensive set of ECG reference values and to evaluate the effect of breed, sex and body weight (BW) on electrocardiogram of healthy Labrador retriever dogs.

MATERIALS AND METHODS

The study was conducted on 24 clinically healthy Labrador retriever dogs of both sexes with body weight ranging from 18-30 kg in right lateral recumbency. None of dogs had clinical history of heart disease. Prior to the recording, their health conditions were carefully validated by physical examination, thoracic radiography, echocardiography and blood chemical analysis. None of the dog had any heart murmur or a gallop rhythm. All dogs were free from circulating microfilaria examined by modified Knott's method. Routine electrocardiographic recordings were made with a single channel electrocardiograph (Cardiart®) at the paper speed of 50 mm sec^{-1} and calibration of 10 mm equal to 1 mV. The Cardiart® thermo-sensitive ECG recording paper (BPL India Ltd.), having a total width of 50 cm and a recording width of 40 mm was used. One small box on vertical and horizontal axis was taken equal to the 0.1 mv and 0.02 sec, respectively. During recording, each dog was manually restrained without any tranquilizer or anaesthetic and maintained in right lateral recumbency. Four limbs were placed perpendicular to the long axis of

Corresponding Author: Mudasir Bashir Gugjoo, Division of Surgery, Indian Veterinary Research Institute-Izatnagar, Bareilly, U.P-243122, India

the body and each limb was held parallel to the corresponding one (Fig. 1). Recordings were obtained for all the standard bipolar limb leads and augmented unipolar limb leads *viz.* leads I, II, III, aVR, aVL and aVF (Fig. 2 a-f). Amplitude of P, Q, R, S and T waves were measured together with durations of PR interval, QRS interval and QT interval. Mean electrical axis and HR were also measured. Mean electrical axis was calculated by finding the lead with isoelectric QRS complex (Q and R waves are of same amplitude) and the axis perpendicular to that lead was taken as Mean Electrical Axis (MEA). In some of the cases, which did not showed isoelectric QRS deflection, other procedures as per Tilley (1992) were used for calculation.

