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Electroencephalographic recordings in dogs: Prevention of muscle artifacts and evaluation of two activation techniques in healthy individuals

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ABSTRACT

This study was performed to improve a standard anesthetic protocol for electroencephalography (EEG) in dogs and to evaluate the effect of photic stimulation and hyperventilation on the EEG of healthy dogs. Ten clinically and neurologically normal beagle dogs were anesthetized with propofol given intravenously with average doses of 7.5 mg/kg for induction and 0.37 mg/kg/min constant rate infusion for maintenance. Rocuronium bromide (0.4 mg/kg IV) was used as a peripheral muscle relaxant in order to prevent muscle artifacts. EEGs were recorded digitally using five subdermal needle electrodes. Photic stimulation and hyperventilation were performed to evaluate two activation techniques commonly used in human EEG recording methods. Monopolar and bipolar montages were analyzed visually and quantitatively. The use of rocuronium produced muscle artifact-free EEG recordings during the given recording procedure which indicates that rocuronium is a valuable adjunct to anesthesia during EEG recording. Photic stimulation and hyperventilation did not provoke paroxysmal discharges in the EEG of healthy dogs. Analysis of quantitative EEG data showed that background activity did not differ significantly between periods with and without stimulation. This data are important basic values and will further help to compare the effects of photic stimulation and hyperventilation of healthy dogs and those suffering from epilepsy.

1. Introduction

In human medicine electroencephalography (EEG) is the most common diagnostic test performed in patients with seizures (Mendez and Brenner, 2006). Use of EEG in veterinary medicine is often limited because analysis of recordings is either impaired by artifacts in awake animals or by anesthesia.

The use of propofol to restrain dogs for EEG recordings has been previously described in epileptic and healthy dogs (Accatino et al., 1997; Jaggy and Bernardini, 1998; Bergamasco et al., 2003). It has been shown that a low dose of propofol to maintain a light plane of anesthesia leads to prevalence of slow delta rhythms but does not suppress the electrical brain activity completely so that further interpretation is still feasible (Bergamasco et al., 2003). Paroxysmal discharges have been detected in the EEGs of epileptic dogs under propofol anesthesia (Accatino et al., 1997; Jaggy and Bernardini, 1998).

Rocuronium is a non-depolarizing peripheral muscle relaxant with a fast onset of action and intermediate duration (Flaherty and Auckburally, 2007). So far it has been used in a variety of surgical procedures to relax skeletal muscles, to prevent movements during surgery and to facilitate the initiation of intermittent positive pressure ventilation (Auer, 2007).

Different stimulation methods are commonly used in human medicine to increase the validity of EEG recordings (Mendez and Brenner, 2006; Angus-Leppan, 2007). To the best of our knowledge, there are no reports in veterinary medicine systematically describing the effects of photic stimulation and hyperventilation in healthy dogs.

The aim of this study was to find a short protocol for EEG recordings which is easily applicable in practice and in clinical studies. For this we established a standard anesthetic protocol in healthy beagle dogs which has only a moderate depressive effect on electrical brain activity and allows interpretation of recordings not impaired by muscular artifacts. Furthermore, the effects of photic stimulation and hyperventilation on the electrical brain activity in healthy beagle dogs during application of this anesthetic protocol were evaluated.

2. Materials and methods

2.1. Dogs

Electroencephalograms of ten neutered (three female, seven male) laboratory beagles were recorded in this study. The mean

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age and weight was 6.2 years (range 5.4–7.9 years) and 18.7 kg (range 16.5–21.6), respectively. Clinical and neurologic examinations prior to anesthesia were unremarkable in all dogs. None of the dogs had a history of seizures up to the time of the study. Routine blood analysis was performed prior to EEG recordings and blood cell count as well as serum biochemistry results were within reference ranges. Prior to induction of anesthesia dogs were fasted for at least 12 h. All procedures fulfilled the requirements of the German Animal Welfare Act and were approved by the Federal State Office for Consumer Protection and Food Safety of Lower Saxony, Germany (AZ 05/983).

