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Full Length Research Paper

Six-Lead Electrocardiographic Studies of the Pigeon (*Columba livia*) in Nigeria

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ABSTRACT

In this study, the normal electrocardiogram of apparently normal, conscious pigeons was described. Standard bipolar and augmented unipolar limb leads were recorded in a total of apparently healthy 30 pigeons. Waveforms were analyzed in all the leads at 50 mm/s and 10 mm/mV. P-wave was monophasic and positive in leads I, II, III, aVL and aVF but negative in aVR. Heart rate ranged from 205 to 342 beats/min with a mean ($\pm$ SD) of 276.0 ± 42.9 beats/min. The MEA ranged between -99 to -90 degrees. The predominant QRS pattern in lead I was rs while the rS was predominant in leads II, III and aVR. The r and Qr morphologies were observed in leads aVF and aVL respectively. ST slurring was found in all the leads. The ECG values and patterns recorded in these clinically healthy pigeons will facilitate better understanding of ECG changes that are seen in diseases and are expected to provide a comparison to aid clinical diagnosis

Keywords: *Electrocardiogram, Pigeons, Limb leads.*

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INTRODUCTION

The electrocardiogram (ECG), a graphic representation of the electrical activity of the heart is a useful diagnostic tool in the evaluation of the cardiovascular system. It is a useful tool for the clinical assessment of patients subsequent to severe trauma, electrocution, or toxicoses and also for the clinical diagnosis and monitoring of several cardiac and whole body abnormalities including arrhythmias, conduction disorders and electrolyte imbalances (Hassanpour *et al.*, 2010; Cushing *et al.*, 2013). Despite its great clinical applicability, avian practitioners have given relatively little attention to electrocardiography probably because of scarcity of reference values in companion, zoo and wild birds (Hassanpour *et al.*, 2014). Although the avian cardiovascular system shares many similarities with those of mammals, several unique and specific details exist. The mass of the avian heart is nearly twice as large as that of a mammal of comparable size and it is designed to meet high-performance demands (Krautwald-Junghanns *et al.*, 2004) as such, stroke volume in avians species is bigger and cardiac output is higher than those of mammals. Consequently, avian heart rate can be as high as 1000 beats/min depending the species (Pees and Krautwald-Junghanns, 2009) allowing for high demands of oxygen during activities like flight, running or diving (de Wit and

Schoemaker, 2005). The cardiac electrical conduction system of birds is similar to that of mammals consisting of a sinoatrial node, an atrioventricular node, and Purkinje fibers. The primary pacemaker is the sinoatrial node which conducts the electrical impulse to the atrioventricular node and by way of the atrioventricular bundle to the ventricles. There is an additional atrioventricular ring which functions to make fast depolarization of the ventricles (Sturkie and Whittow, 2000). The avian ECG differs from those of humans and some other mammals because the depolarization wave of the avian ventricle moves from the epicardium to the endocardium (Lumeij and Ritchie, 1994). Changes in the avian ECG have been reported in some infectious diseases such as *Escherichia coli*, Newcastle and influenza virus infections as well non-infectious conditions such as thiamine deficiency and hyperkalemia (Espino *et al.*, 2001). This study was designed to evaluate the electrocardiographic characteristics of apparently healthy pigeons in Nigeria as reference values to aid detection of variations in clinical conditions.

MATERIALS AND METHODS

Pigeons

A total of thirty adults/juveniles pigeons (*Columba livia*) obtained from a live-bird market in Ibadan, Nigeria were used

in this study. The pigeons were weighed and clinically examined to ascertain their health status. They were kept on a floor pen and placed on feed comprising whole sorghum grains and broiler finisher of 18% crude protein and water ad libitum. The birds were acclimatized to their new environment for 14 days prior to ECG recordings.

ECG recordings

The ECGs were recorded using a 6/7 lead computer ECG machine (EDAN VE-1010, Shanghai, China). The machine was calibrated at 10mm/mV sensitivity and 50mm/s paper speed. Recordings were done without sedation or anaesthesia. Birds were manually and gently restrained in right lateral recumbency on an insulated platform. Electrocardiographic alligator clips were attached as earlier described (Casares *et al.*, 2000). Briefly, clips were attached at the base of the right and left-wing web and also at the right and left thigh. An additional precordial lead was applied to the left side of the sternum over the area of the heart. Electrocardiographic gel was used to establish good skin contact. Standard bipolar (I, II, III) and augmented unipolar (aVR, aVL and aVF) leads were recorded for each pigeon. Amplitudes and durations of the waveforms were measured in all the leads. Mean electrical axis was determined as described by Martinez *et al.*, (1997).

Statistical analysis

Descriptive statistics of the data obtained was done using the SPSS 23 software.

RESULTS

Table 1.

