Veterinary
Anaesthesia and Analgesia
Formerly the Journal of Veterinary Anaesthesia

Veterinary Anaesthesia and Analgesia, 2014 doi:10.1111/vaa.12170

RESEARCH PAPER

# Evaluation of intravenous administration of alfaxalone, propofol, and ketamine-diazepam for anesthesia in alpacas

**Ana M del Álamo*, Ron E Mandsager*, Thomas W Riebold* & Mark E Payton†**

*College of Veterinary Medicine, Oregon State University, Veterinary Teaching Hospital, Corvallis, OR, USA

†Department of Statistics, Oklahoma State University, Stillwater, OK, USA

**Correspondence:** Ana M del Álamo, College of Veterinary Medicine, Oregon State University, 700 SW 30th Street, Corvallis, OR 97331-4801, USA. E-mail: analamo.vet@gmail.com

## Abstract

**Objective** To evaluate the effects of induction of anesthesia with alfaxalone in alpacas.

**Study design** Prospective, randomized, crossover design.

**Animals** Five healthy alpacas (96.7 ± 19.9 kg, 9.6 ± 3.1 years old).

**Methods** The alpacas were anesthetized on three occasions with alfaxalone, propofol, or ketamine-diazepam by intravenous injection. Quality of induction and intubation was assessed using a simple descriptive scale, and quality of recovery was scored: 1 (very poor)–5 (excellent). The auricular artery was catheterized for measurement of systolic (SAP), mean (MAP), and diastolic (DAP) arterial pressures and collection of blood. Variables measured were hemoglobin oxygen saturation ($SpO_2$), respiratory rate, and end-tidal carbon dioxide partial pressure ($P_E'CO_2$), and ECG. Repeated measures ANOVA was used to assess effects of drug and time. Significance was set at $p < 0.05$.

**Results** Mean dose of alfaxalone sufficient to allow intubation was 2.1 mg $kg^{-1}$. Induction was excellent with all protocols. Heart rate (HR), SAP and MAP were significantly higher following alfaxalone compared to ketamine-diazepam. Blood lactate concentration when standing following alfaxalone was higher compared to minutes 1 and 6, and to propofol ($p < 0.05$). All alpacas required oxygen supplementation and mechanical ventilation to treat $SpO_2 < 90\%$ or $P_E'CO_2 > 60$ mmHg. Time from induction to standing was longer with alfaxalone (34.1 ± 3.2 minutes) than propofol (19.0 ± 4.3 minutes) or ketamine-diazepam (24.9 ± 1.7 minutes). Recovery quality median scores were clinically and statistically different: 2 (alfaxalone), 4 (ketamine-diazepam), and 5 (propofol). Tremors, paddling, rolling, seizure-like activity and thrashing characterized recovery from alfaxalone.

**Conclusion** Recovery quality was worst with alfaxalone. HR, SAP, MAP were increased at minute 1 in all protocols. Transient hypercapnia and hypoxia was observed with all protocols.

**Clinical relevance** All protocols were adequate for induction of anesthesia. Alfaxalone alone in unpremedicated alpacas is not recommended.

*Keywords* alfaxalone, alpaca, induction, propofol, recovery.

## Introduction

Alfaxalone (3a-hydroxy-5a-pregnane-11, 20-dione) is a synthetic neuroactive steroid that binds to gamma aminobutyric acid type A ($GABA_A$) cell surface receptors enhancing the effect of the endogenous ligand and acting as a ligand itself. It was previously removed from the market when commercially available as Saffan, a mixture of alphaxalone

and alphadolone in Cremophor-EL, due to adverse reactions related to histamine release. In recent years, alfaxalone has been solubilized in 2-hydroxypropyl-β-cyclodextrin (HCPD) and has been marketed as Alfaxan.

