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Communication

[*Comunicação*]

Electrocardiographic evaluation of baby opossum (*Didelphis albiventris*)

[*Avaliação eletrocardiográfica de gambás bebê (Didelphis albiventris)*]

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An electrocardiogram (ECG) is essential to determine heart rate and rhythm. This method is the only one capable of diagnosing cardiac arrhythmias and electrical conduction disorders (Santilli *et al*., 2018), and ECG abnormalities in neonates (Heier *et al.,* 2010; Koether *et al*., 2016). Therefore, it is essential for therapeutic targeting and before anesthetic procedures in humans and pets (Tilley and Burtnik, 2004). Small wild mammals have a higher mortality rate during anesthesia or sedation than domestic animals; yet, care when anaesthetizing these species still has a long way to go (Felippe, 2020; Kurdie and Ramaswamy, 2015).

The white-eared opossum (*Didelphis albiventris*) is a marsupial widely distributed in South America (Tyndale-Biscoe, 2006; Gardner, 2008). It is not an endangered species but has been often referred to the Wild Animal Screening Centers (CETAS) for complementary diagnostic tests for various conditions, especially imaging tests (Massari *et al*., 2019; Cavalcanti *et al*., 2021). Little is known about the cardiovascular system of this species, but it has been studied in some didelphic species, such as *Didelphis virginiana*, in which heart disease has been reported as an important condition in these animals over 2 years of age (Nascimento and Horta, 2020).

Szabuniewicz and Szabuniewicz (1978) established some electrocardiographic parameters for adults of the *D. virginiana* species, such as P, QRS, and T wave values; however, there are no studies with Brazilian species or with baby opossums.

Thus, this study aimed to establish electrocardiogram reference values for white-eared opossum pups (*D. albiventris*). Pups of the species *D. albiventris* (n=41), 20 males and 21 females, body mass between 100 and 180g, were treated at the Wildlife Rehabilitation Centre (NURFS). The animals were clinically examined and considered healthy by general and specific clinical examinations. Therefore, they were subjected to electrocardiographic evaluation. Some tracings had to be excluded from the present study due to motion artefact, increasing the reliability of parameters obtained here. Thus, 32 exams were used, 16 for males and 16 for females.

The digital electrocardiograph used was InCardio Duo® (InPulse Animal Health, Brazil) along with its software interface (InCardio Duo® - Inpulse Animal Health, Brazil). The animals were manually restrained and positioned in the right lateral decubitus, with limbs parallel and perpendicular to the long axis of the body, on a rubber mat. Electrocardiograph cables were attached as follows: red to the right thoracic limb, yellow to the left thoracic limb, black to the right pelvic limb, and green to the left pelvic limb. Before placing the electrodes, the skin was moistened with alcohol. The electrodes were positioned above the humerus-radio-ulnar and femoral-tibial-patellar joints through metallic “alligator” connectors.

The electrocardiographic recording was performed at a speed of 50mm/second and a sensitivity of 1cm=1mV. Leads DI, DII, DIII, aVR, aVL, and aVF were evaluated. Electrocardiographic tracing in DII lead was assessed by determining heart rate (HR) and

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rhythm, P wave amplitude and duration, PR interval, morphology, QRS complex amplitude and duration, T wave amplitude, QT interval, ST-segment evaluation, and ventricular electrical axis (°) from the values obtained in leads DI and DIII.

Means and standard deviations were calculated using the BioEstat® software. Normality was tested by the Shapiro-Wilk test. Data were subjected to analysis of variance (ANOVA) by the F-test ($p \leq 0.05$), with means compared by the Tukey's test ($p<0,05$), using the BioEstat® software as well. The experiment was approved by the Instituto Chico Mendes (ICMBio) under nº 76962-, and by the Ethics Committee for Animal Use of the Federal University of Pelotas (CEEA/UFPel) under nº 012630/2021-18. The Table 1 show the results of this study.

