



## The Surface Electrocardiogram in Unanesthetized Adult Domestic Cats (*Felis catus*)

Jafrin Ara Ahmed<sup>1\*</sup>, Nawab Nashiruddin<sup>2</sup> and Dipanjali Konwar<sup>3</sup>

<sup>1</sup>Division of Veterinary Physiology & Biochemistry, Faculty of Veterinary Sciences & Animal Husbandry, Sher-e-Kashmir University of Agricultural Sciences & Technology-Jammu, Ranbir Singh Pura, Jammu & Kashmir, INDIA

<sup>2</sup>Division of Veterinary Pathology, Faculty of Veterinary Sciences & Animal Husbandry, Sher-e-Kashmir University of Agricultural Sciences & Technology-Jammu, Ranbir Singh Pura, Jammu & Kashmir, INDIA

<sup>3</sup>Division of Livestock Production & Management, Faculty of Veterinary Sciences & Animal Husbandry, Sher-e-Kashmir University of Agricultural Sciences & Technology-Jammu, Ranbir Singh Pura, Jammu & Kashmir, INDIA

\* Corresponding author: JA Ahmed; Email: jafrinahmed@rediffmail.com

Received: 25 April, 2016

Accepted: 31 August, 2016

### ABSTRACT

The purpose of this study was to describe and suggest normal surface electrocardiographic values of the unanaesthetized indigenous domestic cat (*Felis catus*), reared commonly as a household pet throughout India. Twenty cats, aged between 1-4 years, averaging 2.2 kg body weight (ranging from 1.1 – 3.1 kg) were chosen randomly for the study. Recordings were made using standard limb leads (I, II and III) and augmented limb leads (aVR, aVL and aVF) in right lateral recumbency with a single channel electrocardiograph. The heart rate, normal ECG waves, complexes and intervals were recorded during the study. A sinus rhythm was observed in all animals selected and studied. No ectopic complexes or arrhythmias, nor any abnormalities in electrocardiographic patterns were recorded. Estimated mean heart rate in the cat was  $233.4 \pm 2.34$  beats per minute. The P-R interval and Q-T interval observed in the cat occupied approximately 31 and 69% respectively, of the total electrical cycle. The results of the present study give a fair approximation of the normal ECG values described earlier for the cat. The observed results would be helpful as a guideline to the clinician for perceiving the abnormal electrographic parameters in the domestic cat when diagnosing specific cardiac abnormalities during their clinical presentations.

**Keywords:** Cat, electrocardiogram, heart rate

Electrocardiograph (ECG) is a transthoracic interpretation of the electrical activity of the heart over time by an electrocardiographic device. It has proven to be an important laboratory test in the diagnosis and management of cardiac disease. Most animals with cardiac lesions typically remain asymptomatic and become apparent clinically until very late in the progression of disease. The first and most important step in electrocardiographic interpretation is to differentiate between normal and abnormal, and to correlate the abnormal components with the normal defined cardiac entities (Tilley, 1992).

Electrocardiographic studies to describe the electrical activity of heart in various animals are evident in the literature. Although very few reports on feline electrocardiography have been published (Lourenço and

Ferreira, 2003), the normal heart rhythm described are generally regular (Tilley, 1992; Abbot, 2005), varying from sinus rhythm to sinus tachycardia (Yamaki, 2014). Studies have demonstrated that size and form of heart may vary amongst breeds and influence ECG parameters (Tilley, 1992; Ahmed and Sanyal, 2008) even amongst closely related species (Oda *et al.*, 2009). A careful perusal of literature showed that breed-wise ECG values in cats have been limitedly described (Ghif *et al.*, 2007) except for Angora cats (Atmaca *et al.*, 2014). It was therefore pertinent to describe a set of normal ECG values for common household cat generally found throughout India as a nondescript breed that often find themselves presented as clinical patients requiring electrocardiographic evaluation.



## MATERIALS AND METHODS

### Animals

Twenty normal domestic cats (*Felis catus*) aged between 1 to 4 years consisting equally of male and female animals were included in the study. The average weight of cat was 2.2 kg (ranging between 1.1 – 3.1 kg). All the cats were randomly chosen household pet animals from the vicinity of the institution and were studied at their resident environment with the consent of the respective owners.

### Clinical examinations

All cats appeared healthy after a thorough physical examination. Animals were evaluated as normal based on no recorded clinical history of disease.

### Electrocardiography

The ECG recordings were made by using a single channel electrocardiograph (CARDIART 108 T/ MK-VI, BPL India, India). Three standard limb leads (I, II and III) and three augmented limb leads (aVR, aVL and aVF) were used, as per method described previously for feline electrocardiography (Tilley, 1992). Sites for electrode attachment were trimmed with scissors and the leads were placed proximal to the olecranon on the caudal aspect of the approximate forelimb and over the patellar ligament on the cranial aspect of the appropriate hind limb. To facilitate electrical conduction, skin and electrode was lubricated with a commercial cardiac gel. To obtain ECG recordings, animals were restrained and handled manually in right lateral recumbency on a rubber sheet as has been described as a standard procedure for canines and felines (Ferasin *et al.*, 2006; Bublot *et al.*, 2006). Positioning was consistent to avoid QRS axis changes. The animals were allowed to acclimatize for 10-15 minutes before each recording. ECG recordings were taken in the morning hours to avoid variations of cardiac activities due to circadian rhythm. 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 50 mm/second 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 and expressed in beats per minute (bpm).

### Amplitude of waves

The amplitude of P, R/S and T wave was recorded for all three standard bipolar limb leads (Lead I, II and III) 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, Q to T interval, and T waves were calculated from both the standard bipolar leads and unipolar leads.