Fig. 1: Right lateral recumbent animal for six-limb-lead ECG recording

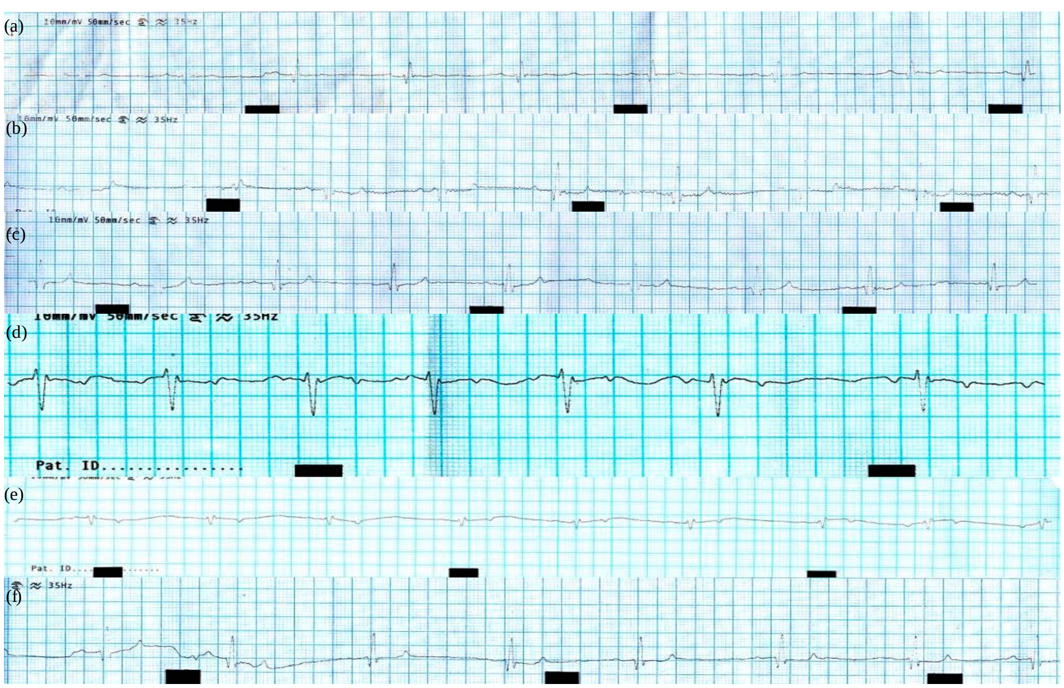

Fig. 2 (a-f): (a) Standard bipolar limb lead I (b) Standard bipolar limb lead II (c) Standard bipolar limb lead III (d) Augmented unipolar limb lead aVR (e)Augmented unipolar limb lead aVL and (f) Augmented unipolar limb lead aVF

Statistical analysis: The data was analysed for statistical significance using SPSS software version 15.0 (SPSS, Inc., Chicago, IL). One way analysis of variance and Duncan's Multiple Range Test (DMRT) were used to compare the means among different groups based on body weight and gender. In each analysis, the differences were considered significant at a value of $p<0.05$. Grouping of animals on the basis of the body weight was done wherein Group 1-3 had animals of body weight in the range of 18-22, >22-26 and >26-30 kg, respectively.

RESULTS

The amplitude and duration of ECG waves are shown in Table 1 and 2, respectively. Data on the basis of body weight and gender is given in Table 3 and 4, respectively. Q wave amplitude appeared to be quite larger while rest of the parameters were well within the range specified for other dog breeds and are shown in Table 1. Non-significant effect of the body weight and gender was observed on the computed values for each wave in all the six limb leads (Table 3, 4). Positive P wave polarities of all dogs were recorded in leads I, II and aVF and negative polarities in lead aVR and aVL. In lead III, P wave was negative in two dogs only and in rest positive. Examining P wave amplitude in general was found to be well within the range specified for other dog breeds. Q wave was found to be directed negatively in the leads I, II, III and aVF and absent in leads aVR and aVL in most of the animals. The maximal Q wave amplitude appears in the ECG of lead II. Q wave was found to be quite deep in this study. Positive polarity of R wave was found in all the six limb leads viz., I, II, III and aVF and aVR and aVL. The maximal R wave amplitudes for dog has been found in the standard lead II and minimum amplitude in lead aVL of ECG. R wave amplitude was found to be well within the range specified for other dog breeds. S wave was found to be deepest in the lead aVR and absent in Lead I. Specific shape of QRS complex of ECG in Labrador retrievers (Table 5) were observed. Frequent change in T wave polarity was observed. The minimum and the maximum values of mean electrical axis obtained were 40° and 90° and the Mean±SE obtained was 75.4±3.92° (Table 2). Mean electrical axis was found to be well in the range specified for other dog breeds. The minimum and the maximum values of heart rate obtained were 90.0 and 124.0 beats/min. Mean±SE obtained for heart rate was 101.4±1.53 beats min^{-1} (Table 2). Heart rate in the present study was found to be slightly lower as compared to the standardized values for general dog population.

DISCUSSION

Electrocardiographic values of different dog breeds have been established including the Labrador retrievers (Sato *et al*., 2000) though not in detail as the study have not correlated the ECG values with body weight and gender of the breed. Also the QRS pattern of different leads in the present study has been established in detail. The present study was conducted in conscious animals in right lateral recumbency. ECG can be recorded in different positions viz., standing, sternal or lateral (left or right). Since the ECG of dogs recorded in different positions yield dramatically different results, so it is preferable to use position-specific reference ranges for comparison to minimize potential misinterpretation of ECG results (Rishniw *et al*., 2002). Also, no anaesthetic agent was used to handle the animals during ECG recording. There occur significant changes in different ECG waves with application of different anaesthetic agents (Kim *et al*., 2010; Owczuk *et al*., 2008). While evaluating the electrocardiographic findings, data should be compared with the one taken in the same protocol.

