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Swagat Mohapatra
Department of Veterinary Physiology, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Ambika Prasad Khadanga Mahapatra
Department of Veterinary Physiology, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Shivani Das
Department of Veterinary Physiology, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Lipika Priyadarsini
Department of Veterinary Physiology, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Ritun Patra
Department of Veterinary Anatomy and Histology,
College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Nirupama Dalai
Department of Veterinary Physiology, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Geeta Rani Jena
Department of Veterinary Clinical Medicine, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Corresponding Author
Swagat Mohapatra
Department of Veterinary Physiology, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

An electrocardiographic study in Spitz dogs: Reference values and comparison among age groups

Swagat Mohapatra, Ambika Prasad Khadanga Mahapatra, Shivani Das, Lipika Priyadarsini, Ritun Patra, Nirupama Dalai and Geeta Rani Jena

Abstract
ECG is a simple and fast diagnostic tool used in canine practice to detect arrhythmias, conduction disturbances, myocardial infarction, electrolyte imbalance etc. While interpreting ECG in dogs, breed and age need to be contemplated as there might be variation in electrocardiogram due to difference in overall morphology of heart. The present study was conducted to investigate the age related changes in electrocardiogram of Spitz dogs and introspect the reasons behind them. Client owned apparently healthy Spitz dogs were categorized into four groups with respect to their age viz., Group 1: Dogs above 6 months and below 1 year of age, n= 15; Group 2: Dogs above 1 year and below 3 years of age, n= 15; Group 3: Dogs above 3 years and below 5 years of age, n= 15 and Group 4: Dogs above 5 years of age, n= 15. Electrocardiograph was set with a paper speed of 25 mm/sec and sensitivity of 1 (1 cm= 1mv) and the ECG was recorded in the dogs positioned in right lateral recumbency. P wave amplitude in dogs belonging to group 1 and group 2 was significantly (P<0.05) lower than the dogs belonging to groups 3 and 4. The amplitude of Q wave, duration of P wave, QRS complex duration and T wave duration did not vary significantly among groups. Dogs belonging to group 1 were found to have significantly lower QRS amplitude from those belonging to groups 2, 3 and 4. Amplitude of T wave did not follow a specific trend although group 3 differed significantly from groups 1 and 4. The heart rate in group 1 was significantly higher from all other groups. Group 4 recorded significantly higher P-R interval than groups 1, 2 and 3. Group 4 recorded significantly higher QT interval than groups 1, 2 and 3. R-R interval in Group I was significantly lower than other groups. However, groups 1, 2 were found to have significantly lower P-R segment duration with respect to groups 3 and 4. S-T segment of groups 2 and 4 was significantly higher from group 1. The T-P segment of group 1 was significantly lower than groups 2, 3 and group 4. The study reported the baseline ECG values in Spitz dogs with respect to age groups.

Keywords: ECG, dogs, spitz, age

1. Introduction
Cardiovascular diseases are reported in the animal populations and most of them are related to genetic factors (Parker *et al*., 2006) [18], improper diet (Smith *et al*., 2021) and obesity (Pongkan, 2020) [19]. Domestic animals are exposed to a variety of biotic and abiotic stress factors. Thermal stress is defined as conditions of extreme environmental temperature leading to disruption in homeostasis of animals (Parida *et al*., 2020) [16]. Heat stress in cattle leads to alteration in cardiac electrical activity and injury to myocardial cells (Mohapatra *et al*., 2021). Thermal stress has detrimental effect on cardiac cells of goats (Parida *et al*., 2020) [17].
Approximately 10-15% of all dogs are affected with cardiac diseases (Hoque *et al*., 2019) [3]. Canine patient owners should be aware of the symptoms of cardiac diseases like exercise intolerance, frequent coughing, dyspnoea, reduced appetite, cyanosis, noticeable weight gain or less, swelling in abdomen and report appropriately to veterinarian for an early diagnosis of cardiac disorder. Accurate diagnosis and treatment of cardiac diseases is warranted to curb down morbidity and mortality in dogs. Electrocardiograph is a voltmeter (or galvanometer) that records the electrical activity in the heart by means of positive and negative electrodes (Martin M, 2001). The proper interpretation of electrocardiogram in dogs needs to take age groups and breeds into account considering the existence of a large number of breeds. Age specific changes in electrocardiographic parameters have been reported by our previous studies conducted on German Shepherd dogs (Mohapatra *et al*., 2013) [13], Labrador Retriever dogs (Mohapatra *et al*., 2015) [7], Ganjam sheep (Mohapatra *et al*., 2015) [7], cats (Sarangi *et al*., 2016) [23], Large White Yorkshire piglets (Mohapatra *et al*., 2016) [8], Black Bengal Goats (Pradhan *et al*., 2017) [21] and cows (Mohapatra *et al*., 2017) [12].

