Veterinary
Anaesthesia and Analgesia
Formerly the Journal of Veterinary Anaesthesia

Veterinary Anaesthesia and Analgesia, 2016 doi:10.1111/vaa.12376

RESEARCH PAPER

Comparison of the effects of an intravenous lidocaine infusion combined with 1% isoflurane *versus* 2% isoflurane alone on selected cardiovascular variables and recovery characteristics during equine general anaesthesia

Inga-Catalina Cruz Benedetti*, Knut Nottrott*, Isabelle Fourel†, Marjolaine Le Bris*, Emilie Mongellas* & Karine Portier*,‡

*Equine Department, VetAgro-Sup, University of Lyon, Marcy l'Étoile, France

†USC1233, VAS-INRA RS2GP, VetAgro Sup, University of Lyon, Marcy l'Étoile, France

‡Laboratoire Carmen, INSERM U1060, INRA U1235, INSA Lyon, Université Claude Bernard Lyon 1, 69621 Villeurbanne Cedex, France

Correspondence: Karine Portier, Equine Department, VetAgro-Sup, Marcy l'Étoile 69280, France. E-mail: karine.portier@vetagro-sup.fr

Abstract

Objectives To compare the effects of a lidocaine constant rate infusion (CRI) combined with 1% isoflurane *versus* those of 2% isoflurane alone on cardiovascular variables in anaesthetized horses, and to estimate the sample size required to detect a difference in recovery quality.

Study design Prospective, randomized, blinded, crossover study.

Animals Twelve healthy experimental horses.

Methods Horses were anaesthetized twice using an intravenous (IV) administration of acepromazine, romifidine, diazepam and ketamine. Horses were placed in dorsal recumbency and ventilated mechanically. During the first 10 minutes (P1), anaesthesia was maintained with a 2% inspired isoflurane fraction (FIIso). During the following 20 minutes (P2), horses received IV lidocaine (1.5 mg kg^{-1}) (group IL) or saline (group I). During the last 60 minutes (P3), group IL received a lidocaine CRI (50 μg kg^{-1} $minute^{-1}$ IV) and FIIso 1%, whereas group I received a saline CRI and FIIso 2%. Three weeks later, the horses received the alternative treatment. Painful stimuli were induced by introducing an 18 gauge needle intramuscularly. Ketamine and dobutamine requirements and physiological variables were recorded. Recoveries were assessed by two anaesthetists unaware of the treatment. Lidocaine plasma concentrations were measured during recovery. Data were analysed with ANOVA.

Results During P3, group IL had a lower heart rate ($p = 0.002$), higher mean arterial pressure ($p < 0.001$) and lower dobutamine requirement ($p < 0.001$) than group I. One horse had lidocaine plasma concentrations above toxic levels. Recoveries did not differ significantly between groups. Sample sizes of 208 horses in each group would be necessary to detect a statistically significant difference (85% statistical power) in recovery quality.

Conclusions and clinical relevance A lidocaine CRI combined with FIIso 1% rather than FIIso 2% alone may improve cardiovascular variables in healthy anaesthetized horses.

Keywords horse, isoflurane, lidocaine, recovery quality.

Introduction

Isoflurane induces dose-related cardiopulmonary depression (Steffey & Howland 1980) and ataxic

recoveries in horses (Matthews et al. 1998). It may therefore be interesting to decrease its inspired/end-tidal fraction (FIIso/F_E'Iso) during the maintenance of anaesthesia. It is possible to achieve a 25% reduction in F_E'Iso by co-administering a constant rate infusion (CRI) of lidocaine (bolus of 2.5 mg kg^{-1} over 10 minutes followed by 50 μg kg^{-1} $minute^{-1}$) (Dzikiti et al. 2003). CRIs of lidocaine have been advertised for their analgesic (Murrell et al. 2005), prokinetic (Guschlbauer et al. 2010) and volatile anaesthetic-sparing (Dzikiti et al. 2003) effects.