P wave is the first deflection on electrocardiogram and represents atrial depolarisation, which spreads radially from the sinoatrial (SA) node to the atrioventricular (AV) node. Positive P wave polarities of all dogs were recorded in leads I, II and aVF and negative polarities in lead aVR and aVL. In lead III, P wave was also positive except in two dogs where it was negative. This variation could be due to the dependence of P wave polarity on the electrical axis and impulse transmission in the conduction system of the heart (Upeniece, 2004). The mean P wave amplitude values (0.21 mV) in Lead II was higher than the normal values (0.191 mV) given by Avizeh *et al*. (2010) but lower than those given by

Table 1: The amplitude of waves of ECG in Labrador retriever dogs

Parameter	I (mV)	II (mV)	III (mV)	aVR (mV)	aVL (mV)	aVF (mV)
P wave	0.07±0.004	0.21±0.009	0.14±0.008	0.13±0.007	0.064±0.004	0.19±0.005
Q wave	0.27±0.020	0.47±0.026	0.29±0.026	-	-	0.29±0.013
R wave	0.64±0.036	1.95±0.070	1.27±0.065	0.39±0.026	0.19±0.0190	1.48±0.041
S wave	-	0.18±0.017	0.18±0.017	1.38±0.035	0.22±0.0110	0.069±0.004
T wave	-	0.43±0.008	0.27±0.065	0.22±0.024	0.24±0.0230	0.34±0.04

Lead I: Right arm (-) compared with left arm (+), Lead II: Right arm (-) compared with left leg (+), Lead III: Left arm (-) compared with left leg (+), Lead aVR: Right arm (+) compared with left arm and left leg (-), Lead aVL: Left arm (+) compared with right arm and left leg (-), aVF: Left leg (+) compared with right and left arm (-)

Table 2: The intervals and duration of each measurement of ECG, heart rate and mean electrical axis in labrador retriever dogs

Parameters	Values
P wave	0.04±0.000
PR interval	0.099±0.001
QRS complex	0.050±0.001
QT interval	0.210±0.007
Mean electrical axis	75.400±3.92°
Heart rate	101.400±1.53

Table 3: Mean±SE of the amplitudes of different waves in six-Limb-lead ECG among different groups

Parameter	Group 1	Group 2	Group 3
Lead I			
P wave (mV)	0.07±0.0060	0.06±0.0080[a]	0.073±0.007[a]
Q wave (mV)	0.25±0.0370	0.26±0.0480[a]	0.31±0.0450[a]
R wave (mV)	0.65±0.0800	0.61±0.0500[a]	0.65±0.0500[a]
Lead II			
P wave (mV)	0.21±0.0140[a]	0.21±0.0130[a]	0.20±0.0230[a]
Q wave (mV)	0.46±0.0300[a]	0.46±0.0300[a]	0.49±0.0600[a]
R wave (mV)	1.94±0.0800[a]	1.93±0.1200[a]	2.00±0.1800[a]
S wave (mV)	0.17±0.0270[a]	0.17±0.0310[a]	0.17±0.0250[a]
T wave (mV)	0.33±0.0400[a]	0.29±0.0400[a]	0.35±0.0700[a]
Lead III			
P wave (mV)	0.14±0.0190[a]	0.14±0.0120[a]	0.14±0.0110[a]
Q wave (mV)	0.31±0.0490[a]	0.29±0.0550[a]	0.31±0.0430[a]
R wave (mV)	1.28±0.1200[a]	1.31±0.1400[a]	1.22±0.0800[a]
S wave (mV)	0.19±0.0210[a]	0.18±0.0360[a]	0.18±0.0350[a]
T wave (mV)	0.31±0.0500[a]	0.31±0.0850[a]	0.24±0.0350[a]
Lead aVR			
P wave (mV)	0.13±0.0120[a]	0.12±0.0160[a]	0.13±0.0130[a]
R wave (mV)	1.07±0.0800[a]	1.12±0.0700[a]	1.03±0.0700[a]
S wave (mV)	0.19±0.0380[a]	0.19±0.0430[a]	0.22±0.0250[a]
T wave (mV)	0.22±0.0190[a]	0.21±0.0230[a]	0.22±0.0250[a]
Lead aVL			
P wave (mV)	0.064±0.007[a]	0.066±0.008[a]	0.063±0.008[a]
R wave (mV)	0.55±0.0400[a]	0.52±0.0400[a]	0.55±0.0500[a]
S wave (mV)	0.22±0.0190[a]	0.22±0.0190[a]	0.23±0.0230[a]
T wave (mV)	0.24±0.0290[a]	0.24±0.0170[a]	0.25±0.0210[a]
Lead aVF			
P wave (mV)	0.19±0.0110[a]	0.19±0.0160[a]	0.19±0.0110[a]
Q wave (mV)	0.31±0.0220[a]	0.28±0.0210[a]	0.29±0.0280[a]
R wave (mV)	1.48±0.0550[a]	1.45±0.0500[a]	1.51±0.1040[a]
S wave (mV)	0.070±0.008[a]	0.067±0.007[a]	0.070±0.008[a]
T wave (mV)	0.37±0.0400[a]	0.31±0.0200[a]	0.36±0.0400

