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Visual and quantitative electroencephalographic analysis of healthy young and adult cats under medetomidine sedation

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Abstract

A study was designed to investigate the effect of medetomidine sedation on quantitative electroencephalography (q-EEG) in healthy young and adult cats to determine objective guidelines for diagnostic EEG recordings and interpretation. Preliminary visual examination of EEG recordings revealed high-voltage low-frequency background activity. Spindles, k-complexes and vertex sharp transients characteristic of sleep or sedation were superimposed on a low background activity. Neither paroxysmal activity nor EEG burst-suppression were observed.

The spectral analysis of q-EEG included four parameters, namely, relative power (%), and mean, median and peak frequency (Hz) of all four frequency bands (delta, theta, alpha and beta). The findings showed a prevalence of slow delta and theta rhythms as opposed to fast alpha and beta rhythms in both young (group A) and adult (group B) cats. A posterior gradient was reported for the theta band and an anterior gradient for the alpha and beta bands in both groups, respectively. The relative power value in group B compared to group A was significantly higher for theta, alpha and beta bands, and lower for the delta band. The mean and median frequency values in group B was significantly higher for delta, theta and beta bands and lower for the alpha band.

The study has shown that a medetomidine sedation protocol for feline EEG may offer a method for investigating bio-electrical cortical activity. The use of q-EEG analysis showed a decrease in high frequency bands and increased activity of the low frequency band in healthy cats under medetomidine sedation.

Keywords: Electroencephalogram; Medetomidine; Spectral analysis; Quantitative electroencephalography; Cats

Introduction

Electroencephalography (EEG) is a useful and non-invasive examination method for the diagnosis of functional central nervous system (CNS) disturbance, and has a special importance as a diagnostic tool for epilepsy in humans and animals. It has been used in animal models of human epilepsy and for the differentiation of CNS diseases in veterinary medicine (Croft, 1988; Sim and Chua, 1989; Otto and Short, 1991; Jaggy and Bernardini, 1998; Bergamasco et al., 1999; Mirsattari et al., 2005).

The EEG recording is characterised by background activity (high-voltage low-frequency or low-voltage

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high-frequency), with superimposed transients that can be physiological or pathological. Unfortunately, the procedure is extremely sensitive to any electrical activity including muscular, cardiovascular and ocular activity of the patient. It also demands the full cooperation of the subject under investigation, which is difficult with animals. Different methods of performing an EEG examination when the animal is awake and under different anaesthetic agents have been reported. However, the effects of different sedatives on the EEG varies (Moruzzi, 1956; Croft, 1962; Seth and Weingarten, 1972; Clark and Rosner, 1973; Daube et al., 1990; Hikasa et al., 1993; Reddy et al., 1993; Akrawi et al., 1996; Bergamasco et al., 2003). Propofol alone or in combination with medetomidine sedation has been described as a useful anaesthetic protocol for EEG recordings in dogs (Jaggy and Bernardini, 1998; Bergamasco et al., 2003), but in cats there is no uniform and objective protocol that provides for a reliable assessment, interpretation and comparison of EEGs and that can be applied in different scientific units.

Medetomidine, a sedative administered alone or as part of balanced anaesthetic protocol, is an alpha-2 adrenergic agonist commonly used in cats (Stenberg et al., 1987; Ansah et al., 2000; Granholm et al., 2006). Medetomidine used alone affects the EEG quantitatively (q-EEG) (Itamoto et al., 2001) and the effect when used in combination with halothane and ketamine has been described in dogs (Short et al., 1992). Medetomidine with propofol has been used in anaesthetic protocols for the EEG examination of dogs (Srenk and Jaggy, 1996; Accatino et al., 1997; Jaggy and Bernardini, 1998; Bergamasco et al., 2003).

EEG examination in cats is performed mostly in studies using an animal model for human epileptic focus development, intractable epilepsy, sleep, learning process models or physiological brain reactions to various agents (Croft, 1962; Klemm, 1968; Beaver and Klemm, 1973; Bilinska-Nigot and Majkowski, 1976; Majkowski et al., 1976; Majkowski et al., 1981; Majkowski and Sobieszek, 1988; Sobieszek and Majkowski, 1988; Majkowski et al., 1989; Hikasa et al., 1993). These studies were performed using different non-homogenous methods which make them difficult to compare, and they are of little relevance to clinical veterinary electroencephalography.