The present study was designed to investigate the age related changes in electrocardiogram of Spitz dogs and introspect the reasons behind them. The values of the ECG parameters of clinically healthy Spitz dogs taken into consideration in this study will serve as baseline values for the veterinary practitioners to detect ECG abnormalities in Spitz dogs.

2. Materials and Methods

The study was conducted at the Department of Veterinary Physiology, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha in collaboration with the Veterinary Clinical complex, College of Veterinary Science and Animal Husbandry, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, India during the year 2021-22.

Client owned apparently healthy Spitz dogs presented to the clinic for the purpose of vaccination or routine health check were categorized into four groups with respect to their age viz Group 1: dogs above 6 months and below 1 year of age, n= 15; Group 2: dogs above 1 year and below 3 years of age, n= 15; Group 3: dogs above 3 years and below 5 years of age, n= 15 and Group 4: dogs above 5 years of age, n= 15.

A 12-lead standard ECG recorder, Cardiart 108 T-MK VII-BPL, India was used for evaluation of cardiac status of all the dogs. No pharmacological preparations were used and the ECG was taken after the dogs were comfortably settled on an wooden table. The ECG machine was set for a paper speed of 25 mm/sec and sensitivity of 1 (1 cm= 1mv) with the filter 'on'. The ECG was recorded with the dog in standard body position (Mohapatra *et al*., 2015) [7] restrained in right lateral recumbency on a wooden table with the legs positioned parallel to each other and perpendicular to the long axis of the body and keeping the head and neck flat on the table. The chain or lease of the animal is removed along with the collar to avoid any metallic interference. The skin and electrodes were moistened by the gel. The owner was asked to be present near the dog to keep the dog calm and comfortable. The attendant holding the dog in the right position was asked to wear rubber gloves. The right forelimb (RA) and left forelimb (LA) electrodes were placed proximal to the olecranon on the caudal aspect of the respective forelimbs and the right hind limb (RF) and left hind limb (LF) electrodes were placed over the patellar ligament on the anterior aspect of the respective hind limbs as described by Mohapatra *et al*., 2012 [9]. The cables attached to the electrodes were made to fall on the table and not over the body of the animal. A minimum of 6 complexes each in II, III were recorded.

3. Statistical analysis

All the data of the entire study was analyzed using Microsoft excel and processed using SPSS 11.00 for windows, adopting a significant level of 95 percent (P<0.05) in all cases.

4. Results and Discussion

The results mentioned here are in accordance to table 1.