[a](Values with same superscript differ non-significantly; p>0.05)

Table 4: Mean±SE of the amplitudes of different waves in male and female animals

Parameter	Male	Female
Lead I		
P wave (mV)	0.07±0.0060*	0.07±0.006*
Q wave (mV)	0.28±0.0300*	0.26±0.030*
R wave (mV)	0.64±0.0560	0.64±0.046*
Lead II		
P wave (mV)	0.21±0.0120*	0.21±0.017*
Q wave (mV)	0.45±0.0400*	0.47±0.020*
R wave (mV)	1.96±0.1500*	1.84±0.110*
S wave (mV)	0.19±0.0260*	0.17±0.025*
T wave (mV)	0.35±0.0500*	0.30±0.030*
Lead III		
P wave (mV)	0.15±0.0140*	0.14±0.009*
Q wave (mV)	0.30±0.0410*	0.34±0.038*
R wave (mV)	1.20±0.0940*	1.35±0.087*
S wave (mV)	0.19±0.0260*	0.17±0.025*
T wave (mV)	0.29±0.0350*	0.28±0.029*
Lead aVR		
P wave (mV)	0.13±0.0090*	0.13±0.012*
R wave (mV)	1.15±0.0730*	1.01±0.041*
S wave (mV)	0.19±0.0320*	0.20±0.026*
T wave (mV)	0.22±0.0190*	0.21±0.017*
Lead aVL		
P wave (mV)	0.061±0.006*	0.065±0.007*
R wave (mV)	0.55±0.0390*	0.53±0.030*
S wave (mV)	0.22±0.0160*	0.22±0.016*
T wave (mV)	0.25±0.0180*	0.24±0.018*
Lead aVF		
P wave (mV)	0.19±0.0060*	0.20±0.008*
Q wave (mV)	0.29±0.0190*	0.29±0.019*
R wave (mV)	1.48±0.0500*	1.48±0.070*
S wave (mV)	0.068±0.005*	0.070±0.006*
T wave (mV)	0.35±0.0300*	0.34±0.030*

(Values with same superscript differ non-significantly; p>0.05)

Burman *et al.* (1966) and Too and Umemoto (1959), where it was 0.250 and 0.288 mV, respectively. However, values in general were well within the range given for German shepherd (Rezakhani *et al.*, 1990) and Beagles (Osborne and Leach, 1971) and equal to those given by Sato *et al.* (2000). This variation may be explained by the fact that there is dependence of P wave amplitude on the heart rate and breed of the animal. Also the variations in P wave amplitude may result due to stress that dogs undergo during the electrocardiographic examinations (Avizeh *et al.* 2010). Non-significant effect of gender on P wave was observed in all the six limb leads. This finding was similar to the other previous reports (Su *et al.*, 2002; Hanton and Rabemampianina, 2006; Changkija, 2007). However, Upeniece (2004) showed that the P wave of lead I and aVF were significantly correlated with the sex and body weight. Analysis on the basis of body weight also did not showed any significant effect on its amplitude. Similar findings were also reported by the others (Su *et al.*, 2002). However, a report on Mastin Espanol breed (Bernal *et al.*, 1995) and Littermate mongrels (Avizeh *et al.*, 2010) showed significant increase in P wave amplitude with the increase in body weight.

