THE EFFECT OF PREANESTHETIC ADMINISTRATION OF LACTATED RINGER SOLUTION ON BLOOD PRESSURE IN ISOFLURANE–ANESTHETIZED HORSES

BRKLJACA BOTTEGARO NIKA, VNUK D, SMOLEC O, RADISIC B, PIRKIC B, VRBANAC Z and KOS J

University of Zagreb, Faculty of Veterinary Medicine, Croatia

(Received 15th May 2010)

Hypotension induced by volatile agents is particularly notorious in horses and it is probably one of the major causes of the high anaesthetic risk in this species. In the present study we investigated the influence of 10 mL/kg lactated Ringer solution on the values of arterial blood pressure during the elective surgical procedure, administered right before the induction of anaesthesia. The goal was to establish if it was possible to lower the risk of hypotension development with this type of therapy. Nine horses divided in two groups were used in this study. All the horses were submitted to the same anesthetic regimen. The second group of horses received 10 mL/kg i.v. lactated Ringer solution in the 15 minutes time before the induction of anesthesia. The effect of lactated Ringer solution was noted at the beginning of anesthesia. Statistically significant differences among groups were noticed during the first measurement. The results indicate that the suggested method may provide a very simple way of supporting the cardiovascular system at least at the beginning of the surgical procedure.

Key words: crystalloids, equine anesthesia, hemodynamic support, hypotension

INTRODUCTION

The management of anesthetized animals undergoing surgery includes sufficient central nervous system depression and muscle relaxation to facilitate surgical conditions, while maintaining adequate perfusion of the vital organs with oxygenated blood. Tissue oxygen supply during equine anaesthesia is often inadequate as a result of hypotension and poor tissue perfusion, even in clinically healthy horses (Schauvliege et al., 2008).

Awake horses have an average cardiac output (CO) of approximately 70 mL/kg/min, which decreases by approximately $\frac{1}{3}$ to $\frac{1}{2}$ during inhalation anesthesia (Steffey et al., 1987). This decrease in CO was associated with a decreased arterial blood pressure. Because CO measurement is generally too complicated for routine clinical applications, anesthetists generally rely on
measurements of arterial blood pressure to assess the adequacy of circulatory function (Wagner, 2000; Valverde et al., 2007). The cursory survey of equine anesthesia records from the Veterinary Teaching Hospital at Colorado State University for the month of August 1999 revealed that 91% of horses subjected to halothane, isoflurane or sevoflurane anesthesia for elective surgical procedures were treated for hypotension (Wagner, 2000). Reduction of anaesthetic depth, high volume fluid therapy and inotropic support are important in an attempt to prevent or reduce the severity of complications, including post-anaesthetic myopathies (Duke et al., 2006). Ideally, prevention of the hypotensive episode is the best approach (Swanson, 1985).

The purpose of this study was to examine the effect of 10 mL/kg lactated Ringer solution given before the induction of anesthesia on values of arterial blood pressure. The goal was to establish if it was possible to prevent hypotension induced by volatile anesthetics with this type of therapy.

MATERIALS AND METHODS

Nine male horses undergoing elective surgery (castration) were included in this study. The horses were of various breed, age 2 to 10 years and weighting 450 to 576 kg. Two treatment groups (5 and 4 horses) were randomly selected. A 14-gauge central venous catheter (Secalon®, 2.0 x 160 mm, Becton Dickinson, Franklin Lakes, USA) was placed in the left jugular vein for drug and fluid administration. The same anesthetic regimen was used for all horses, however the second group received 10 mL/kg i.v. lactated Ringer solution (Infusol®, Pliva, Zagreb, Croatia) in the 20 minutes time right before the induction of anesthesia. The anesthetic regimen included administration of detomidine (Domosedan®, Pfizer, Kent, UK) 0.015 mg/kg i.v. and butorphanol (Butomidor®, Richter Pharma, Austria) 0.02 mg/kg i.v., followed by midazolam (Dormicum®, Roche, Basel, Switzerland) 0.05 mg/kg i.v. and ketamine (Narketan 10®, Vetoquinol, Bern, Switzerland) 2.2 mg/kg i.v. administered by intravenous injection through the preplaced jugular catheter. General anesthesia was maintained by isoflurane (Forane®, Abbott Laboratories Ltd., Queenborough, UK) in oxygen. The delivered anaesthetic concentrations were set to produce a level of anesthesia considered necessary for the surgical procedure rather than a specified end-tidal value. All horses were mechanically ventilated and ventilation was adjusted to ensure an arterial carbon dioxide (CO2) tension in the range of 4.66-5.99 kPa. During the procedure all the horses had been receiving 10 mL/kg/h of lactated Ringer solution. Systolic, diastolic and mean blood pressure were measured by indirect oscilometric method with the cuff placed around the tail (the middle coccygeal artery). The ratio for cuff width to tail circumference was of 0.2 to 0.25. Data collection was performed every 5 minutes.