Table 1: Electrocardiographic Parameters of Spitz Dog in Different Age Groups

Age Group	P-wave Amplitude(mV)	P-wave Duration (sec)	Q-wave Amplitude (mV)	QRS amplitude (mV)	QRS Duration (sec)	S-wave Amplitude (mV)	T-wave Amplitude (mV)	T-wave Duration (sec)
Group-1	0.19 ± 0.01^{a}	0.04 ± 0.008	0.09 ± 0.02	0.7 ± 0.05^{a}	0.02 ± 0.004	0.12 ± 0.012^{a}	0.23 ± 0.012^{b}	0.07 ± 0.004
Group-2	0.18 ± 0.01^{a}	0.03 ± 0.004	0.08 ± 0.02	1.2 ± 0.07^{b}	0.02 ± 0.004	0.06 ± 0.018^{a}	0.16 ± 0.02^{ab}	0.06 ± 0.009
Group-3	0.21 ± 0.01^{b}	0.03 ± 0.004	0.06 ± 0.02	1.18 ± 0.05^{b}	0.02 ± 0.004	0.05 ± 0.02^{a}	0.14 ± 0.02^{a}	0.05 ± 0.009
Group-4	0.29 ± 0.04^{ab}	0.04 ± 0.0	0.10 ± 0.03	1.02 ± 0.17^{ab}	0.02 ± 0.004	0.08 ± 0.012^{ab}	0.24 ± 0.04^{b}	0.06 ± 0.008

Group 1: Dogs above 6 months and below 1 year of age.
Group 2: Dogs above 1 year and below 3 years of age.
Group 3: Dogs above 3 years and below 5 years of age.
Group 4: Dogs above 5 years of age.

Age Group	Heart Rate (bpm)	P-R Interval (sec)	Q-T Interval (sec)	R-R Interval (sec)	P-R Segment (sec)	S-T Segment (sec)	T-P Segment (sec)
Group-1	144.54 ± 3.34^{b}	0.08 ± 0.006^{a}	0.12 ± 0.012^{a}	0.41 ± 0.009^{a}	0.04 ± 0.004^{a}	0.06 ± 0.008^{a}	0.10 ± 0.008^{a}
Group-2	116.80 ± 4.55^{a}	0.09 ± 0.007^{ac}	0.16 ± 0.012^{b}	0.51 ± 0.026^{b}	0.06 ± 0.009^{a}	0.08 ± 0.009^{b}	$0.15 \pm 0.01\ 3^{b}$
Group-3	112.42 ± 4.20^{a}	0.10 ± 0.006^{c}	0.15 ± 0.008^{b}	0.53 ± 0.02^{b}	0.08 ± 0.009^{b}	0.07 ± 0.004^{ab}	0.15 ± 0.008^{b}
Group-4	120.65 ± 7.50^{a}	0.12 ± 0.01^{b}	0.19 ± 0.008^{c}	0.50 ± 0.027^{b}	0.08 ± 0.007^{b}	0.08 ± 0.004^{b}	0.17 ± 0.02^{b}

Note: Different superscripts A B C read column wise differs significant at 5% level (P<0.05).

4.1 Amplitude and duration of P-wave

P wave in ECG represents depolarization of atria. One-way analysis of variance revealed that the amplitude of P wave of dogs belonging to group 1 had no significant difference (P>0.05) from dogs belonging to group 2. Similarly, the dogs belonging to group 3 had no significant difference from those of dogs belonging to group 4. However, P wave amplitude in dogs belonging to group 1 and group 2 were significantly (P<0.05) lower from the dogs belonging to group 3 and group 4. Our findings are in coherence with findings of Mohapatra *et al*., 2013 [13] who reported higher P waves in older age groups in comparison to younger age groups in German Shepherd dogs. P-wave amplitude increased steadily until approximately eight years of age in dogs (Murphy *et al*., 2022) [15]. Interestingly, the duration of P wave which is a marker of atrial conduction had no significant difference (P>0.05) between the dogs belonging to group 1, group 2, group 3 and group 4.

4.2 Amplitude of Q-wave

Q wave is caused by initial depolarization of left side of ventricular septum with respect to right side. In our study, spitz dogs belonging to group 1, group 2, group 3 and group 4 had no significant difference between them. In contrary, Mohapatra *et al*., 2015 [7] found decreasing amplitude of Q wave with respect to advancing age in Labrador dogs. The difference in findings might be attributed to breed as Labrador Retriever is a heavier breed than Spitz. Accordingly, the anatomy of heart will certainly vary.

4.3 Amplitude and duration of QRS complex

QRS complex in ECG represents ventricular depolarization.