The term enlargement is used in conditions like right atrial hypertrophy and/or dilatation where tall P waves are seen in leads II, III and aVF. The latter portion of the P wave as is produced by the left atrial depolarisation, so in left atrial enlargement, the P wave is of increased duration and is best seen in Lead II (Tilley, 1992).

The Q wave represents the electrical transmission through interventricular septum and was found to be present in Lead I, II, III and aVF and absent in lead aVR and aVL. This finding was similar to those reported by Burman *et al.* (1966). However, a report by Avizeh *et al.* (2010) and Bernal *et al.* (1995) showed presence of Q wave in almost all the leads. Compared to values given for general dog population, Q wave was found to be quite deep in this study in leads I, II and aVF as also reported by Sato *et al.* (2000). Such a finding could be possibly related to thoracic peculiarities of different

Table 5: QRS patterns of ECG (%) in Labrador retriever

Leads	qR	Qr	R	QS	qRs	qrS	Rs	qRsr'	rS	rSr'
I	94.5	3.2	2.7	1.25	0.0	0.0	0.0	0.00	0.0	0.0
II	52.5	0.0	0.0	0.00	46.3	0.0	1.2	0.00	0.0	0.0
III	22.5	0.0	0.0	0.00	66.0	0.0	9.5	1.75	0.0	0.0
aVR	0.0	0.0	0.0	1.20	0.0	8.5	0.0	0.00	91.2	0.0
aVL	1.5	0.0	0.0	0.00	0.0	14.0	0.0	0.00	78.0	6.5
aVF	16.0	0.0	0.0	0.00	73.5	0.0	11.0	0.00	0.0	0.0

Lead I: Right arm (-) compared with left arm (+), Lead II: Right arm (-) compared with left leg (+); Lead III: Left arm (-) compared with left leg (+), Lead aVR: Right arm (+) compared with left arm and left leg (-), Lead aVL: Left arm (+) compared with right arm and left leg (-), aVF: Left leg (+) compared with right and left arm (-)

dog breeds and also due to the reason that the depth of the Q wave is connected with the activation processes of cardiac ventricles i.e., different distribution of Purkinje fibers in the ventricular walls. Statistical analysis on the basis of body weight and sex showed non-significant differences in the Q wave amplitude as was reported by Bernal *et al*. (1995). However, a report on Littermate mongrels reported a significant difference with respect to gender. The reason given was significant differences in body weight among males and females.

The R wave is the most commonly used clinical measurement of the left ventricular function and is considered a good indicator of ventricular compliance and contractility. Mean R wave values in present study were larger than those reported for Littermate mongrels but smaller than those of Doberman Pinschers (Kovacevic *et al*., 1999). The reason for higher values compared to Littermate mongrels could be due to the larger size of dogs in our study. An enlarged ventricle with an increased surface area and thickened walls produces greater potential. Also there is breed dependence of R wave amplitude with larger breed having large R wave amplitude (Tilley, 1992). Analysis of the data revealed slightly higher but statistically non significant values in males compared to females. This finding was similar to the reports by others (Avizeh *et al*., 2010; Changkija, 2007) in lead II. On the contrary, higher R wave amplitude in female Dalmatians (Mazue *et al*., 1975) and Mastin Espanol (Bernal *et al*., 1995) were reported compared to males. Non-significant differences were observed between groups when compared with respect to the body weight. Similar findings were also reported in previous studies (Su *et al*., 2002; Hanton and Rabemampianina, 2006; Changkija, 2007). However, a report on Mastin Espanol (Bernal *et al*., 1995) and Littermate mongrel dogs (Avizeh *et al*., 2010) showed significant increase in R wave amplitude with the increase in body weight, possibly owing to the predominance in the development of the left ventricle at the end of the first week of age (Bernal *et al*., 1995).