Nevertheless, lidocaine CRIs (bolus of 2 mg kg^{-1} over 15 minutes followed by 50 μg kg^{-1} $minute^{-1}$) have been shown to induce ataxia during recovery (Valverde et al. 2005). For this reason, several studies advise the discontinuation of lidocaine prior to the end of surgery (Valverde et al. 2005; Schuhbeck et al. 2012). Valverde et al. (2005) compared two groups of horses that had received the same F_E'Iso with and without a lidocaine CRI. Horses that had received isoflurane and a lidocaine CRI had higher ataxia scores than horses that had received only isoflurane. However, the study failed to detect a significant difference in recovery scores.

For clinical cases in our institution, we reduce the isoflurane dose when co-administering a lidocaine CRI, taking advantage of lidocaine's anaesthetic-sparing effect. We have the clinical impression that lidocaine (bolus of 1.5 mg kg^{-1}, followed by 50 μg kg^{-1} $minute^{-1}$) does not increase ataxia even when it is administered until the end of surgery.

Therefore, the objectives of this study were: 1) to compare selected cardiovascular parameters in healthy horses anaesthetized with isoflurane (FIIso 1%) co-administered with lidocaine [1.5 mg kg^{-1} bolus, 50 μg kg^{-1} $minute^{-1}$ administered intravenously (IV)] *versus* isoflurane alone (FIIso 2%); 2) to confirm that lidocaine and isoflurane at the studied dosages can successfully maintain an adequate level of anaesthesia; and 3) to compare the recovery characteristics associated with each of the two protocols in order to estimate the minimum sample size required for future clinical studies.

Materials and methods

The present study was performed in accordance with the Federation of European Laboratory Animal Science Associations (FELASA) Euroguide. The experimental procedure was approved by the ethics committee of VetAgro-Sup, Campus Vétérinaire de Lyon, France and is registered under no. 1277.

A power analysis was used to estimate the minimum sample size (for paired data) required in each group to obtain a 90% chance (at $\alpha = 0.05$) of detecting a difference of 10 mmHg in average mean arterial pressure (MAP) between groups, considering a standard deviation (SD) of 10 mmHg. The calculated minimum sample size was 12 horses per group.

Therefore, 12 healthy [American Society of Anesthesiologists (ASA) class I] adult research horses were anaesthetized on two occasions, separated by a washout period of 3 weeks.

For the first anaesthesia, horses were randomly (random draw) assigned to one of two treatment groups: group I (isoflurane alone) or group IL (isoflurane co-administered with lidocaine). During the second anaesthesia, all horses were submitted to the alternative protocol. The preanaesthetic assessment included a physical examination and blood tests to measure packed cell volume and total proteins. The horses were fasted, but water was not withheld, for 12 hours prior to anaesthesia induction. Anaesthesia was performed by the same experienced anaesthetist, who was unaware of treatment assignment. An assistant was in charge of regulating the vaporizer setting and the anaesthetist filled in the anaesthetic record.

Each horse was premedicated with IM acepromazine (0.04 mg kg^{-1}; Calmivet; Vétoquinol SA, France), after which a 14 gauge catheter (BD Angiocath, BD Vialon; Becton Dickinson) was placed in the left jugular vein. One hour later, the horse was brought into the induction box and sedated with IV romifidine (0.04 mg kg^{-1}; Sedivet; Boehringer Ingelheim, Belgium). Anaesthesia was induced with diazepam (0.05 mg kg^{-1} IV; Valium Roche; Roche France, France) and ketamine (2.2 mg kg^{-1} IV; Imalgene 1000; Merial SA, France).

Once the horse was recumbent, the trachea was intubated and the animal was placed on a padded table in dorsal recumbency and connected to a primed (2% isoflurane) large-animal circle system (T0). A fresh gas flow of 10 L $minute^{-1}$ of oxygen was maintained throughout anaesthesia. Mechanical ventilation (Stephan Respirator-GT; F. Stephan GmbH, Germany) was started immediately and initially set to 6 breaths $minute^{-1}$ at a peak inspiratory airway pressure of 20 cmH_2O. The respiratory rate was adjusted during anaesthesia to maintain an end-tidal partial pressure of carbon dioxide ($P_E'CO_2$) of 35–45 mmHg (4.7–6 kPa).

During the first 10 minutes (P1), anaesthesia was maintained with FIIso (Vetflurane; Virbac SA,