## RESULTS AND DISCUSSION

The observed mean SE values for different wave amplitudes (P, R/S and T wave) and intervals (P, P-R interval, QRS complex, Q-T interval and T waves) recorded during the study has been presented in Table-1. A sinus rhythm was observed in all animals under the study. The mean heart rate in the cats studied was  $233.4 \pm 2.34$  bpm and ranged between 230 and 240 bpm. These values are in accordance with those reported by Tilley (1992), Ware (1999), Lourenço and Ferreira (2003), and Atmaca *et al.* (2014). It has been observed that the heart rate was reportedly lower in older cats, when animals of two age groups were compared (Ware, 1999). In the present study, the accelerated heart rate values in the younger cats are therefore reasonable than those previously described for aged animals. This may be due to a predominant sympathetic system during neonatal period in contrast to the adult parasympathetic predominance (Davidowski and Wolf, 1984).

Recordings were traced consistently in the morning hours as earlier twenty-four-hour ambulatory electrocardiographic reports suggest significant changes in the average, minimum and maximum heart rates related to time of day that rose from mid-afternoon to about 21:00 hrs and become lowest just after midnight (Ware, 1999). Anesthesia was also avoided due to the adverse effects on heart function, potentially affecting the electrocardiographic parameters (Piskin *et al.*, 1999).

**Table 1:** Mean and standard error of means of ECG wave amplitude and duration in the unanesthetized adult cat

Leads	wave amplitude (millivolts)			wave duration (seconds)				
	P	R/S	T	P	PR interval	QRS	QT interval	T
I	0.090 ± 0.008	0.138 ± 0.016	0.256 ± 0.031	0.032 ± 0.002	0.050 ± 0.009	0.030 ± 0.000	0.112 ± 0.002	0.064 ± 0.004
II	0.096 ± 0.002	0.156 ± 0.010	0.178 ± 0.034	0.032 ± 0.002	0.052 ± 0.002	0.034 ± 0.002	0.116 ± 0.002	0.070 ± 0.005
III	0.086 ± 0.008	0.148 ± 0.007	0.226 ± 0.022	0.034 ± 0.003	0.058 ± 0.002	0.038 ± 0.002	0.120 ± 0.003	0.066 ± 0.003
aVR	0.080 ± 0.008	0.152 ± 0.014	0.292 ± 0.005	0.036 ± 0.002	0.058 ± 0.002	0.036 ± 0.003	0.120 ± 0.003	0.070 ± 0.005
aVL	0.078 ± 0.007	0.152 ± 0.010	0.230 ± 0.020	0.038 ± 0.002	0.058 ± 0.002	0.036 ± 0.003	0.124 ± 0.002	0.064 ± 0.004
aVF	0.092 ± 0.008	0.152 ± 0.014	0.178 ± 0.019	0.030 ± 0.003	0.056 ± 0.004	0.038 ± 0.002	0.132 ± 0.005	0.060 ± 0.003

The mean amplitude of P, R/S and T wave and mean duration of P, P-R interval, QRS complex, Q-T interval and T waves exhibited slight variations between cats. Interpretatively, minor differences in amplitudes (less than 0.1 mV) and likewise duration less than 0.02 seconds may not be considered clinically relevant.

The duration of P and QRS waves and PR interval were similar to those described in adult cats (Tilley, 1992; Ettinger, 2000; Lourenço and Ferreira, 2003).

The average observed P wave voltage indicative of atrial depolarization was lower than those of adult cats (Tilley, 1992; Ettinger, 2000; Lourenço and Ferreira, 2003) but however within range limits described previously (Atmaca *et al.*, 2014). These variations may be due to breed and weight differences.

Duration of P and QRS waves, PR and QT intervals values were within the range described for adult kittens (Nara *et al.*, 1986; Lourenço and Ferreira, 2003; Silva *et al.*, 2005; Atmaca *et al.*, 2014) although average values were often found to vary.

In general, the variability in the wave (form and amplitude) of the ECG may be attributed as Breazile (1971) suggests 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 ventricles. Variations in electrocardiographic parameters between animals were observed in time to time recordings of the present study. Some authors observe these variations as particularly common for QRS complex either in the same animal or between animals of the same and different species (Swenson and Reece, 1996; Ayala *et al.*, 1998). Reportedly in cats, arrhythmias (Yamaki, 2014), atrial or ventricular extra-systoles (Nara *et al.*, 1986) are common

findings, particularly in aged cats of 8-14 years (Ware, 1999; Yamaki, 2014). However, they were not recorded in the present study.

When comparing the electrocardiograph parameters of cats with other animals, both similarities and variations in waveforms were noticed. The time occupied by the P-R and Q-T intervals in the ECG of animals depends on the heart rate (Prosser and Brown, 1975). The P-R interval and Q-T interval observed in the present study in the cat approximately occupied 31 and 69% of the total electrical cycle respectively. Earlier attempts to compare the ECG parameters with similar sized mammals such as the three toed sloth (*Bradypus variegates*), rabbit and cats showed variability on the waveform patterns due to differing heart rate in these groups of animals (Silva *et al.*, 2005). For comparison, the slower heart rate (81 bpm) of the three-toed sloth and monkey share approximately 26 and 74% PR and QT interval (Silva *et al.*, 2005).

The results of the present study give a fair approximation of the normal ECG values described earlier for the cat. No abnormalities in electrocardiographic patterns were recorded. The observed values would be helpful as a guideline to the clinician for perceiving the abnormal electrographic parameters in the domestic cat when diagnosing specific cardiac abnormalities.

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