Electrocardiographic parameters of bipolar and augmented unipolar limb leads in the pigeon

	P-wave duration (ms)	PR-interval (ms)	QRS duration (ms)	R-amplitude (mV)	QT interval (ms)	QTc (Bazett)
Lead I	22.1±5.0	45.5±7.6	15.4±4.7	0.175±0.07	77.9±18.8	167.9±48
Lead II	27.5±4.2	47.0±6.7	14.6±4.9	0.291±0.16	90.4±12.6	193.9±36.6
Lead III	20.7±5.2	37.5±6.4	18.4±5.1	0.200±0.12	87.1±10.7	186.3±30.1
AVR	26.0±5.3	48.3±6.8	19.4±10.1	0.540±0.31	84.6±10.3	181.5±31.3
AVL	20.4±4.9	44.9±9.1	19.5±3.4	0.370±0.18	82.0±16.0	175.7±40.8
AVF	23.9±3.8	44.5±11.1	19.2±6.2	0.18±0.12	87.1±12.0	186.5±33.8

The weight of the birds ranged between 160 g and 276g with a mean bodyweight of 217g. Normal sinus rhythm was recorded in all the pigeons studied and no arrhythmias were observed in any of them. Heart rate ranged from 205 to 342 beats/min with a mean ($\pm$ SD) of 276.0±42.9 beats/min. In lead I, the predominant QRS pattern was rs while the rS pattern was found predominantly in leads II, III and aVR. The r and Qr morphologies were found in leads aVF and aVL, respectively. ST slurring was found in all the leads. The P-wave was monophasic and was positive in leads I, II, III, aVL and aVF but was negative in lead aVR. T wave was positive in leads I, II, III and aVF while it was negative in leads aVR and aVL. Mean electrical axis was -99 to -90 degrees

DISCUSSION

Electrocardiography is a useful tool for the evaluation of cardiac function of animals in both infectious and non-infectious conditions (Olkowski and Classen, 1998; Hassanpour *et al.*, 2009). Just like in mammalian species, ECG parameters differ significantly among avian species (Nap *et al.*, 1992; Machida and Aohagi, 2001). This study was conducted in birds without anesthesia because of the known effects of anesthetic agents on heart rate and QT interval (Nap *et al.*, 1992; Tilley, 1992; Burtinck and Degernes, 1993). Average heart rate in this study was similar values reported in pouler pigeons by Lopez Marcia *et al.*, (2005) but lower than what was earlier reported in homing pigeons by Naddaf *et al.*, (2006).



Figure 1

Standard bipolar limb lead Electrocardiogram in a clinically normal pigeon (50mm/s, 10mm/mV)



Figure 2:

Unipolar limb lead electrocardiogram of a clinically normal pigeon (50mm/s, 10mm/mV)

This might be attributable to the physiological response of birds to environmental factors such as ambient temperature and relative humidity (Donkoh, 1989). The avian heart rate is affected by factors such as exercise, age, conditions, stress factors, toxins, diet, body fat and blood pressure (Lumeij and Ritchie, 1994).

Normal sinus rhythm was observed in all the pigeons evaluated in this study similar to the study by Lopez Marcia *et al.*, (2005) in the Spanish pouler pigeon. The recorded positive P-wave in leads I, II, III, aVL and aVF is similar to the findings in earlier studies conducted in conscious raptors (Pees and Krautwald-Junghanns, 2009). The phenomenon of ST-slurring, as observed in this study, has been described in pigeons in which they either have a short ST segment or none at all (Lumeij and Stochhof, 1985). However, while Lopez *et al* (2004) and Papahn *et al* (2006) reported this phenomenon in 46.8 and 42.2 % of pigeons sampled, respectively, it was detected in all pigeons sampled in this study. The cause of ST-slurring in birds is not fully understood but it is considered insignificant (Nap *et al.*, 1992) however in mammals, its occurrence is associated with cardiac disease (Bolton, 1975; Castellanos and Meyerburg, 1986). In this study, no Ta wave was observed. In the dog, the Ta wave is a sign of right atrial hypertrophy (Tilley, 1985) but it is considered normal in birds (Lumeij and Sthokof, 1985; Boulianne *et al.*, 1992).

The QT-interval, measured from the beginning of the Q-wave to the end of the T-wave, is a measure of the beginning to the end of ventricular depolarization. Lead II QT interval in our study was 90.4 ± 12.6 ms. This is similar to earlier findings in pigeons (Lumeij and Stokhof, 1985; Lopez Murcia *et al.*, 2005; Papahn *et al.*, 2006), Eurasian kestrel (Talavera *et al.*, 2008) and Golden eagles (Hassanpour *et al.*, 2010). In dogs and cats, prolongation of the QT interval may be reported with drug toxicities, electrolyte imbalance, central nervous system disease and strenuous exercise (Tilley and Smith, 2015). Negative MEA as recorded in this study (-99 to -90), is characteristic of the avian ECG and this implies the negative polarity of the QRS complex in leads II, III and aVF (Hassanpour *et al*, 2011). This is the major difference between the avian ECG and those of the dog, cat or man (Tilley, 1992). Negative MEA polarity in birds stems from the fact that the depolarization wave in the ventricles originates from the subepicardium and spreads through the myocardium to the endocardium, whereas in the dog, ventricular depolarization starts from the sub-endocardium (Lumeij and Ritchie, 1994).

This study adds to existing body of knowledge on avian electrocardiography and would act as a clinical guide for veterinary clinicians and researchers studying the cardiovascular system of pigeons.

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