Table 1. Electrocardiographic values of *Didelphis albiventris* pups.

Electrocardiographic parameters	*D. albiventris* pups
Heart rate	214 (163 - 261 bpm)
Heart rhythms	Sinus rhythm Sinus arrhythmia
P wave	
Amplitude	0.03mV (±0.01)
Duration	0.04s (±0.05)
Middle electrical axis in the frontal plane	47º (26º to 75º)
T wave	
Amplitude	0.04mV (±0.04)
Duration	0.04s (±0.09)
QRS complex	
Q wave amplitude	-0.04mV (±0.05)
R wave amplitude	0.23mV (±0.16)
S wave amplitude	-0.07mV (±0.08)
Duration	0.05s (±0.07)
Morphology	RS or QRS
Middle electrical axis in the frontal plane	40º (-9º to 170º)
PR interval	0.05s (±0.08)
QT interval	0.08 a 0.21s
ST-segment	0.05s (±0.02)

* s: seconds; mV: millivolts; bpm: beats per minute.

The number of orphaned baby opossums referred to the CETAS is high. This is because, during the breeding season, opossum mothers forage for food and are often victims of interactions with domestic animals or humans (Massari *et al*., 2019). As a result, many puppies have been orphaned, several others have needed pediatric care, and some have arrived injured and need special care.

Animal body mass and sex did not affect the electrocardiographic tracing. Most of the animals evaluated had normal sinus rhythm (75%; 24/32), some had sinus arrhythmia (25%; 8/32), but no animal showed atrial or ventricular arrhythmias, nor atrioventricular blocks. Mean heart rate (HR) was 214 beats per minutes (from 163 to 261 bpm), mean QRS electrical axis was 40° (-9 to 170º), and mean P electrical axis was 47º (from 26 to 75º).

From the electrocardiographic tracing, the P wave represents atrial depolarization, its duration indicates the time in which electrical impulse travels from the sinus node to the atrioventricular node. For instance, the P wave in dogs, cats, and lions, in Lead II, is positive (Muzzi and Nogueira, 2007; Larsson *et al*., 2008; Santilli *et al*., 2018). Szabuniewicz and Szabuniewicz (1978) found a negative deflection in *D. virginiana*. In our study, most of the deflections were positive and some negative (18.7%; 6/32). A negative P wave can occur as a function of cardiac depolarization orientation. Depolarization usually occurs from right to left and from superior to inferior. In opossums, Szabuniewicz and Szabuniewicz (1978) described the direction from left to ventral-caudal (anterior-inferior).

The QRS complex represents ventricular depolarization and is composed of Q waves (first negative deflection), followed by R (positive) and S (negative) waves, with different morphological presentations. For the opossums studied here, the QRS complex showed an RS morphology in about 31% (10/32) of the evaluated tracings, that is, a variation that can also occur in other species (Tilley and Burtnik, 2004; Larsson *et al*., 2008). Szabuniewicz and Szabuniewicz (1978) described a morphology with the presence of Q wave in some cases and absence of S wave, which was not noticed in this study. Moreover, the QRS complex lasted longer than that of felines (Tilley and Burtnik, 2004).

The T wave represents ventricular repolarization, and, for *D. virginiana*, it is negative

(Szabuniewicz and Szabuniewicz, 1978). In small animals (Tilley and Burtnik, 2004) and the present study, this electrocardiographic wave had varied morphology and may be positive, negative, or biphasic. According to Larsson (2004), the T wave should not exceed 25% of the R wave in dogs or 0.03mV in cats. In the current study, a T wave was observed in some cases greater than the R wave, but with a mean T amplitude of 0.04mV, while for R it was 0.22mV. Therefore, for the most part, the amplitude of the T wave in D. albiventris pups was 20% less than that of the R wave.

PR interval is the time required for an electrical impulse to travel from the sinus node to ventricular activation. In healthy dogs and cats, it is not less than 0.06s (Larsson, 2004), while the opossums studied here had an average of 0.05s (±0.08s). Such a difference can be explained by anatomical differences and potential smaller myocardial mass of opossums.