The term enlargement is mostly used in conditions causing hypertrophy and/or dilatation of left ventricle. The heart is composed mainly of left ventricle. Because of the order of depolarization and dominance of the left ventricle, the right ventricle must be markedly enlarged to cause changes on the electrocardiogram. Right ventricular enlargement therefore, is often not detectable by electrocardiography (Tilley, 1992).

The S wave was found to be deepest in the lead aVL and absent in lead I. However, Avizeh *et al*. (2010) reported absence of S wave in Littermate mongrels after 3 weeks of age. The reason cited was that S wave values are quite variable and are greatly influenced by the different techniques used in the recording of the ECGs. The decrease in the S wave in recordings taken after the second week reflects the increasing predominance of the left ventricle. Non-significant effect of gender and body weight was seen on S wave as also reported by Su *et al*. (2002) in Taiwanese dogs. T wave amplitude was well within the normal limits i.e., not greater than 25% of the amplitude of R wave. Changes in the polarity of the T wave were more frequent and these changes are possibly related to the influence of the autonomic nervous system. Changes of the T wave in lead II can be caused by the elevation of the diaphragm that occurs during respiration (Tilley, 1992).

In relation to QRS pattern, among the standard limb leads, most of the dogs showed qR pattern in Lead I, qR and qRs patterns in Lead II and in Lead III, qRs was found in most of the animals but some cases also showed qR pattern. Among augment unipolar limb leads, most of the dogs showed rS pattern in aVR. rS pattern was also predominantly seen in aVL but some dogs also showed qrS and rSr' and in lead aVF, qRs followed by qR and Rs patterns was observed. The differences in morphology of the QRS complex could be due to the different distribution of Purkinje fibers in the ventricular walls. Other reasons for wave morphology differences could be the position of the animal and the different electrocardiographic techniques used.

P wave duration represents the atrial depolarisation time. P wave duration was well within the range specified for other dogs (Tilley, 1992; Edwards, 1987) and similar to those reported in German shepherd (Rezakhani *et al*., 1990) and Hound dogs (Blumenthal *et al*., 1996). However, higher values were reported in Mongrels

(Venkateshwarlu *et al.*, 1977) and Alaskan sled dogs (Hinchcliff *et al.*, 1997). PQ interval represents the time required for an impulse to travel from the SA node to the ventricle. Values obtained in present study were comparable to those reported for other breeds (Tilley, 1992). However, values obtained in Littermate mongrels below 2 weeks old were less comparable to 3 weeks or greater of age. The reason cited was that newborns have a lower level of vagal tone because the myocardial sympathetic nervous innervations is not completed at birth and responses of the autonomic nervous system in the newborn are decreased compared with adults (Avizeh *et al.*, 2010). QRS interval represents the duration of ventricular depolarisation. Non-significant effect of gender and body weight was found on all these durations. These findings were well supported by reports of previous workers (Changkija, 2007). Since the latter portion of the P wave is produced by the left atrium, so in left atrial enlargement, the P wave is of increased duration. PQ interval is used to check any kind of heart block as in such cases its duration increases. There is increase in QRS complex duration during the ventricular enlargement (Tilley, 1992).

QT interval is the summation of ventricular depolarisation and repolarisation and represents ventricular systole. In all the 6 leads investigated, practically similar values were observed as reported in previous reports for general dog population. Q-T interval values were between wide ranges, but this is generally considered as normal (Avizeh *et al.*, 2010; Bavegems *et al.*, 2009). There is clear evidence of the influence of the autonomic nervous system on the Q-T interval due to the sympathetic innervations of the heart, the action of catecholamines and vagal activity.

Mean Electrical Activity (MEA) refers to the average direction of the electrical activity of heart during cardiac cycle. The thoracic shape of various breeds affects the MEA and the normal range for dogs varies between +40° and +100° as were seen in the present study (+40 to +90). MEA was calculated by using different methods as in some cases isoelectric QRS complexes were absent. There is no difference in the values of the MEA while calculating by different methods (Spasojevic-Kosic, 2011). In general, it is reported that breeds with a narrow thorax (Collie, French poodle and German shepherd breed) had a more vertical axis on the frontal plane than those with a broader thorax (Cocker Spaniel and Boxer) which had an intermediate axis (Avizeh *et al.*, 2010; Gonin, 1962). MEA, in Labrador retrievers, which have moderately broad chest, was found to be 75.4±3.92° in the present study. Non-significant effect of the gender or body weight was observed on MEA.

