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RESEARCH PAPER

Cardiopulmonary effects of anaesthesia maintained by propofol infusion *versus* isoflurane inhalation in cheetahs (*Acinonyx jubatus*)

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Abstract

Objective To compare the cardiopulmonary effects of propofol total intravenous anaesthesia (TIVA) with isoflurane in cheetahs (*Acinonyx jubatus*) to evaluate feasibility for field use.

Study design Prospective clinical study.

Animals A group of 24 adult cheetahs, 12 per group.

Methods Cheetahs were immobilised with zolazepam/tiletamine (1.2 mg kg^{-1}) and medetomidine [40 μg kg^{-1}, both intramuscular (IM)] by darting. A maintenance protocol of propofol TIVA (group P) or isoflurane inhalation (group I) was assigned randomly to each cheetah. Anaesthesia was maintained for at least 60 minutes. Cheetahs breathed spontaneously throughout; oxygen was supplemented at 3 L $minute^{-1}$. Cardiopulmonary parameters were recorded at 5 minute intervals and three arterial blood gas samples were analysed. Following maintenance, atipamezole was administered IM (200 μg kg^{-1}) and recovery was observed. Data are reported as mean ± standard deviation; variables over time were compared using a linear mixed model (fixed: time, treatment; random: cheetah).

Results Lack of response to manipulations was maintained in all cases (end-tidal isoflurane percentage 1.1 ± 0.1%, propofol rate maintained at 0.1 mg kg^{-1} $minute^{-1}$). The heart and respiratory rates were acceptable throughout maintenance. The end-tidal carbon dioxide tension increased slowly [44.0 ± 5.0 mmHg (5.87 ± 0.67 kPa)] with no differences between groups. All cheetahs were initially markedly hypertensive [mean arterial blood pressure (MAP): (163 ± 17 mmHg)]. The MAP normalised for group I (125 ± 30 mmHg) but remained high for group P (161 ± 17 mmHg) ($p < 0.001$). Arterial carbon dioxide tension [48.9 ± 14.6 mmHg (6.52 ± 1.95 kPa)] never differed between groups. Initial arterial oxygen tension indicated borderline hypoxaemia, but improved with oxygen supplementation. Recovery time was 10.8 ± 5.0 and 51.9 ± 23.5 minutes for group I and group P, respectively.

Conclusions and clinical relevance Both protocols provided acceptable cardiopulmonary values. Propofol may be an alternative to isoflurane for field use, but the prolonged recovery may make it less suitable for long-term anaesthesia.

Keywords *Acinonyx jubatus*, cheetah, isoflurane, propofol, total intravenous anaesthesia.

Introduction

Cheetahs (*Acinonyx jubatus*) are classified as vulnerable by the International Union for Conservation of Nature (International Union for Conservation of Nature 2016). The large decline in wild populations as a result of human population expansion, human–wildlife conflict and decreased availability of natural prey has led to increased emphasis being placed on

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captive cheetahs for potential maintenance of the species (Marker 2002). With their increased numbers and value in zoo and conservation collections, the ability to safely anaesthetise cheetahs for veterinary procedures is increasingly important.

To be feasible, an anaesthetic protocol must allow for flexible control of the anaesthetic depth and extension of anaesthesia duration while maintaining stable cardiopulmonary function and a calm, complete and rapid recovery that allows for immediate release of wild animals. Although there are many published immobilisation strategies (Bush et al. 1978; Lewandowski et al. 2002; Stegmann & Jago 2006), there is a paucity of literature describing maintenance of anaesthesia in wild felids.

Traditionally, inhalant anaesthesia has been used for invasive procedures. Isoflurane is an inhalant anaesthetic that is associated with relative cardiovascular stability, the ability to change anaesthetic depth rapidly and a swift, calm recovery in most species (Keegan & Greene 1993). However, inhalation agents are known to cause dose-dependent respiratory and cardiovascular depression, making their use at concentrations higher than the minimum alveolar concentration (MAC) undesirable. Further, inhalation agents traditionally require bulky equipment such as anaesthetic machines, which are impractical in field settings (Dzikiti 2013), while purpose-built field-ready anaesthetic machines are cost prohibitive for veterinarians occasionally administering inhalation anaesthesia in the field.

Propofol (2,6-diisopropylphenol) is an ultra-short-acting hypnotic agent, which has been used for anaesthetic maintenance in a wide variety of species. Propofol infusions are associated with a stable anaesthetic and calm, rapid recovery in most domestic species. However, propofol can also cause decreased arterial blood pressure, through arterial and venous vasodilation, as well as decreased myocardial contractility and dose-dependent respiratory depression, which may result in hypoxia (Clarke et al. 2014). Studies in domestic dogs have shown better mean arterial blood pressure (MAP) with propofol infusion compared with isoflurane (Keegan & Greene 1993). Propofol use in wild felids for short periods is well documented (Epstein et al. 2002; Bharathidasan et al. 2014), but there is currently sparse literature available on the use of total intravenous anaesthesia (TIVA) in wild felids and none on the use of propofol continuous infusions in cheetahs.

The aim of this trial was to compare propofol with isoflurane for maintenance of anaesthesia of at least 60 minutes in cheetahs, by focussing on the ability to maintain adequate depth of anaesthesia for minimally invasive procedures (abdominal ultrasound, gastroscopy and dental examination) as assessed by lack of response to stimuli while maintaining stable and optimal cardiopulmonary function [as indicated by arterial blood pressure and arterial partial pressure of oxygen (PaO_2) and carbon dioxide ($PaCO_2$)]. We hypothesised that the MAP and end-tidal carbon dioxide ($P_E'CO_2$) would not differ between anaesthesia maintenance with isoflurane and propofol nor over time.

Materials and methods

The prospective, randomised paired clinical trial was approved by the University of Pretoria's Animal Ethics and Research Committee (protocol V014-14). Data collection took place over 1 week during winter 2015. A total of 24 healthy adult captive cheetahs (eight female and 16 male), housed at the AfriCat Foundation near Otjiwarongo in Namibia, were included in the study. The animals were immobilised, in a random order (immobilisation schedule set on the morning of the 1st day), and then anaesthetised to allow for annual health examinations, encompassing clinical examination, blood tests, abdominal ultrasonography, ocular examinations and gastroscopy. A maintenance protocol was assigned to each cheetah using a first-come-first-serve method of allocation as either propofol IV infusion or isoflurane inhalation anaesthesia using paired sampling (the first cheetah was always administered propofol). At every data-collection period two cheetahs were studied, at the same time, with one assigned to each protocol, without biases or preferences.

Immobilisation

Food was withheld for 24 hours prior to anaesthesia, although free access to water was allowed until darting. To facilitate capture, the cheetahs were called from their large 'home' camps into adjacent smaller management camps prior to darting.

All animals were captured with the same immobilisation protocol: a combination of tiletamine/zolazepam (1.2 mg kg^{-1} Zoletil; Virbac, South Africa) and medetomidine (40 µg kg^{-1}; Kyron Laboratories, South Africa). Historical records and visual

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