Partial intravenous anaesthesia in 5 horses using ketamine, lidocaine, medetomidine and halothane

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Abstract

A partial intravenous protocol was used successfully to maintain anaesthesia in 5 healthy horses. Horses were premedicated with acepromazine, romifidine and butorphanol, induced with guaifenesin and ketamine and maintained on a constant rate infusion of lidocaine, ketamine and medetomidine together with halothane inhalation anaesthesia. Mean end-tidal halothane concentration to maintain a surgical plane of anaesthesia was 0.8 ± 0.2 %. Mean dobutamine requirement to maintain mean arterial pressure above 9.31 kPa was 0.42 ± 0.3 µg/kg/min. The administration of relatively low doses of lidocaine, ketamine and medetomidine together with halothane resulted in haemodynamically stable anaesthesia, followed by smooth recovery.

Keywords: anaesthesia, halothane, horse, ketamine, lidocaine, medetomidine.

INTRODUCTION

In recent years, many reports have added potentially beneficial drugs to the equine anaesthetist’s arsenal. Volatile anaesthetics such as halothane cause significantly greater cardiorespiratory depression than intravenous anaesthetic agents and are associated with an increased risk of perioperative complications and mortality. Halothane is often used in South Africa for maintenance of anaesthesia in equines. It is characterised by good muscle relaxation and poor analgesia. It causes dose-dependent cardiorespiratory depression and has been shown to sensitize the myocardium to catecholamines, increasing the risk of developing arrhythmias.

Balanced anaesthesia for equine patients has come to include intravenous infusions of sedatives, muscle relaxants, analgesics and anaesthetic agents in order to decrease volatile anaesthetic requirement and preserve cardiovascular function. In addition to reducing the minimum alveolar concentration (MAC) of volatile anaesthetic agents, beneficial effects of such combinations are numerous. Ketamine produces beneficial haemodynamic effects during halothane anaesthesia. Combining guaifenesin and ketamine with halothane increases anaesthetic stability and decreases the need for dobutamine compared with halothane alone. The use of guaifenesin, ketamine and medetomidine with sevoflurane results in better transition and maintenance phases, improves cardiovascular function and reduces the number of attempts to stand compared with sevoflurane alone. Ketamine and lidocaine intravenous infusions improve cardiovascular stability during isoflurane anaesthesia. Lidocaine administration during halothane anaesthesia is antinociceptive. Using medetomidine with sevoflurane decreases the dobutamine requirement compared with sevoflurane alone.

In a recent review, lidocaine, ketamine and medetomidine were singled out as the main drugs used together with volatile anaesthetics for balanced anaesthesia. To our knowledge there is no report where all 3 these drugs have been used together with halothane for balanced anaesthesia.

MATERIALS AND METHODS

Five healthy horses that were presented for elective surgical procedures are included in this report (Table 1). Food, but not water, was withheld for 8 hours prior to premedication. Preanaesthetic examination of each patient included a physical examination, detailed cardiac and thoracic auscultation (including rebreathing bag), haematology, total serum protein and electrocardiogram (ECG). No abnormalities were detected. Preoperative treatment included tetanus vaccination and intramuscular procaine penicillin (20 mg/kg). After recovery from anaesthesia, phenylbutazone (4.4 mg/kg) was administered intravenously.