Heart rate was calculated according to the P-P or R-R intervals. Heart rate was found slightly lower (101.4±1.53 beat min^{-1}, range-90-124 beats/min) compared to the values specified for Dalmatian (Kovacevic *et al.*, 1999; Tilley, 1992). The possible reason could be the predominance of parasympathetic tone over sympathetic tone in animals having regular exercise as Labrador retrievers used under study were mostly army trained. Non-significant effect of gender and body weight was seen on heart rate. There are contrasting reports over the gender effect on heart rate. Some workers (Changkija, 2007; Vailati *et al.*, 2009; Bernal *et al.*, 1995) have reported higher heart rate in females compared to males while others (Kovacevic *et al.*, 1999) reported higher heart rate in males compared to females. The possible reason for gender difference could be the effect of adrenergic system on heart rate. There is predominance of parasympathetic tone over sympathetic tone in animals having regular exercise (Bavegems *et al.*, 2009). The difference in body weight could also affect the heart rate (Vailati *et al.*, 2009) as there is large basal metabolic rate in animals of higher surface area (small body weight) compared to the animals with small surface area (large body weight). Regarding body weight similar findings were also reported by other workers (Ferasin *et al.*, 2010) as seen in our study. They reported that heart rate seen higher in young animals compared to mature ones are more related to their demeanour or age and dogs less than 12 months of age have higher heart rate.

CONCLUSION

It was concluded that majority of the parameters were well in the normal range specified for other dog breeds. However, significant difference was found with respect to the QRS complex shape which should be kept in mind whenever evaluating the ECG. Also there are non-significant differences in ECG parameters of all the six leads with respect to gender or body weight.

ACKNOWLEDGMENT

The authors are thankful to the Director of Indian Veterinary Research Institute, Izatnagar for providing the necessary facilities.

REFERENCES

Avizeh, R., A.A. Papahn, R. Ranjbar, A.R. Rasekh and R. Molaee, 2010. Electrocardiographic changes in the littermate mongrel dogs from birth to six months of life Iran. J. Vet. Res., 11: 304-310.

Bavegems, V., L. Duchateau, L. van Ham, A. De Rick and S.U. Sys, 2009. Erratum to Electrocardiographic reference values in whippets. Vet. J., 182: 59-66.

Bernal, L.J., A.M. Montes, M.J.F. del Palacio and C.G. Panizo, 1995. Electrocardiographic changes in the growing Mastin. Espanol. J. Small Anim. Pract., 36: 221-228.

Blumenthal, S.R., M.A. Vonderhaar, L.P. Tilley, C.L. Pulliam and B.E. Gordon, 1996. P-wave duration in a clinically normal hound population. Lab. Anim. Sci., 46: 211-214.

Burman, S.O., S. Kahn and P. Panagopoulos, 1966. The electrocardiogram of the normal dog J. Thoracic Cardiovasc. Surg., 51: 379-382.

Changkija, B., 2007. Electrocardiographic studies in dogs with reference to management of cardiac tachyarrythmia by alternative drugs. Ph.D Thesis, IVRI, Izatnagar, India.

De Caterina, R., S. Husted, L. Wallentin, F. Andreotti and H. Arnesen *et al*., 2012. New oral anticoagulants in atrial fibrillation and acute coronary syndromes: ESC working group on thrombosis-task force on anticoagulants in heart disease position paper. J. Am. Col. Cardiol., 59: 1413-1425.

Edwards, N.J., 1987. Bolton's Hand Book of Canine and Feline Electrocardiography. 2nd Edn., W.B. Saunders Co., Philadelphia, pp: 1-80.

Ferasin, H., L. Ferasin and C.J. Little, 2010. Lack of correlation between canine heart rate and body size in veterinary clinical practice. J. Small Anim. Pract., 51: 412-418.

