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Electroretinography in Wild Canids (*Lycalopex gymnocercus* and *Cerdocyon thous*) - Anesthetic Quality of a Multimodal Protocol

Luiza Tonietto Mangini[1], Jean Carlos Gasparotto[1], Anita Marchionatti Pigatto[2], Guilherme Rech Cassanego[2], Beatriz Perez Floriano[1], Júlia Odorissi Oliveira[1], Francini Arboit[1], Luís Felipe Dutra Corrêa[1], Gabrielle Coelho Freitas[1] & André Vasconcelos Soares[1]

ABSTRACT

***Background*:** Ophthalmic parameters and diseases affecting wild animals remain poorly investigated, and electroretinography (ERG) stands out as an objective and non-invasive tool for assessing retinal function. However, its application in wild mammals relies on the use of safe and effective anesthetic protocols. The aim of this study was to evaluate the duration and anesthetic quality of the protocol employed for ERG, as well as its potential interferences with the examination and possible complications for the patient.

***Cases*:** Nine cases of wild canids housed at the Municipal Zoo of Cachoeira do Sul were reported, in which animals were sedated for electroretinography (ERG). The intended anesthetic protocol consisted of an intramuscular (IM) combination of ketamine (8 mg·kg^{-1}), dexmedetomidine (3 µg·kg^{-1}), and midazolam (0.5 mg·kg^{-1}). When anesthesia was deemed superficial, rescue was performed with intravenous administration of propofol (1 mg·kg^{-1}) over 1 min, followed by a continuous rate infusion (CRI) at 0.1–0.3 mg·kg^{-1}·h^{-1}, in order to maintain immobility without ocular globe rotation until completion of the procedure. Parameters monitored every 5 min included heart rate (HR), respiratory rate (*f*), electrocardiogram (ECG), rectal temperature (TR°C), oxygen saturation of hemoglobin (SpO_2), systolic arterial pressure (SAP), diastolic arterial pressure (DAP), mean arterial pressure (MAP), and sedation score. At the end of the procedure, dexmedetomidine and midazolam were antagonized with intravenous atipamezole (9 µg·kg^{-1}) and flumazenil (0.01 mg·kg^{-1}), respectively.

***Discussion*:** In this study, the estimated body weight was close to the actual weight of the patients, preventing pharmacological underdosing or overdosing. Given the irascible behavior of the animals and the lack of facilities for general anesthesia, dissociative anesthesia was chosen. Fisher's exact test revealed no significant association between whether the administered dose was higher or lower than estimated and sedation duration longer than 30 min. The mean propofol infusion rate required to maintain an adequate anesthetic plane was 0.23 mg·kg^{-1}·h^{-1}, and only 2 animals required ocular positioning adjustments after the onset of propofol infusion. Among the monitored parameters, only rectal temperature (°C) showed statistical significance, decreasing over time as a result of propofol administration. Electrocardiographic changes were observed in 4 animals; however, no interventions were necessary, as no concurrent alterations in oxygen saturation or arterial blood pressure were detected.

Keywords: ketamine, dexmedetomidine, electroretinography, ERG, wild canid, midazolam.

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[1]Department of Small Animal Clinic, Post-Graduation Program in Veterinary Medicine, Centre of Rural Sciences (CCR), University of Santa Maria (UFSM), Santa Maria, RS, Brazil. [2]São Paulo State University (UNESP), Botucatu, SP, Brazil. CORRESPONDENCE: A.V. Soares [andre.v.soares@ufsm.br]. CCR - UFSM. Av. Roraima n. 1000. CEP 97105-900 Santa Maria, RS, Brazil.

INTRODUCTION

The Pampas fox (*Lycalopex gymnocercus*) and the crab-eating fox (*Cerdocyon thous*) are 2 wild canid species commonly found in Brazil (southern Rio Grande do Sul state), Argentina, Uruguay, and Paraguay [11]. Their body weight ranges from 3 to 8.5 kg depending on genus, sex, and age, and these animals are omnivorous with nocturnal habits [5].

For ocular examination in wild mammals, manual restraint or chemical immobilization is usually required [6]. Chemical capture is commonly employed in wild species as it provides greater safety for both the veterinary team and the patient. In these animals, sedation and general anesthesia procedures are considered challenging, as several factors must be taken into account to ensure procedural success. Among the most relevant are environmental and pharmacological factors, as well as physiological particularities inherent to each species [1].

Considering the importance of standardizing anesthetic protocols to obtain reliable electroretinography (ERG) data in wild canids, the aim of this report was to evaluate the duration and anesthetic quality of the protocol employed, as well as its possible interferences with the examination and potential impacts on the animals.

