RESEARCH PAPER

Cardiorespiratory effects of a 7° reverse Trendelenburg position in anaesthetized horses: a randomized clinical trial

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Abstract

Objective To evaluate the cardiorespiratory effects of a 7° reverse Trendelenburg position (RTP) in anaesthetized horses.

Study design Randomized, non-blinded clinical trial.

Animals A total of 125 horses undergoing elective surgery in dorsal recumbency.

Methods Horses were allocated to one of three weight classes and assigned to be positioned either on a horizontal table or on a table in 7° RTP, according to a randomized block design. In all horses, anaesthesia was maintained with isoflurane in oxygen and a constant rate infusion of romifidine. All horses were mechanically ventilated throughout anaesthesia, and routine cardiovascular monitoring and arterial blood gas analysis were performed at 15-minute intervals and relevant variables calculated. Data from the first 60 minutes of anaesthesia were compared between both positions using a mixed model analysis of variance.

Results A significant interaction was found between position and weight class for the alveolar to arterial oxygen tension gradient and F-shunt: these variables were lower in RTP than in horizontal position in the two lowest weight classes and *vice versa* in the highest weight class. Arterial oxygen tension and oxygenation indices were significantly worse in the horses in the higher weight classes.

Conclusions and clinical relevance A 7° RTP did not result in clinically relevant changes in gas exchange or cardiovascular function. Horses with a higher body weight are at increased risk for hypoxaemia during anaesthesia in dorsal recumbency.

Keywords anaesthesia, cardiovascular, horse, respiratory, reverse Trendelenburg.

Introduction

During anaesthesia, large alveolar−arterial oxygen tension gradients [$P(A\text{-}a)O_2$] and low arterial oxygen tensions (PaO_2) are commonly encountered in horses (Hall et al. 1968). The incidence of hypoxaemia is influenced by several factors, such as the health status and the conformation of the horse. Round-bellied horses had a lower PaO_2 and a larger $P(A\text{-}a)O_2$ than flat-bellied horses in both dorsal and lateral recumbency (Moens et al. 1995). In a later study, it was also demonstrated that the height at the withers and the thoracic circumference, each expressed per unit body mass, strongly correlate with arterial oxygen tensions during anaesthesia (Mansel & Clutton 2008). Furthermore, in human medicine, an inverse relationship was found between body mass index and functional residual capacity (Pelosi et al. 1998; Jones & Nzekwu 2006).

Besides the conformation of the horse, the position of the animal and the table position can influence ventilation and cardiovascular function. Studies performed in the early 1980s and 1990s showed that PaO_2 in anaesthetized horses was lower in dorsal than in lateral recumbency, mainly as a result of the pressure of the abdominal organs on the diaphragm and lungs (Sorensen & Robinson 1980; Schatzmann et al. 1982; Stolk 1982; Day et al. 1995). The latter effect is even more pronounced when the table is placed in the Trendelenburg position. Horses in this position had lower PaO_2 values compared with those positioned on a horizontal table (Hofmeister et al. 2008). It may be hypothesized that the reverse Trendelenburg position (RTP) will cause a reduction in the pressure exerted on the lungs by the abdominal organs, which may improve gas exchange. During bariatric surgery in humans, this position indeed resulted in an improvement in $P(A-a)O_2$ and total respiratory system compliance (Perilli et al. 2000, 2003). Compared to the use of positive end-expiratory pressure (PEEP), RTP resulted in lower airway pressures, with similar improvements in total respiratory system compliance and oxygenation. However, in both groups, a significant decrease in cardiac output was also observed (Perilli et al. 2003).

Limited information is available on the effect of RTP in horses. An experimental study from 2017 compared the effects of a Trendelenburg position and RTP on cardiorespiratory parameters in anaesthetized horses (Binetti et al. 2016). Oxygenation parameters were significantly better in RTP than in the Trendelenburg position when these positions were applied immediately after induction of anaesthesia, with little to no effect on cardiovascular parameters.

To the authors' knowledge, no comparison has been made between a horizontal position (HP) and RTP in anaesthetized horses. The purpose of the present study was to compare the effects of HP and RTP on cardiorespiratory function in healthy horses anaesthetized for elective surgery in dorsal recumbency.

Materials and methods

This prospective, randomized, clinical study was approved by the Ethical Committee of the Faculty of Veterinary Medicine at Ghent University (EC Nr. 2014-132). This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Animals and inclusion criteria

The study was performed over a period of 9 months, aiming to include at least 100 horses undergoing elective surgery in dorsal recumbency, with written owner consent. All horses underwent a preoperative clinical examination; horses with a body weight less than 300 kg or an ASA status higher than II were excluded. Each horse was allocated to one of three weight classes depending on body weight: weight class I (300−499 kg), weight class II (500−599 kg) or weight class III (≥600 kg). Food was withheld for 12 hours before anaesthesia, whereas water was available *ad libitum*. The height at the withers, thoracic circumference (measured immediately caudal to the withers) and belly score [scale of 1 (extremely flat bellied) to 5 (extremely round bellied)] were recorded before anaesthesia. The belly score was recorded a second time during the anaesthetic procedure, in dorsal recumbency. The mean of both belly scores was used for statistical comparison.

Randomization

A randomized block design was used: within each weight class, the horses were ranked in chronological order (according to the date of presentation for surgery). All horses with an uneven number were positioned on a horizontal surgical table (HP), while horses with an even number were placed on a table in a 7° RTP. Before induction of anaesthesia, the angle of the surgical table was measured using a digital clinometer placed at a fixed solid part of the table and was set to be 0 ± 0.1° for HP and 7 ± 0.1° for RTP.

Anaesthesia and instrumentation

All horses were premedicated with acepromazine maleate 0.02 mg kg^{-1} (Placivet; Kela, Belgium) intramuscularly (IM) at least 30 minutes and not longer than 3 hours before induction of anaesthesia. Sedation consisted of romifidine 0.08 mg kg^{-1} (Sedivet; Boehringer Ingelheim, Germany) and morphine 0.1 mg kg^{-1} (Morphine HCl; Sterop, Belgium). After aseptic preparation of the skin, a 12 standard wire gauge (SWG) catheter [Intraflon 2 (PTFE); Vygon, France] was positioned in the jugular vein and antibiotics and/or non-steroidal anti-inflammatory drugs were administered, depending on the requirements of the horse.

General anaesthesia was induced by intravenous (IV) administration of ketamine hydrochloride 2.2 mg kg^{-1} (Ketamidor; Ecuphar NV/SA, Belgium) combined with midazolam 0.06 mg kg^{-1} (Dormicum; Roche, The Netherlands). After blind orotracheal intubation, all horses were placed in dorsal recumbency on a padded surgical table, previously placed in HP or RTP.

The endotracheal tube was connected to a large animal anaesthetic unit (Matrx Medical Inc., NY, USA) with an out-of-circuit vapourizer (Drägerwerk AG, Germany), combined with a large animal ventilator (Smith respirator LA 2100, model 2002; Veterinary Technics/BDO-Medipass, The Netherlands). Anaesthesia was maintained with isoflurane (Isoflo; Zoetis S/A, Belgium) in a mixture of oxygen and air

Please cite this article in press as: Schauvliege S, Binetti A, van Dijk JJ et al. Cardiorespiratory effects of a 7° reverse Trendelenburg position in anaesthetized horses: a randomized clinical trial, Veterinary Anaesthesia and Analgesia (2018), https://doi.org/10.1016/j.vaa.2018.03.011