Gonin, P., 1962. On the position of electrical axis of the heart in dogs. Inaug Diss, Berlin, pp: 1-31.

Hanton, G. and Y. Rabemampianina, 2006. The electrocardiogram of the Beagle dog: Reference values and effect of sex, genetic strain, body position and heart rate. Lab. Anim., 40: 123-136.

Hinchcliff, K.W., P.D. Constable, J.W. Farris, K.E. Schmidt and R.L. Hamlin, 1997. Electrocardiographic characteristics of endurance-trained Alaskan sled dogs. J. Am. Vet. Med. Assoc., 211: 1138-1141.

Hsieh, J. and M. Hsu, 2012. A cloud computing based 12-lead ECG telemedicine service. BMC Medical Inform. Decision Making, Vol. 12. 10.1186/1472-6947-12-77

Kim, S.H., S.Y. Park, W.S. Chae, H.C. Jin, J.S. Lee and Y.I. Kim, 2010. Effect of desflurane at less than 1 MAC on QT interval prolongation induced by racheal intubation. Br. J. Anaesthesiol., 104: 150-157.

Kovacevic, A., M. Duras and T. Gomercic, 1999. Contribution to standardisation of heart rate and electrocardiographic values in Doberman pinschers. Vet. Arch., 69: 211-219.

Mazue, G., J. Berthe, M. Serre and B. Dupius, 1975. Analysis of the electrocardiogram of Dalmatian dogs. Rec. Med. Vet., 126: 1289-1294.

Osborne, B.E. and G.D.H. Leach, 1971. The beagle electrocardiogram. Food Cosmet. Toxicol., 9: 857-864.

Owczuk, R., M.A. Wujtewicz, W. Sawicka, A. Piankowski, A. Polak-Krzeminska, E. Morzuch and M. Wujtewicz, 2008. The effect of intravenous lidocaine on QT changes during tracheal intubation. Anaesthesia, 63: 924-931.

Rezakhani, A., R.B. Atwell and J. Webster, 1990. Electrocardiographic values of German Shepherd dogs. Aust. Vet. J., 67: 307-309.

Rishniw, M., F. Porciello, H.N. Erb and G. Fruganti, 2002. Effect of body position on the 6-lead ECG of dogs. J. Vet. Intern. Med., 16: 69-73.

Sato, H., Y. Fujii and Y. Wakao, 2000. Standard electrocardiographic values in normal retrievers. Adv. Anim. Cardiol., 33: 11-15.

Spasojevic-Kosic, L.J., 2011. Comparison of two methods in the determination of heart's mean electrical axis in dogs. Savremena Poljoprivreda, 60: 190-194.

Su, W.L., K. Too, M.H. Wang, Y.N. Jiang and M.J. Pan, 2002. Reference values of six-limb-lead ECG in conscious Taiwanese dogs. Adv. Anim. Cardiol., 35: 86-95.

Tilley, L.P., 1992. Essentials of Canine and Feline Electrocardiography. In: Interpretation and Treatment, Cann, C.C. (Ed.). Vol. 3. Lea and Febiger, Philadelphia.

Too, K. and H. Umemoto, 1959. Studies on clinical applications of electrocardiogram on dogs I: Electrocardiogram of shepherd dogs and karafuto (saghalien) dogs. Jap. J. Vet. Res., 7: 215-245.

Upeniece, D., 2004. Electrocardiophysiological parameters of the Cocker Spaniel Rottweiler and German Shepherd dogs. Ph.D Thesis, Latvia University of Agriculture, Faculty of Veterinary Medicine Preclinical Institute, Jelgava.

Vailati, M.C.F., A.A. Camacho, D.S. Schwartz, M.L.G. Lourenco, R.K. Takahira, S.R.V. Franco and S. Da, 2009. Electrocardiographic findings in Boxer dogs. Veterinaria e Zootecnia, 16: 698-707.

Venkateshwarlu, K., N.S. Sunder and P.C. Choudhuri, 1977. Electrocardiographic observations in healthy dogs. Indian Vet. J., 74: 155-158.