CASES

Nine cases of wild canids housed at the Municipal Zoo of Cachoeira do Sul (Rio Grande do Sul state), were reported, in which animals were sedated for electroretinography (ERG). Prior to the anesthetic procedure, the animals were subjected to an 8-h food fast, while water was not withheld. The intended anesthetic protocol consisted of an intramuscular (IM) combination of ketamine[1] [Cetamin® - 8 mg·kg^{-1}], dexmedetomidine[2] [Dexdomitor® - 3 µg·kg^{-1}], and midazolam[3] [Dormire® - 0.5 mg·kg^{-1}], administered into the semitendinosus muscle. Because pre-procedural weighing was not possible due to the animals' irascible behavior, all drug doses were calculated based on an estimated body weight of 7 kg. Following drug administration, the animals were transported to the procedure room and subsequently weighed.

Ten minutes after drug administration, trichotomy of the left forelimb was performed to establish venous access via the cephalic vein using a 22G catheter, allowing for the administration of supportive or emergency medications if required. The anesthetic duration provided by the pharmacological combination was insufficient to complete the entire examination, with anesthetic times ranging from 16 to 65 min (Figure 1). Despite not providing a duration adequate for the whole procedure, the chosen protocol produced an appropriate depth and anesthetic quality in 8 out of 9 patients.

When anesthesia was considered superficial, rescue was performed with intravenous administration of propofol[3] [Propovan® - 1 mg·kg^{-1}] over 1 min, followed by a continuous rate infusion (CRI) at 0.1–0.3 mg·kg^{-1}·h^{-1}, in order to maintain immobility

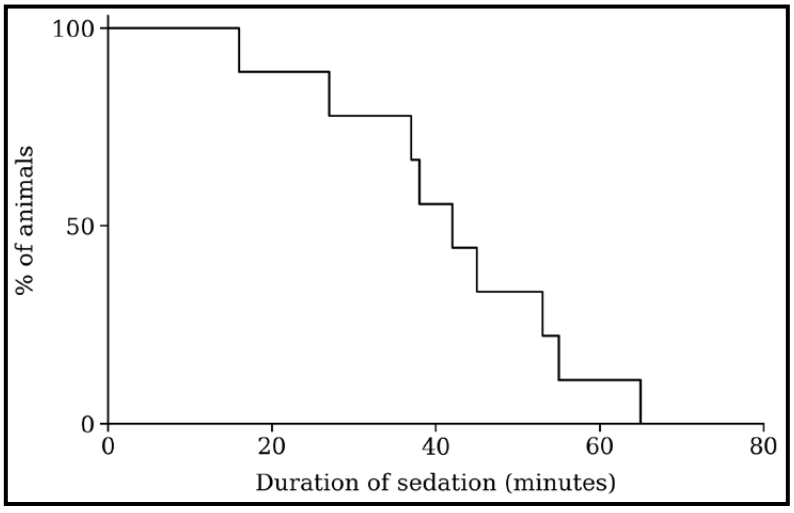

Figure 1. Kaplan-Meier survival curve showing the duration of sedation and recumbency following after anesthesia with ketamine, dexmedetomidine and midazolam in 9 wild canids (*Lycalopex gymnocercus* and *Cerdocyon thous*).

without ocular globe rotation until completion of the procedure.

The animals were continuously monitored using a multiparameter monitor, with recordings obtained every 5 min on an anesthetic monitoring sheet. The monitored parameters included heart rate (HR), respiratory rate (*f*), electrocardiogram (ECG), rectal temperature (TR°C), peripheral oxygen saturation (SpO_2) via pulse oximetry, and systolic (SAP), diastolic (DAP), and mean arterial pressures (MAP) measured by the oscillometric method. To avoid interference with the ophthalmic diagnostic results, all anesthetic maintenance and monitoring devices were covered with red cellophane, as this color produces less interference with A-waves and consequently with the electroretinographic tracing. At the beginning of the procedure, the devices were also disconnected from the electrical power supply.

At the end of the procedure, dexmedetomidine and midazolam were antagonized with intravenous administration of atipamezole[2] [Antisedan® - 9 μg·kg^{-1}, IV] and flumazenil[4] [0.01 mg·kg^{-1}, IV], respectively. All animals remained under observation until complete anesthetic recovery and were subsequently returned to their respective enclosures.

The physiological variables of the 9 animals were subjected to the Shapiro-Wilk test to verify normal distribution, in order to determine whether data would be presented as mean ± standard deviation (parametric data) or as median and interquartile ranges (non-parametric data). To assess the impact of the anesthetic protocol on these variables, comparisons between time points were performed using analysis of variance (ANOVA) followed by Tukey's post hoc test, with differences considered significant at $P < 0.05$. In addition, Fisher's exact test was applied to verify whether there was a dependence between the actual dose administered and the estimated dose (prior to weighing) and the duration of sedation (≤30 min or >30 min).