In order to compare the influence of the treatment of the second group with the lactated Ringer solution descriptive statistics and t-test (Visual Stats software) were used. The value of $p<0.05$ was considered significant. Due to differences in the duration of the surgical procedures, the first 5 measurements were taken into statistical analysis.
RESULTS

The characteristics (mean arterial blood pressure ± standard deviation) of the horses in each group in the first 20 minutes of anesthesia (in kPa) are presented in Figure 1. The first measurement was taken in the first three minutes after induction. Horses in the second group had a significantly higher MAP in the first measurement compared with the first group. In the next measurements no significant differences in MAP among groups were noted (Figure 1).

The MAP values of the horse in the first group reached 6.38 kPa in the fifth measurement, so the horse received dobutamine (Dobutamin Admeda 250®, Wuelfing Pharma GmbH, Gronau, Germany) 2 μg/kg/min i.v. and the values increased rapidly in the sixth measurement (8.78 kPa). A horse from the second group reached the MAP value of 7.05 kPa in the 40th minute of the surgical procedure and was treated with dobutamine 2 μg/kg/h i.v. for the last 10 minutes of surgery. Those horses were excluded from the analysis because the drugs administration took place after the 20th minute.

DISCUSSION

Hypotension is the most commonly reported morbidity cause during equine anesthesia and is associated with an increased risk of anesthetic complications (Grandy et al., 1987; Lindsay et al., 1989; Johnston et al., 2002). These risks can be mitigated by the constant monitoring of arterial blood pressure and the treatment of all hypotensive animals during the preoperative period (Donaldson, 1988).
Administration of 10 mL/kg i.v. lactated Ringer solution during the preinduction period, was used to support the cardiovascular system during elective surgery in dorsal recumbency. A greater depression of the cardiovascular function has been observed in horses in dorsal recumbency in comparison with the same regime used in the study in lateral recumbency (Steffey et al., 1990; Blissit et al., 2008). The used dosage of lactated Ringer solution was half of the volume suggested in the literature (Dyson and Pascoe, 1990), because it is easier to use it due to the lack of time in a period prior to surgical procedures. Isofluran induces depression of myocardial contractility and peripheral vascular resistance which lead to secondary hypotension (Doherty and Valverde, 2006). The result of decreased peripheral vascular resistance is peripheral vasodilatation which causes a decrease in the venous return and preload. When hypotension develops consequent to decreased ventricular filling, the main goal of fluid therapy is to increase cardiac output by increasing and then maintaining cardiac preload (Starling’s law) (Corley, 2004). For routine fluid therapy during anesthesia, or for replacement of large volume deficits, the use of lactated Ringer solution is recommended in order to maintain relatively normal serum levels of sodium, potassium, calcium and chloride (Wagner, 2000). Crystalloid fluid therapy rates in the range 10-20 mg/kg are recommended during anesthesia for horses, and probably help to prevent the development of post-anesthetic myopathy by improving the venous return, cardiac output and perfusion of tissues (Duke et al., 2006). Both clinical impressions and experimental work indicate that horses are more susceptible to anesthetic-induced cardiovascular depression than dogs.

MAP of horses at 1.5 minimum alveolar concentration (MAC) halothane is decreased approximately by 38% compared to the awake state, while dogs at the same anesthetic depth have only a 19% decrease in MAP (Wagner, 2000). MAP in awake horses is generally in the range of 13.97-17.96 kPa, but decreases during inhalation anesthesia (Aida et al., 1996). In most species, a MAP of 7.98-9.31 kPa is considered to be the minimum pressure that will result in adequate perfusion of vital organs and tissues, such as the brain and kidney. Anesthetic-induced hypotension and hypoperfusion may lead to inadequate perfusion of their large muscle mass, which can be evidenced in the immediate recovery period as post-anesthetic myopathy (Wagner, 2000). Experimentally, post-anesthetic myopathy has been produced by maintaining horses for 3.5 hours at the level of halothane anesthesia deep enough to result in MAP between 7.32 and 8.65 kPa and CO between 23 and 29 mL/kg/min (Grandy et al., 1987). In two horses the measured values of MAP were lower then 7.05 kPa, but through the longest anesthetic procedure lasted not more then 90 min, no horse in the study developed postanesthetic myopathy caused by the decreased perfusion of the large muscles. Clinically, it has been noted that the greater the degree of hypotension and the longer duration of anesthesia, the greater is the incidence of post-anesthetic lameness (Richey et al., 1990).