The use of the new formulation of alfaxalone has been reported in dogs (Muir et al. 2008; Maddern et al. 2010), cats (Muir et al. 2009; Mathis et al. 2012), horses (Goodwin et al. 2012; Keates et al. 2012), rabbits (Marsh et al. 2009), pigs (Keates 2003), sheep (Andaluz et al. 2012; Walsh et al. 2012), iguanas, amphibians, turtles, and fish. To the authors' knowledge, there are no publications concerning the administration of alfaxalone to camelids.

Ketamine, an NMDA receptor antagonist, is widely used in all species for induction of anesthesia and, in some instances, for its antihyperalgesic properties. Its use has often been reported in both Old World and New World camelids. Ketamine does not provide good muscle relaxation and pharyngeal reflexes are generally maintained after induction of anesthesia, which can hinder intubation (García-Pereira et al. 2006). Combinations of ketamine with muscle relaxing drugs, such as diazepam, midazolam, guaifenesin or alpha-2 adrenergic agonists, are recommended in camelids (Abrahamsen 2009).

Propofol (2,6-diisopropylphenol) provides smooth and reliable induction in llamas (Duke et al. 1997) and camels (Fahmy et al. 1995) with fast and uneventful recoveries. Propofol, administered either as an intravenous (IV) bolus or as a constant rate infusion, has been used more extensively in other ruminants, such as sheep and goats. Smooth inductions along with fast and good quality recoveries have been observed in these species after administration of propofol (Lin et al. 1997; Prassinos et al. 2005).

The objective of this study was to evaluate induction of anesthesia, maintenance and recovery quality, and cardiopulmonary variables after administration of alfaxalone titrated IV in non-premedicated alpacas. The results were compared to the administration of propofol or ketamine and diazepam IV in the same group of alpacas. The hypothesis was that administration of alfaxalone IV would provide equivalent quality of induction, maintenance, and recovery from anesthesia and similar cardiopulmonary effects as IV administration of either propofol or ketamine-diazepam to healthy unpremedicated alpacas.

## Materials and methods

This study was approved by the Institutional Animal Care and Use Committee (IACUC) at Oregon State University. Five alpacas belonging to the University were included in this study. Their weights ranged from 79.7 to 101.3 kg (mean 96.7 ± 19.9 kg) and they were between 8 and 10 years old (mean 9.6 ± 3.1 years old). Within this group there was one intact male, one gelding and three females. Based on history and physical examination, they were all healthy animals.

### Study design

This was a prospective randomized crossover study. Each alpaca was administered one of three protocols on different occasions with a washout period of at least 1 week between treatments. The anesthetic protocols were group A, alfaxalone (2 mg $kg^{-1}$; Alfaxan; Vétoquinol, Spain) IV; group P, propofol (3 mg $kg^{-1}$; Propoflo; Abbott Laboratories, IL, USA) IV; and group KD, ketamine (4 mg $kg^{-1}$; Fort Dodge, KS, USA) combined in one syringe with diazepam (0.2 mg $kg^{-1}$; Hospira Inc., IL, USA) IV. All drugs, with doses rounded to one decimal point, were drawn up with an extra 25% of the dose. Each protocol was administered as follows: one quarter (25%) of the calculated dose was injected every 15 seconds while a designated assistant assessed the relaxation and sedation of the alpaca. When jaw tone was reduced and there was lack of lingual response to traction stimulation, administration of drugs ceased and endotracheal intubation was performed. The mean and SD of the amount of drug necessary to achieve successful intubation was later calculated. No other drugs were administered to these alpacas during the study. All alpacas were kept in sternal recumbency for the duration of anesthesia and recovery.

Each animal was admitted to the Large Animal Hospital and housed in the same stall as one other alpaca from the same study group to reduce their stress level. Feed was withheld for 12 hours but free access to water was allowed until the time of induction. A physical examination was performed and llamas were weighed before each anesthetic protocol.

### Catheterization

Before each trial, the alpacas were placed in a camelid restraining chute without sedation for

 