DISCUSSION

At the end of the procedures, the mean actual body weight of the animals was 6.1 ± 0.54 kg. Accordingly, the mean doses of ketamine, dexmedetomidine, and midazolam were 9.1 ± 1.1 mg·kg^{-1}, 3.4 ± 0.4 μg·kg^{-1}, and 0.56 ± 0.06 mg·kg^{-1}, respectively. These findings indicate that the previously estimated body weight was close to the actual values, preventing both underdosing and overdosing of the administered drugs. Given the irascible behavior of the animals and the lack of facilities for general anesthesia, dissociative anesthesia was selected.

The lowest and highest doses of each drug were as follows: ketamine 6.8 and 10.4 mg·kg^{-1}, dexmedetomidine 2.6 and 3.9 μg·kg^{-1}, and midazolam 0.3 and 0.64 mg·kg^{-1}. Fisher's exact test demonstrated no significant association between whether the administered dose was higher or lower than estimated and sedation lasting longer than 30 min.

The mean propofol infusion rate required to maintain patients in an adequate anesthetic plane was 0.23 mg·kg^{-1}·h^{-1}. In the study conducted by Lin *et al*. [8], all animals that received propofol at 6 mg·kg^{-1} IV or medetomidine at 750 μg·kg^{-1} IM required the use of Barraquer eyelid specula and bulbar conjunctival sutures to maintain the cornea in a ventral position. In contrast, in the present study only 2 animals required ocular positioning adjustments after the onset of propofol infusion. Table 1 shows the medium values for the parameters evaluated over 85 min.

Heart rate (HR) reached a maximum value of 161 ± 27 bpm (T5) and a minimum of 137 ± 30 bpm (T65 and T75). These findings are consistent with those reported by Ribeiro *et al.* [10] and Silva [12], who observed mean HR values of 138.27 ± 27.66 bpm and 201.70 ± 29.2 bpm, respectively, after administration of a ketamine (10 mg·kg^{-1}) and midazolam (1 mg·kg^{-1}) combination for sedation of *Cerdocyon thous*.

The lowest systolic arterial pressure (SAP) recorded was 126 ± 19 mmHg (T35) and the highest was 150 ± 24 mmHg (T85). For most of the evaluated time points, SAP values were in agreement with those reported by Ribeiro *et al.* [10] (126.92 ± 38.97 mmHg) and Silva [12] (124.13 ± 15.50 mmHg). However, during the 1st 10 min, SAP values were higher. This difference is likely attributable to the pharmacological effects of dexmedetomidine, which induces vasoconstriction and bradycardia [3]. From T60 onwards, SAP, as well as MAP and DAP, showed a tendency to increase again.

Mean arterial pressure (MAP) showed its lowest value at T30 (95 ± 17 mmHg) and its highest at T85 (119 ± 17 mmHg), while diastolic arterial pressure (DAP) ranged from 78 ± 18 mmHg (T30) to 103 ± 17 mmHg (T85). In non-sedated domestic dogs, physiological values are considered to be 70-110 mmHg for MAP and 60-90 mmHg for DAP, depending on

breed, age, behavior, and time of day at which measurements are taken [2,9]. Dogs sedated with dexmedetomidine at 10 μg·kg^{-1} and maintained under continuous infusion (CRI) of propofol have been reported to show elevated MAP values ranging from 100 to 120 mmHg [7]. In the present study, when extrapolated to domestic dogs, MAP and DAP values were found to be within or close to the normal physiological range for this species.

It can also be observed that the values for both variables at T30 were lower than those recorded at T85. This may be explained by the fact that at T30 the patients were still under the anesthetic effects of the initial protocol, subsequently requiring the addition of propofol to potentiate anesthesia and enable completion of the examination. By T60, given the half-life of the drugs administered, the animals no longer exhibited significant anesthetic effects, and their physiological parameters had returned to baseline values.

A decrease in respiratory rate (*f*) was observed throughout the procedure. The maximum value was recorded at T5 (28 ± 9 breaths per minute) and the minimum at T85 (21 ± 9 breaths per minute). This decrease in *f* over time is presumed to be related to the continuous rate infusion (CRI) of propofol. Cuniberti *et al.* [4] evaluated the cardiorespiratory parameters of dogs anesthetized with propofol CRI and reported a marked reduction in respiratory rate, from 39 ± 2 breaths per minute at baseline to 3-18 breaths per minute within 2 min of induction, which persisted until the end of the procedure. In contrast, in the present study respiratory rate values did not decrease to the same extent, likely because Cuniberti *et al*. [4] used a higher induction dose (4 mg·kg^{-1}).