Horses were premedicated with intramuscular acepromazine (Aceprom 10, Bayer) at 0.02 ± 0.004 mg/kg (mean dose 9 ± 2.2 mg), 60 min prior to induction. Intravenous (IV) Romifidine (Sedivet 2%, Boehringer Ingelheim) at 40 ± 7 µg/kg (mean dose 17.4 ± 4.3 mg), and IV butorphanol (Torbugecic, Fort Dodge Animal Health) at 20 ± 4 µg/kg (mean dose 10.6 ± 1.3 mg) were given 5 minutes prior to induction. Horses were induced intravenously, first with a 5% guaifenesin solution (GGE, Kyron Laboratories) at 1.3 ± 0.1 ml/kg (mean dose 620 ± 84 ml), infused until they became ataxic, followed by a ketamine (Anaket-V, Bayer) bolus at 2.4 ± 0.13 mg/kg (mean dose 1140 ± 261 mg), in a padded induction room, intubated and connected to a circle anaesthetic machine. Ventilation was controlled with intermittent positive pressure ventilation and end-tidal carbon dioxide concentration (ETCO2) maintained between 4 and 6%. Anaesthesia was maintained during the 1st 10 min with an end-tidal halothane (ETHal) concentration of 1.2% and fresh gas flow rate set to 30 ml/kg/min. Thereafter the fresh gas flow rate was reduced to 10 ml/kg/min and the EThal maintained in a range between 0.6–0.85% when combined with a constant-rate infusion (CRI) of lidocaine (2 mg/kg/hour), ketamine (2 mg/kg/h) and medetomidine (1 µg/kg/h), delivered via an infusion pump (Injectomat Agilia, Fresenius Kabi SA, Halfway House). The EThal maintenance concentration and CRI rate used in this report were previously determined in routine surgical cases from the Onderstepoort Veterinary Academic Hospital (OVAH) to minimize risk of movement during surgery (unpublished results). When the EThal concentration during surgery decreased to 0.6%, the vapouriser setting was temporarily increased to 5% until the EThal concentration increased to 0.85%. Any spontaneous muscle movement...
ment could have been countered with a single or multiple 100 mg IV ketamine boluses but this was not required.

Blood volume was maintained with an IV isotonic crystalloid solution (PlasmaVet, Sabax) administered at 10 ml/kg/h and mean arterial pressure (MAP) maintained with an IV infusion of dobutamine administered at an initial dose rate of 2 µg/kg/min. Thereafter the dose rate was adjusted to maintain MAP between 9.31 and 11.97 kPa. Clinical parameters used to evaluate anaesthetic depth were the palpebral reflex, corneal reflex, nystagmus and spontaneous movement. Recovery was assisted with romifidine (40 µg/kg) at the 1st sign of recumbency. Horses were sedated with palmer digital neurectomy –

**RESULTS**

Individual and group mean (±SD) cardiorespiratory variables are summarised in Table 2 and Fig. 1. Changes in variables over time were not statistically significant for HR (P = 0.46), SAP (P = 0.36), DAP (P = 0.49), MAP (P = 0.44), RR (P = 0.32), ET-CO2 (P = 0.53). Capillary refill time remained normal (<2 s), but the oral mucous membranes became progressively paler over time. This was associated with an inability of the pulse oximeter to measure SpO2 due to the plethysmographic wave amplitude becoming a nearly flat line.

Horse 3 had a 2nd-degree atrioventricular (AV) block in the stable prior to induction of anaesthesia. His bladder was catheterised and emptied prior to recovery. Horse 2 dribbled urine during the procedure. His bladder was catheterised and emptied prior to recovery. Horse 2 dribbled urine during the procedure. His bladder was catheterised and emptied prior to recovery.

**DISCUSSION**

Inhalation anaesthetic potency is expressed in terms of MAC, which is the concentration of anaesthetic that will
prevent purposeful movement in 50% of animals\textsuperscript{35}. The MAC for halothane has been reported as 0.88 ± 0.03 \%\textsuperscript{37}, 0.91 ± 0.04 \%\textsuperscript{32} and 0.94 ± 0.03 \%\textsuperscript{7}. To prevent movement in 100\% of cases, it is necessary to maintain an anaesthetic concentration of 1.2–1.5 MAC. This would require an EThal concentration of 1.2–1.4 \% in the horse. Medetomidine, ketamine and lidocaine infused during this investigation contributed to a decrease in isoflurane requirement to maintain surgical anaesthesia.