Dobutamine is catecholamine which directly increases myocardial contractility and heart rate, and depending on its adrenergic pharmacological profiles has variable vasoconstrictive and vasodilatatory actions (Swansson et al., 1985; Schauvliege et al. 2008; De Vries et al., 2009). It was administred to the
horse whose MAP value reached 6.38 kPa, which is the 37% increase of MAP in
the next 5 minutes. The administration of dobutamine to two horses in our study
took place after the 20th minute, so it hasn’t influenced our results.

Fluid therapy administered before induction of anesthesia was useful in
keeping the values of the arterial blood pressure between limits which resulted in
adequate perfusion of vital organs and tissues. The effect of the lactated Ringer
solution was pronounced in the first minutes of anesthesia when it reached its
peak, although later on, the power of effect decreased up to the 20th minute until
there was no differences in arterial pressure values between two groups.
Improvement of arterial blood pressure was secondary to volume maintenance,
rather then directly related to myocardial stimulation (Dayson and Pascoe, 1990).
Statistically significant differences among groups were measured just in the first
measurement because the application of the solution started 20 minutes before
the induction and just 30% of isotonic solution remains in the circulation after
30 minutes (Spalding and Goodwin, 1999). As the cristalloid solution passes from
the blood vessels to the intercellular space, it looses its influence on blood
volume, therefore on arterial blood pressure.

Lately sevofluran is more often used in equine anesthesia. Sevoflurane is a
halogenated inhalant anesthetic with favorable physico-chemical and
pharmacodynamic properties. Its low blood solubility facilitates rapid induction
and recovery from anesthesia and better control of anesthetic depth during
maintenance when compared to other commonly used volatile agents (Brown,
1995). Horses under sevoflurane anesthesia require less pharmacological
support in the form of dobutamine than isoflurane-anesthetized horses to
maintain adequate hemodynamic functions, which may be due to less severe
suppression of the vasomotor tone. Therefore, sevofluran could also potentially
provide a benefit for its use in critically ill equine patients that are often affected by
substantial vasodilatation (Driessen et al., 2006) where there is seldom enough
time for preinduction fluid therapy. On the other hand, findings during the infusion
of injectable anesthetic drug combinations to horses suggest that
cardiopulmonary parameters are better maintained during total intravenous
anesthesia (TIVA) compared to inhalation anesthesia (Bettschart-Wolfensberger
et al., 2001; Bettschart-Wolfensberger et al., 2005). Cardiovascular parameters
including cardiac index, stroke volume, and MAP were well maintained in all
horses with different TIVA protocols (Umar et al., 2007). This finding has important
implications and suggests that the development of TIVA techniques for use in
horses should continue and that the maintenance of cardiac output and MAP are
the key factors in maintaining adequate muscle perfusion (Lee et al., 1998).
However, those techniques are still unsuitable for many surgical procedures. In
such cases a useful alternative is the use of PIVA protocols which provide better
intraoperative analgesia, less cardiovascular depression and better quality of
recovery than protocols based primarily on inhalant anaesthetics (Valverde et al.,
2010).

In conclusion, this regimen provided a very simple method of supporting the
cardiovascular status at least at the beginning of the surgical procedure. We must
have in mind that hypotension is the most commonly reported cause of
morbidity during equine anesthesia and is associated with an increased risk of anesthetic complications (Grandy et al., 1987; Lindsay et al., 1989). Therefore, every possible effort should be taken to prevent it.

Address for correspondence:
Brkljača Bottegaro Nika
Clinic for Surgery, Orthopedics and Ophthalmology
Faculty of Veterinary Medicine
University of Zagreb
Heinzelova 55
10000 Zagreb, Croatia
E-mail: nikabb@vet.hr

REFERENCES

UČINAK PREANESTETIČKE PRIMJENE RASTVORA RINGEROVOG LAKTATA NA KRVNI PRITISAK KOD KONJA ANESTEZIRANIH ISOFLURANOM
BRKLJACA BOTTEGARO NIKA, VNUK D, SMOLEC O, RADISIC B, PIRKIC B, VRBANAC Z i KOS J

SADRŽAJ