Among the parameters reported above, none showed significance in the ANOVA test ($P > 0.05$). Rectal temperature (TR, °C), however, presented a significant difference in the ANOVA test ($P < 0.05$). Tukey's post hoc analysis demonstrated that from T60 (37.3 ± 1.2) rectal temperature was significantly lower compared with T10 (38.2 ± 0.9). This reduction may be associated with the continuous rate infusion (CRI) of propofol, a finding similar to that described by Cuniberti *et al.* [4].

It is important to emphasize that 4 out of the 9 canids presented electrocardiographic alterations, including second-degree atrioventricular block (AV block type II), sinus arrhythmia, ventricular escape, and a markedly increased T wave. Despite these findings, no treatment was required since no concurrent variations in oxygen saturation or arterial pressures were observed.

The multimodal anesthetic protocol employed provided good anesthetic quality and cardiorespiratory stability in Pampas foxes and crab-eating foxes. However, its duration was insufficient to allow completion of the electroretinography, indicating the need for association with a general anesthetic to ensure the feasibility of the procedure.

Table 1. Physiological variables monitored in 9 wild canids (*Lycalopex gymnocercus* and *Cerdocyon thous*) anesthetized with ketamine, dexmedetomidine and midazolam followed by propofol.

Variable	Time (min)																
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
HR (beats. minute^{-1})	161 ± 27	156 ± 22	156 ± 20	153 ± 20	147 ± 21	141 ± 21	142 ± 27	146 ± 25	143 ± 26	151 ± 34	145 ± 29	144 ± 30	137 ± 30	139 ± 31	137 ± 30	144 ± 35	150 ± 34
f (breaths. minute^{-1})	28 ± 9	28 ± 17	26 ± 10	21 ± 8	22 ± 9	20 ± 5	20 ± 6	22 ± 7	22 ± 6	21 ± 3	22 ± 7	21 ± 7	20 ± 9	23 ± 12	26 ± 14	24 ± 10	21 ± 9
TR (°C)	37.9 ± 1.2	38.2 ± 0.9	38.2 ± 0.9	38.1 ± 0.9	38.1 ± 1.0	37.8 ± 1.1	37.7 ± 1.1	37.6 ± 1.1	37.6 ± 1.2	37.5 ± 1.2	37.3 ± 1.4	37.3 ±1.2*	37.3 ± 1.2*	37.2 ± 1.2*	37.1 ± 1.3*	37.2 ± 1.2*	37.1 ± 1.2*
SAP (mmHg)	141 ± 26	138 ± 17	137 ± 16	137 ± 17	130 ± 20	127 ± 20	126 ± 19	135 ± 23	135 ± 20	135 ± 29	138 ± 25	138 ± 19	138 ± 20	143 ± 15	145 ± 22	148 ± 29	150 ± 24
DAP (mmHg)	90 ± 25	91 ± 13	90 ± 14	83 ± 11	87 ± 17	78 ± 18	86 ± 18	87 ± 21	85 ± 15	88 ± 28	88 ± 20	95 ± 15	88 ± 16	91 ± 13	91 ± 18	93 ± 16	103 ± 17
MAP (mmHg)	106 ± 24	106 ± 13	107 ± 14	102 ± 18	99 ± 16	95 ± 17	98 ± 17	102 ± 21	103 ± 18	106 ± 26	104 ± 20	109 ± 16	105 ± 16	110 ± 12	106 ± 19	114 ± 18	119 ± 17
SpO_2 (%)	94 ± 3	97 ± 1	96 ± 2	97 ± 1	96 ± 2	97 ± 1	96 ± 2	96 ± 2	97 ± 2	97 ± 2	96 ± 1	97 ± 2	96 ± 1	96 ± 2	96 ± 1	97 ± 1	95 ± 1

*Significantly different from min 10, 15 and 20 according to Tukey test ($P < 0.05$). HR, heart rate; f, respiratory rate; TR, rectal temperature; SAP; systolic arterial pressure; DAP, diastolic arterial pressure; MAP, mean arterial pressure; SpO_2, peripheral oxyhemoglobin saturation.

MANUFACTURERS

[1]Syntec do Brasil Ltda. Tamboré, PR, Brazil.
[2]Zoetis Indústria de Produtos Veterinários Ltda. Campinas, SP, Brazil.
[3]Cristália Produtos Farmacêuticos Ltda. Itapira, SP, Brazil.
[4]União Química Farmacêutica Nacional S.A. São Paulo, SP, Brazil.

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Ethical approval. The study was approved by the local Ethics Committee for Animal Usage (protocol No. 8776130722) and SISBIO (83634-1).

Declaration of interest. The authors report no conflicts of interest. The authors alone are responsible for the content of the paper.

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