For Fillipi (2011), QT interval represents ventricular depolarization and repolarization and varies as a function of heart rate. In cats, this interval lasts from 0.12 to 0.18s (Tilley and Burtnik, 2004). For opossums, we observed a range from 0.08 to 0.21s, whose minimum is below the reference for dogs and cats and the maximum is near the maximum for dogs (from 0.15 to 0, 25s). Probably such a difference is due to the high heart rate in baby opossums.

S-T segment represents the interval from the end of the QRS complex to the beginning of the T wave. In other words, the initial phase of ventricular repolarization may vary from the baseline of the electrocardiographic tracing (Santilli *et al*., 2018). In our experiment, the value found was 0.05 ms (±0.02), which is a slight variation from most reference values for numerous species (Tilley and Burtnik, 2004). Such discrepancy can be explained because the electrocardiographic wave of the studied species has a lower amplitude than those of the species available in the literature.

Myocardial cells and transverse tubules (t-tubules) are known to complete their development after birth during the first days of life (Hirakow and Krause, 1980). The t-tubules propagate action potential into myocardial cells (Orchad *et al*., 2009). Most cardiac cells are differentiated from the 105th postnatal day in *D. virginiana* (Hirakow and Krause, 1980). At this age, animals body mass between 180 and 200g, which is higher than the animals studied in this study. Thus, some changes could be justified, especially when compared to another adult Didelphis.

This is the first electrocardiographic description for *Didelphis albiventris* and the first study with pups without anesthetic effect. Our results can help in the care of these animals in clinical routine, in addition to serving as basic information about the species. Therefore, it was observed that it was possible to perform the ECG in baby opossum, and there was no influence of sex or body mass on the measurements performed. The morphology and the mean values found for the measured parameters differed from those described for small animals and other animal species.

Keywords: Cardiology, electrocardiogram, wildlife animals

RESUMO

*O eletrocardiograma (ECG) é um importante método diagnóstico, essencial para determinar o ritmo e o funcionamento elétrico do coração. Os gambás (*D. albiventris*) frequentemente são atendidos nos Centros de Triagem de Animais Silvestres (CETAS), contudo pouco se sabe sobre o sistema cardiovascular dessa espécie. Dessa forma, o objetivo foi estabelecer valores de referência dos parâmetros eletrocardiográficos dessa espécie. Foram utilizados 32 filhotes, considerados hígidos nos exames clínicos geral e específico. Avaliaram-se a frequência cardíaca, o ritmo, a morfologia, a amplitude e a duração das ondas P, o complexo QRS e T, a duração dos intervalos PR e QT e o segmento ST. A frequência cardíaca média foi de 214 batimentos por minuto (bpm), o ritmo sinusal mostrou-se normal e houve arritmia sinusal em 25% dos pacientes. O eixo médio foi de 40º(QRS)e 47º (P). A onda P apresentou morfologia positiva (81,3%) e negativa (18,7%), amplitude de 0,03mV (±0,01) e duração de 0,04s (±0,04). O complexo QRS apresentou morfologia QRS ou RS (31%) e duração de 0,05s (±0,06). A amplitude de Q foi de -0,04mV (±0,05), a de R foi 0,23mV (±0,16) e S -0,07mV (±0,08). Já a onda T* *apresentou morfologia variada, amplitude de 0,04mV (±0,04) e duração de 0,04s (±0,09). O intervalo PR obteve duração de 0,05s (±0,08), QT com intervalo entre 0,08 e 0,21 e o segmento ST médio de 0,05s (±0,02). Dessa forma, observou-se que foi possível realizar o ECG em gambás filhotes e que o sexo e o peso não influenciaram no traçado obtido. Os resultados diferiram de cães, gatos e de outras espécies de gambás.*

Palavras-chave: animais silvestres, cardiologia, eletrocardiograma

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