To our knowledge, the first attempt in veterinary medicine to record EEG was an experiment by Croft (1962) that included three cats with neurological dysfunction. The EEG was recorded without anaesthesia using 2-channel analogue equipment. An attempt was later made by Klemm (1968) using a 7-channel polygraph, subcutaneous (stainless-steel) and epidermal (silver disc) electrodes on two cats anaesthetised with sodium pentobarbital. The analyses and interpretation were based on visual examination and compared with normal and pathological human EEG activity. The first attempts to record an EEG in normal anaesthetised cats were made by Beaver and Klemm (1973) with a thiopental–pentobarbital combination anaesthesia using an 8-channel EEG analogue equipment.

Reference values are essential in order to use the EEG clinically to differentiate between the various CNS disorders in any species. In cats, as in other animals, values should be derived from a healthy population of varying ages, under a repeatable and widely available anaesthetic protocol. The aim of our study was to investigate the visual and q-EEG in two groups of healthy young and adult cats under medetomidine sedation to determine objective guidelines for diagnostic EEG recordings and interpretation.

Materials and methods

Animals

The study was performed at the Department of Internal and Parasitic Diseases, Faculty of Veterinary Medicine, Wroclaw University of Environmental and Life Sciences, Poland. All cats were from the Department's permanent closed animal colony. The study protocol was approved by the Ethics Committee on Animal Trials (permit number 12-306).

Two groups of cats were studied: 11 healthy young cats (group A; mean age 46.2 months, range 36–50) and 11 healthy adult cats (group B; mean age 89.8 months, range 75–108). The weight of the cats ranged from 2.48 to 6.55 kg, mean 3.83 kg. All cats had to fulfil the following inclusion criteria: (1) continuous monitoring 2 years before and 2 years after the study, including monthly clinical, neurological and behavioural evaluations, and monthly faecal, blood and urine examinations over the 4 year observation period and blood examination 10 days before the experiment; (2) regular annual vaccination and deworming (every 6 months) throughout the 4 year observation period; (3) readable EEG recordings.

Blood evaluations included haematology (complete blood cell count, differential leucocyte count) and serum biochemistry (sodium, potassium, calcium, phosphorus, magnesium, glucose, total protein, albumin, globulin, cholesterol, blood urea nitrogen, creatinine, total bilirubin, alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, creatine kinase, ammonia, total thyroxine, free thyroxine and triiodothyronine) with serum titres for feline infectious peritonitis (FIP), feline immunodeficiency virus (FIV), feline leukaemia virus (FeLV) and toxoplasmosis. Urinalysis comprised measurement of specific gravity, chemistry and sediment examination.

Sedation protocol

EEG was performed under medetomidine (Domitor, Orion Corporation) sedation. The drug was injected into the right supra- or infraspinatus muscle in doses of 0.04 mg/kg. An additional 0.01 mg/kg of medetomidine was given intramuscularly if the cat was not ready for manipulation 10 min after the initial injection. Twenty minutes after the EEG recording, an injection of atipamezole (Antisedan, Orion Corporation) in doses of 2 μg/kg was deposited in the left supra- or infraspinatus muscle. The EEG recording continued until the first recovery movement.

Electroencephalographic recordings

EEG examinations were performed in a quiet, darkened room. Cats were placed in sternal recumbency and needle electrodes were inserted subcutaneously over the calvaria. A 12-channel monopolar montage was used (F3, F4, T3, C3, Cz, C4, T4, P3, Pz, P4, O1, O2) modified from a 17-channel monopolar montage, as previously described (Bergamasco et al., 2003) (Fig. 1). The acquisition parameters to record bio-electrical activity were set as follows: sensitivity = 5 μV/mm; time constant = 0.3 s; high filter (Hf) = 30 Hz; notch filter inserted; reference: on the bridge of the nose; ground: caudally to the external occipital pro-