Amplitudes of QRS complex greater than 2.5 mV might be indicative of ventricular enlargement (Martin, 2001). The amplitude of QRS complex of dogs belonging to group 2 had no significant difference from dogs belonging to group 3 and group 4. However, the dogs belonging to group 1 were found to have significantly lower amplitude from those belonging to group 2, 3 and 4. The findings are in concurrence with findings of Mukherjee *et al*., 2020 [14]. Ventricular size increases with advancement of age (Kerkhof *et al*., 1998) [4] which might be the reason behind such results. Duration of QRS complex represents the time taken for ventricular depolarization. There was no significant difference in between the age groups as far as the duration of QRS complex was concerned.

4.4 Amplitude of S-wave
S wave indicates the final depolarization of the ventricles at base of the heart. S amplitude in dogs of different age groups had no significant difference amongst each other.

4.5 Amplitude of T-wave
Ventricular repolarization is represented by T wave of ECG and T wave occurs just before the end of ventricular contraction. Transient deep and giant negative T waves have been reported in dogs with myocardial damage (Romito and Cipone, 2021) [22]. Analysis of variance revealed that the amplitude of T wave of dogs belonging to group 2 had no significant difference from dogs belonging to group 1, group 3 and group 4. However, the dogs belonging to group 3 differed significantly from the dogs belonging to group 1 and group 4. T wave is highly variable in dogs and cats (Tiley, 1998).

4.6 Duration of T-wave
The duration of T-wave amongst different age groups of the dogs were not found to be significantly different from each other.

4.7 Heart rate
The heart rate measured from ECG (1500/R-R) in group 1 was significantly higher from all other groups although the other groups viz. 2, 3 and 4 had no significant difference amongst each other. Increased nervous activity in strange environment might be the reason behind higher heart rates in younger dogs (Mohapatra *et al*., 2013) [13].

4.8 Duration of P-R Interval
P-R interval represents atrio-ventricular conduction time. The P-R interval of group 1 and 2 had no significant difference among each other, same was the case between group 2 and 3. But, group 4 recorded significantly higher P-R interval than group 1, 2 and 3. The P-R interval is inversely correlated with heart rate. Since, heart rate was reportedly lower in older aged dogs in the present investigation, accordingly P-R interval was higher in older groups.

4.9 Duration of Q-T Interval
QT interval denotes duration of depolarization of the ventricles and the time required to complete the repolarization of ventricles. It is has an inverse exponential relationship with heart rate. Multifactorial affections of QT interval has been reported viz circadian rhythm, nervous system activity, duration of cardiac cycle, age group, gender, electrolyte concentrations and ion channels involved in cardiac repolarization (De Ponti *et al*., 2002; Luo *et al*., 2004) [2, 5]. A number of studies in dogs have revealed that uncorrected baseline QT values are within normal range at similar heart rates (Agudelo *et al*., 2011) [1]. The Q-T interval of group 2 and 3 had no significant difference among them but both were found to be significantly different from group 1 and 4. Similarly, group 4 recorded significantly higher QT interval than group 1, 2 and 3.

4.10 Duration of R-R Interval
The R-R interval was found to have no significant difference between groups 2, 3 and 4 but was found to be varying significantly from group 1. The R-R interval represents one cardiac cycle.

4.11 Duration of P-R Segment
The PR segment is the portion of the isoelectric line in the electrocardiogram from the end of the P wave to the beginning of the QRS complex. Group 1 and 2 were not found to bear any significant difference between each other, a similar pattern was observed between groups 3 and 4. However, groups 1, 2 were found to have significantly lower duration with respect to groups 3,4.

4.12 Duration of S-T Segment
Group 2, 3 and 4 did not differ significantly from each other in case of S-T segment but varied significantly from group 1.

4.13 Duration of T-P Segment
The T-P segment of group 1 was significantly different from group 2, 3 and group 4.

5. Conclusion
The study reported the baseline ECG values in Spitz dogs with respect to age groups and delineated the age-related changes in electrocardiogram construing the reasons thereof.

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