Medetomidine, is a \(\alpha_2\)-adrenergic agonist that has potent sedative, analgesic and anaesthetic-sparing properties in equines\textsuperscript{3}, facilitates smooth anaesthesia and contributes to muscle relaxation\textsuperscript{8}. It is reported to be an ideal drug for CRI in ponies, owing to its short distribution half-life\textsuperscript{33} and has been used to decrease volatile anaesthetic MAC in horses at 1.25–3.5 \mu g/kg/h\textsuperscript{3,10,29}. A potential complication of lidocaine and ketamine anaesthesia is ataxia and excitation during the recovery period. Lidocaine infusions are reported to cause ataxia in the recovery period\textsuperscript{30}, while prolonged ketamine infusion may lead to muscle rigidity and excitation\textsuperscript{11}. This problem can be overcome by discontinuing the lidocaine infusion 30 min prior to the end of surgery, decreasing the ketamine dose to 65\% after 50 min and discontinuing the ketamine infusion 15–20 min prior to the end of surgery\textsuperscript{3,10,29}. We did not observe increased ataxia or excitation when using the protocol described in this report compared with maintenance with halothane alone. Romifidine was administered during recovery to delay the 1st attempt to stand, and to allow more time for plasma levels of the infused and inhaled anaesthetic drugs to decline sufficiently for a strong, coordinated 1st attempt to stand. Subjectively assessed, the recovery times appeared longer compared with halothane-only anaesthesia used at this institution. A significant increase in the time to 1st movement, produced by combining guaifenesin, ketamine and medetomidine with sevoflurane anaesthesia, is reported to significantly decrease the number of attempts to stand\textsuperscript{31}. Longer recoveries in equine patients may be better, because catastrophic post-operative complications occur when horses attempt to stand too soon after the end of anaesthesia. The use of head and tail ropes and romifidine may have contributed to the smooth recoveries observed here. In this investigation preference was given to romifidine for recovery from anaesthesia as it is associated with reduced attempts to stand and improved coordination during recovery from anaesthesia\textsuperscript{32}.

Medetomidine, like other \(\alpha_2\)-adrenergic agonists, causes mild, dose-dependent cardiovascular suppression in horses\textsuperscript{11,34}. The effect at 1 \mu g/kg/h during anaesthesia may, however, be negligible, because a medetomidine CRI at 3.5 \mu g/kg/h is reported to cause no cardiovascular suppression in conscious ponies\textsuperscript{35}. Any potential cardiovascular suppression would, however, be offset by a reduction in halothane requirement. The \(\alpha_2\)-adrenergic agonists (most likely the romifidine premedication) would have caused the 2nd-degree AV block in 1 of the horses in this report\textsuperscript{11}. The observed progressive pallor of the oral mucous membranes is probably the result of peripheral vasocostriction caused by medetomidine and also the reason for the inability of the pulse oximeter to obtain oxyhaemoglobin saturation readings from the mucous membrane of the tongue\textsuperscript{35}. It is important to note that eye reflexes should be brisker with medetomidine as an anaesthetic adjunct and insufficient anaesthetic depth is only indicated by nystagmus. Anaesthesiologists should be aware that spontaneous blinking could occur at appropriate depths of anaesthesia during surgery. Alpha\(\_2\)-adrenergic agonists cause a significant increase in urine production. One of the horses in this report demonstrated this effect by dribbling urine during anaesthesia. It is advisable to catheterise and empty the bladder prior to recovery in order to prevent post-operative discomfort in horses that received a medetomidine infusion, especially after prolonged anaesthesia\textsuperscript{35}. The benefits of PIVA extend beyond merely decreasing the MAC of volatile agents. In addition to the anaesthetic-sparing effects, lidocaine contributes to antinociception and has anti-inflammatory properties\textsuperscript{3,12}.

Very low doses of dobutamine were required to keep MAP within acceptable limits. This may be attributed to a decrease in halothane MAC as well as ketamine’s positive haemodynamic effects. The cardiovascular depressant effects of halothane are dose-dependent, resulting in a decrease in arterial blood pressure with increased dose\textsuperscript{36}. In addition, the peripheral vasoconstriction induced by medetomidine may also have contributed to the increase in blood pressure\textsuperscript{36}. Decreasing the requirement of dobutamine is beneficial to the patient, because dobutamine administration may be associated with supraventricular tachycardia, especially in colic patients\textsuperscript{23,35}.

Fig. 1: Mean cardiovascular variables over time in halothane-anaesthetised horses and lidocaine-ketamine-medetomidine constant-rate infusion.
Drug dose rates in this report are expressed in terms of the amount of drug given per kilogram, per time unit. The future of CRI drug therapy lies within the realm of target-controlled drug infusions (TCI), where pharmacokinetic models are used to calculate the dose rate necessary in order to attain a desired plasma concentration of the drug infused. A physiologically based pharmacokinetic model for ketamine in ponies has been developed\(^3\). Using such models in computer-controlled infusions, anaesthetists will have greater control during the anaesthetic period and perhaps even better recoveries in the future.

In conclusion, the constant-rate infusion of relatively low doses of lidocaine, ketamine and medetomidine during halothane anaesthesia resulted in haemodynamically stable anaesthesia, followed by smooth recovery.

REFERENCES


