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RESEARCH PAPER

Cardiopulmonary effects of dexmedetomidine and ketamine infusions with either propofol infusion or isoflurane for anesthesia in horses

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Abstract

Objective To examine the cardiopulmonary effects of two anesthetic protocols for dorsally recumbent horses undergoing carpal arthroscopy.

Study design Prospective, randomized, crossover study.

Animals Six horses weighing 488.3 ± 29.1 kg.

Methods Horses were sedated with intravenous (IV) xylazine and pulmonary artery balloon and right atrial catheters inserted. More xylazine was administered prior to anesthetic induction with ketamine and propofol IV. Anesthesia was maintained for 60 minutes (or until surgery was complete) using either propofol IV infusion or isoflurane to effect. All horses were administered dexmedetomidine and ketamine infusions IV, and IV butorphanol. The endotracheal tube was attached to a large animal circle system and the lungs were ventilated with oxygen to maintain end-tidal CO_2 40 ± 5 mmHg. Measurements of cardiac output, heart rate, pulmonary arterial and right atrial pressures, and body temperature were made under xylazine sedation. These, arterial and venous blood gas analyses were repeated 10, 30 and 60 minutes after induction. Systemic arterial blood pressures, expired and inspired gas concentrations were measured at 10, 20, 30, 40, 50 and 60 minutes after induction. Horses were recovered from anesthesia with IV romifidine. Times to extubation, sternal recumbency and standing were recorded. Data were analyzed using one and two-way ANOVAS for repeated measures and paired *t*-tests. Significance was taken at $p \leq 0.05$.

Results Pulmonary arterial and right atrial pressures, and body temperature decreased from pre-induction values in both groups. PaO_2 and arterial pH were lower in propofol-anesthetized horses compared to isoflurane-anesthetized horses. The lowest PaO_2 values (70–80 mmHg) occurred 10 minutes after induction in two propofol-anesthetized horses. Cardiac output decreased in isoflurane-anesthetized horses 10 minutes after induction. End-tidal isoflurane concentration ranged 0.5%–1.3%.

Conclusion and clinical relevance Both anesthetic protocols were suitable for arthroscopy. Administration of oxygen and ability to ventilate lungs is necessary for propofol-based anesthesia.

Keywords dexmedetomidine, horse, infusion, isoflurane, ketamine, propofol.

Introduction

Infusions of sedative, analgesic and anesthetic drugs can provide a stable plane of anesthesia or analgesia

depending on the drugs used. Infusions can be used to provide total intravenous anesthesia (TIVA) without the need for administration of volatile anesthetic agents or used as part of an inhalation anesthetic technique. Using an inhalation agent with partial intravenous anesthesia (PIVA) can reduce some adverse effects produced by volatile drugs resulting in reduced response to noxious stimuli and hemodynamic stability in horses, especially with infusions of analgesic drugs. Both the TIVA and PIVA techniques have been comprehensively reviewed in previous articles (Bettschart-Wolfensberger & Larenza 2007; Lerche 2013; Valverde 2013).

Alpha$_2$-adrenergic agonist drugs are particularly useful for PIVA techniques in horses. A medetomidine infusion enabled reduced concentrations of volatile anesthetic agent to be used and produced superior skeletal muscle relaxation while maintaining hemodynamic stability and body temperature (Creighton et al. 2012). Dexmedetomidine also provided good quality of PIVA with stable hemodynamic variables and smooth recovery from anesthesia (Marcilla et al. 2010, 2012; Gozalo-Marcilla et al. 2013). Alpha$_2$-adrenergic agonist drugs have also been used in combination with infusions of other injectable drugs to provide good quality anesthetic conditions for surgery (Valverde et al. 2010; Benmansour & Duke-Novakovski 2013).

Propofol is a suitable drug for PIVA and TIVA techniques because of its ideal pharmacokinetic profile (Oku et al. 2005, 2006; de Vries et al. 2013). Its use in larger animals as the sole anesthetic agent is limited by the low concentration of the available commercial formulation to deliver an appropriate infusion rate and by its lack of analgesic properties, resulting in unacceptable induction and anesthetic qualities (Mama et al. 1995, 1996). Techniques have been developed to reduce the amount of propofol required, prevent physiological responses to surgery and yet still make use of the anesthetic and rapid recovery properties of propofol (Bettschart-Wolfensberger et al. 2003, 2005a; Oku et al. 2011). Ketamine is an effective anesthetic and analgesic agent in horses, but also requires to be given with other drugs such as alpha$_2$-adrenergic agonists to reduce any adverse effects such as muscle rigidity and excitement (Mama et al. 2005). Ketamine has been co-administered with propofol to provide a suitable quality of induction for endotracheal intubation (Wagner et al. 2002; Posner et al. 2013). Furthermore, ketamine infusions have been used as part of PIVA and TIVA techniques alongside propofol (Nolan et al. 1996; Flaherty et al. 1997; Ohta et al. 2004; Umar et al. 2006, 2007; de Vries et al. 2013).

This crossover study was designed to compare the use of propofol, ketamine and dexmedetomidine infusions for anesthesia (TIVA) with a PIVA technique by replacing the propofol infusion with isoflurane in horses undergoing two arthroscopy procedures several weeks apart.

Material and methods

Six mixed breed horses (three mares and three geldings) aged 7 ± 4.2 years (mean ± SD; range 3–14 years), and weighing 488.3 ± 29.1 kg (mean ± SD, range 460–535 kg) were used for this study. The horses were deemed healthy according to physical and hematological examinations, kept outdoors in paddocks and brought indoors for the study (altitude 482 m above sea level). Horses were fed hay with free access to water and were fasted for 12 hours prior to induction of anesthesia, but not denied water. Horses entered a crossover trial with their first treatment assigned according to a computerized random number generator (Graphpad Prism 6.0 for Windows, GraphPad Software, CA, USA), with a rest period of at least 14 days before receiving the alternate treatment. Approval was obtained from the University of Saskatchewan Animal Review Ethics Board (protocol number: 20130013) and animals were kept in accordance with the guidelines provided by the Canadian Council for Animal Care.

On the day of the study, horses were sedated with xylazine hydrochloride (0.5 mg kg^{-1}; Rompun; Bayer Healthcare, ON, Canada) intravenously (IV) and subcutaneous infiltration of lidocaine was used to aseptically place two 8 Fr catheter introducers (Fast-Cath Hemostasis Introducer; St. Jude Medical, MN, USA) proximally and distally within the right jugular vein, and a 14 gauge 133 mm over-the-needle catheter (BD Angiocath; Becton Dickinson, Infusion Therapy Systems Inc., UT, USA) in the left jugular vein for administration of replacement crystalloid fluids and drugs.

Between 20 and 30 minutes following xylazine administration, a 7 Fr 110 cm thermistor-tipped, triple lumen pulmonary artery balloon catheter (Edwards Lifesciences Swan-Ganz; Edwards Lifesciences LLC, CA, USA) was passed through the caudal introducer, so the distal tip of the catheter was positioned in the pulmonary artery. Positioning was guided through observation of characteristic