2.2. Anesthetic protocol

A catheter was placed either into the cephalic or the lateral saphenous vein, and anesthesia was induced with propofol (Narcofol®, CP-Pharma Handelsgesellschaft mbH, Burgdorf, Germany) intravenously (IV). A mean dose of 7.5 mg/kg (range 5.0–9.4 mg/kg; Short and Bufalari, 1999) was given as a slow injection until endotracheal intubation was possible. A light plane of anesthesia (absence of purposeful movements and swallowing reflex) was maintained with a constant rate infusion (CRI) of propofol (Propofol ratiopharm® 20 mg/ml, ratiopharm GmbH, Ulm, Germany) at a mean rate of 0.37 mg/kg/min (range 0.3–0.5 mg/kg/min; Short and Bufalari, 1999) using a syringe pump (Perfusor® fm, B. Braun Melsungen AG, Melsungen, Germany). Lactated Ringer's solution (Sterofundin®, B. Braun Melsungen AG, Melsungen, Germany) was administered at a rate of 10 mL/kg/h IV. The oxygen flow rate was 1.5 L/min delivered via a small animal rebreathing system. The dogs' lungs were ventilated by intermittent positive pressure ventilation. Dogs were placed in right or left lateral recumbency. Direct arterial blood pressure was measured via an arterial catheter placed in the dorsal pedal artery connected to a precalibrated pressure transducer (PMSET ART.Safedraw™ (Basic Flexi), Becton Dickinson Critical Care Systems Inc., Sandy, Utah) via fluid-filled noncompliant tubing. The height of the sternum was used as zero reference for the dogs in lateral recumbency. End-tidal carbon dioxide ($EtCO_2$) tension was measured with a side stream capnograph, calibrated according to the manufacturer's recommendations. Peripheral oxygen saturation of haemoglobin (S_PO_2) and pulse rate were monitored with a pulse oximeter with the sensor clip attached to the tongue. A lead II electrocardiogram (ECG) was recorded via alligator clips and also via two needle electrodes (disposable subdermal stainless steel EEG needle, 12 mm long, 0.4 mm (27 G) diameter, 1.5 m cable, Viasys Healthcare Neurocare Group, Madison, Wisconsin) of the electroencephalograph (NicoletOne nEEG, Viasys Healthcare Inc., Madison, Wisconsin). A temperature probe was positioned in the ventral nasal meatus in order to continuously measure the body temperature which was held at a mean of 36.5 °C (sd ± 0.5) during the EEG recording procedure. Physiologic parameters were constantly measured throughout anesthesia, being displayed on an anesthetic multiparameter monitor (Datex-Ohmeda Compact Anesthesia Monitor, GE Healthcare, Helsinki, Finland) and recorded every 10 s (Collect, GE Healthcare, Helsinki, Finland). Criteria for the optimum depth of anesthesia were the absence of purposeful movements and severely diminished or absent palpebral reflexes. The propofol infusion rate was adapted accordingly. After complete instrumentation and stabilization the muscle relaxant rocuronium bromide (Esmeron® 10 mg/ml, N. V. Organon, BHOss, Netherlands) was given at a dosage of 0.4 mg/kg IV. Dogs were allowed to recover from neuromuscular block spontaneously.

2.3. Electroencephalographic recordings

Electrodes were placed as described by Redding (1978) (Fig. 1). Five subdermal needle electrodes (F3, F4, Cz, O1 and O2) were placed over the scalp in order to record the EEG (sensitivity = 70 μV/cm, time constant = 0.3 s, Hf = 70 Hz, Lf = 0.5 Hz, notch filter inserted, impedance <10 kΩ). The reference electrode was placed in the middle of the bridge of the nose, the ground electrode in the neck caudal to the protuberantia occipitalis. Digital EEG recording was started after complete instrumentation and a stable plane of anesthesia was achieved. Administration of rocuronium was followed by a recording period of 3 min without any stimulation (pre-stimulation phase). Afterwards, photic stimulation with a photic stimulator (Photic stimulator, Viasys Healthcare Inc., Madison, Wisconsin) placed approximately 20 cm in front of the closed eyes was started. Periods of 8 s with varying flash rates were followed by breaks of 5 s. Flash rates were increased in steps of 5 Hz after every break from 5 to 50 Hz and decreased again in the same way. Recordings were continued with a 3-min period free of any stimulation. After these 3 min dogs were hyperventilated for a full 3 min or longer until an $EtCO_2$ tension of at least 25 mmHg had been reached which was controlled via the side stream capnograph and, in addition, via arterial blood gas analysis (Rapidlab 248, Siemens Healthcare Diagnostics GmbH, Eschborn, Germany). Post-hyperventilation EEG recordings lasted for a further 3 min (Fig. 2).

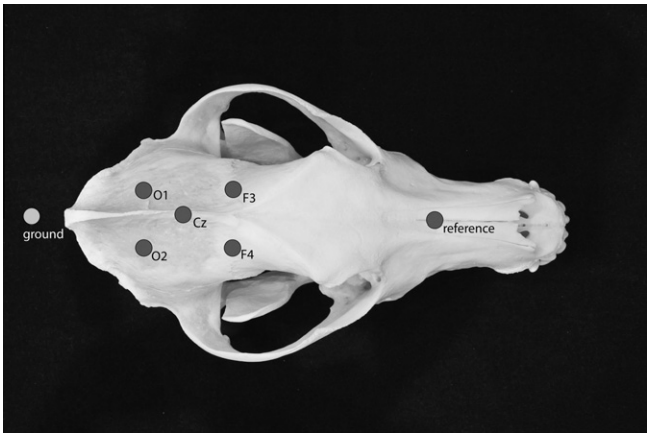

Fig. 1. Electrode placement. Two frontal (F3, F4), one central (Cz) and two occipital (O1, O2) electrodes were used to record either in a five channel monopolar montage (reference electrode on the bridge of the nose) or in bipolar montages. The ground electrode is placed in the neck.

2.4. Visual examination of the EEGs

All recordings were examined visually in monopolar and bipolar montages in order to detect biologic artifacts (e.g. from respiratory function or electrocardiogram), or exogenous artifacts from the recording environment (e.g. from electrical or acoustic interferences or movements of investigators in the recording room). Visual examination was also used to determine paroxysmal epileptiform

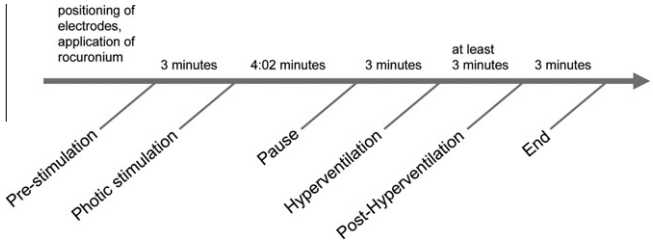

Fig. 2. Time scale. The time scale shows the chronology of the recording procedure. The whole recording procedure takes at least 16 min.