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REVIEW ARTICLE

Partial intravenous anaesthesia in the horse: a review of intravenous agents used to supplement equine inhalation anaesthesia. Part 1: lidocaine and ketamine

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Abstract

Objective To review the literature with regard to the use of different intravenous agents as supplements to inhalational anaesthesia in horses. These drugs include lidocaine, ketamine, opioids and α_2-agonists. The Part 1 of this review will focus in the use of lidocaine and ketamine.

Databases used Pubmed & Web of Science. Search terms: *horse, inhalant anaesthesia, balanced anaesthesia, partial intravenous anaesthesia, lidocaine, ketamine.*

Conclusions Different drugs and their combinations can be administered systemically in anaesthetized horses, with the aim of reducing the amount of the volatile agent whilst improving the recovery qualities and providing a multimodal analgesic approach. However, full studies as to whether these techniques improve cardiopulmonary status are not always available and potential disadvantages should also be considered.

Keywords equine, inhalation anaesthesia, intravenous drugs, ketamine, lidocaine.

Introduction

During inhalation anaesthesia, reduction of concentration of volatile anaesthetic is one of the general principles to prevent and treat cardiopulmonary depression. Modern volatile anaesthetics have poor analgesic properties (Tomi et al. 1993; Petersen-Felix et al. 1995) and consequently, it may not be practicable to reduce their concentration for maintenance of anaesthesia, especially during painful surgical procedures. Lack of intra-operative analgesia also may lead pain after the anaesthetic period, which in turn may influence the recovery negatively. The use of systemically administered supplementary anaesthetics/analgesics can reduce the need for volatile anaesthetics while improving the recovery qualities in the so-called 'balanced anaesthetic protocols'.

The concept of balanced anaesthesia can be defined as the use of a combination of pharmacological agents that will act together to provide the desired effects for the procedure, most usually some or all of hypnosis, analgesia and muscle relaxation, whilst resulting in reduced side-effects compared with the use of higher doses of one agent alone (Gray & Halton 1946; Tonner 2005). In horses, balanced anaesthesia for prolonged surgery usually is based on a combination of volatile anaesthetics with either locoregional anaesthetic techniques or supplementary intravenous (IV) anaesthetics/analgesics, the technique also being called partial IV anaesthesia (PIVA). The aim is to maintain adequate conditions for surgery whilst maintaining good intraoperative cardiopulmonary function, this then being followed by a calm, smooth and coordinated recovery (Bettschart-Wolfensberger & Larenza 2007). The concept

of PIVA has been used frequently in equine anaesthesia (Doherty & Valverde 2006; Bettschart-Wolfensberger & Larenza 2007) and has been defined as 'a form of balanced anaesthesia that implies the use of low concentrations of inhalation anaesthetics in combination with injectable agents in order to reduce the cardiorespiratory depressant effects of the inhalants and to improve analgesia and anaesthetic stability' (Nannarone & Spadavecchia 2012).

The following sections will review the current literature with regard to the different drugs that can be used for these purposes. The focus will be placed on the local anaesthetic agent lidocaine, the dissociative anaesthetic agent ketamine, the analgesic opioids and the sedative/analgesic α_2-agonists.

To assess the effects of anaesthetic methods cardiovascular function it is necessary to know not only blood pressures and heart rate (HR), but also cardiac output (CO). In the equine anaesthetic literature, measurement of this vital parameter often is not performed, and the term 'cardiovasular depresssion' taken to refer only to arterial blood pressures, neglecting the important features of cardiac performance and resultant blood flow. Since the introduction of lithium dilution measurement for CO, more equine studies have included this parameter. Unfortuately recent work has demonstrated that the lithium sensor is influenced by clinically relevant blood concentrations of, in particular xylazine (Ambrisko et al. 2013; Ambrisko & Moens 2014; Hopster et al. 2014a), in general resulting in an overestimation of CO. Thus the potential for error has to be taken into consideration for all research in this field that used this method of CO measurement.

Lidocaine

In human medicine, the IV use of the local anaesthetic, lidocaine, for anaesthetic and analgesic purposes was first reported over 60 years ago (Gilbert et al. 1951; De Clive-Lowe et al. 1958). Its use decreased for thirty years mainly due to toxicity matters and the development of other drugs and analgesic/anaesthetic techniques. However, as local anaesthetics were shown to be efficient at blood concentrations lower than those causing toxicity (Rimbäck et al. 1986, 1990), a renewed interest of IV lidocaine was created in the 1980s for applications such as the treatment of neuropathic pain (Kastrup et al. 1987; Ferrante et al. 1996) and the reduction of the duration of colonic stasis (Rimbäck et al. 1990). Additionally, IV lidocaine was reported to decrease postoperative pain (Koppert et al. 2004), to have antihyperalgesic (Koppert et al. 1998) and anti-inflammatory properties (Hollmann & Durieux 2000), to improve gastrointestinal function postoperatively (Groudine et al. 1998), to facilitate rehabilitation (Kaba et al. 2007) and also to reduce the minimum alveolar concentration (MAC) of volatile agents (Himes et al. 1977). However, its negative inotropic effects limit its use in human anaesthesia (Wilson et al. 1993).

With regard to antinociception, the mechanism whereby systemic lidocaine exerts an analgesic action has not been completely elucidated. Tanelian & MacIver (1991) suggested that the analgesia produced by lidocaine is the result of the suppression of tonic neural discharges in injured peripheral A-δ and C fibre nociceptors, although a direct action on spinal transmission in the spinal cord has also been proposed (Woolf & Wiesenfeld-Hallin 1985; Nagy & Woolf 1996; Koppert et al. 2000). It is also possible that both peripheral and central actions contribute to the analgesic action of systemic lidocaine and that the predominant mechanism varies according to the nature of pain (Wallace et al. 1996). Low doses of systemic lidocaine have been used with good results for the treatment of severe cases of laminitis in equine patients (Malone & Graham 2002). Furthermore, electroencephalographic findings have demonstrated that lidocaine provides antinociception contributing to additional analgesia during castration in ponies (Murrell et al. 2005). However, much less is understood about the action of lidocaine on visceral pain. Indeed, lidocaine failed to have a significant effect on the response to colorectal or duodenal distension in horses (Robertson et al. 2005), although it did inhibit, in a dose dependent manner, the cardiovascular responses to colorectal distension in rats (Ness 2000). Furthermore, lidocaine significantly increased the thermal threshold in horses (Robertson et al. 2005), which was in clear contrast with the findings in human volunteers, where systemic lidocaine had no effect on thermal thresholds (Wallace et al. 1997).

Systemically administered lidocaine has recently gained popularity for use in equine anaesthetized patients as it produces anaesthetic-sparing (Doherty & Frazier 1998; Dzikiti et al. 2003), analgesic (Murrell et al. 2005; Robertson et al. 2005) and anti-inflammatory effects (Nellgård et al. 1996; Cook et al. 2009). The mechanism by which lidocaine reduces the MAC of volatile anaesthetics may involve different receptor types, such as sodium,