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

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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 1/3 to 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 halotane, 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 (CO_2) 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).

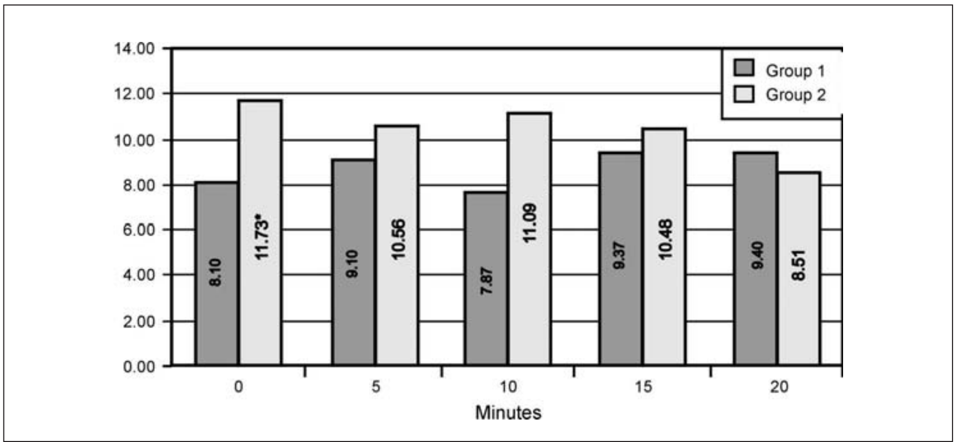

Figure 1. The values of mean arterial pressure in the first 20 minutes of anesthesia in kPa, *significant difference compared to Group 1 ($p<0.05$)

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 cloride (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) halotane 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 hypothension 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 maintaing 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 hypothension 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.

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REFERENCES

1. *Aida H, Mizno Y, Hobo S, Yoshida K, Fjinaga T*, 1996, Cardiovascular and pulmonary effects of sevoflurane anesthesia in horses, *Vet Surg*, 25, 164-70.
2. *Bettschart-Wolfensberger R, Bowen MI, Freeman SL, Feller R, Bettschart RW, Nolan A et al.,* 2001, Cardiopulmonary effects of prolonged anesthesia via propofol-medetomidine infusion in ponies, *Am J Vet Res*, 62, 1428-35.
3. *Bettschart-Wolfensberger R, Kalchofner K, Neges K, Kastner S, Furst A,* 2005, Total intravenous anesthesia in horses using medetomidine and propofol, *Vet Anaesth Analg*, 32, 348-54.
4. *Blissitt KJ, Raisis AL, Adams VJ, Rogers KH, Henley WE, Yong LE*, 2008, The effect of halotane and isoflurane on cardiovascular function in dorsally recumbent horses undergoing surgery, *Vet Anaesth Analg*, 35, 208-19.
5. *Brown B*, 1995, Sevoflurane: introduction and overview, *Anesth Analg*, 81, S1-3.
6. *Corley KTT*, 2004, Fluid therapy, In: Bertone JJ, Horspool LJI, editors, Equine clinical pharmacology, Philadelphia: Saunders. Inc, 327-64.
7. *De Vries A, Brearlay JC, Taylor PM*, 2009, Effects of dobutamine on cardiac index and arterial blood pressure in isoflurane-anaesthetized horses under clinical conditions, *J Vet Pharmacol Therap*, 32, 353-8.
8. *Doherty T, Valverde A*, 2006, Complications and emergencies, In: Dorherty T, Valverde A, editors, Manual of equine anesthesia and analgesia, Oxford: Blackwell, Inc, 305-37.
9. *Donaldson LL*, 1988, Retrospective assessment of dobutamine therapy for hypotension in anesthetized horses, *Vet Surg*, 17, 53-7.
10. *Dyson DH, Pascoe PJ*, 1990, Influence of preinduction metoxamine, lactated Ringer solution, or hypertonic saline solution infusion or postinduction dobutamine infusion on anesthetic-induced hypotension in horses, *Am J Vet Res*, 51, 17-21.
11. *Driessen B, Nann L, Benton R, Boston R*, 2006, Difference in need for hemodynamic support in horses anesthetized with sevoflurane as compared to isoflurane, *Vet Anaesth Analg*, 33, 356-67.
12. *Duke T, Filzek U, Read MR, Read EK, Fergson JG*, 2006, Clinical observations surrounding an increased incidence of postanesthetic myopathy in halotane-anesthezied horses, *Vet Anaesth Analg*, 33, 122-7.
13. *Grandy JL, Steefy EP, Hodgson DS, Woliner MJ*, 1987, Arterial hypotension and the development of postanesthetic myopathy in halotane-anesthetized horses, *Am J Vet Res*, 48, 192-7.
14. *Johnston GM, Eastmen JK, Wood JLN, Taylor PM,* 2002, The confidential enquiry into perioperative equine fatalities (CEPEE): mortality results of Phases 1 and 2, *Vet Anaesth Analg*, 29, 159-70.
15. *Lee YH, Clarke KW, Alibhai HI, Song D*, 1998, Effects of dopamine, dobutamine, dopexamine, phenylephrine, and saline on intramuscular blood flow and other cardiopulmonary variables in halotane-anesthetized ponies, *Am J Vet Res*, 59, 1463-72.
16. *Lindsay WA, Robinson GM, Brnson DB*, 1989, Induction of equine postanesthetic myositis after halotane-induced hypotension, *Am J Vet Res*, 50, 404-10.

17. *Richey MT, Holland MS, McGrath DJ*, 1990, Equine post-anesthetic lamness, A retrospective study, *Vet Surg*, 19, 392-7.
18. *Schauvliege S, Van den Eede A, Duchateau L, Gasthuys F*, 2008, Effects of dobutamine on cardiovascular function and respiratory gas exchange after enoximone in isoflurane-anaesthetized ponies, Vet Anaesth and Analg, 35, 306-18.
19. *Spalding HK, Goodwin SR*, 1999, Fluid and electrolyte disorders in the critically ill, *J Crit Care*, 18, 15-26.
20. *Steffey EP, Dunlop CI, Farver RB, Woliner MJ*, 1987, Cardiovascular and respiratory measurements in awake and isoflurane-anesthetized horses, *Am J Vet Res*, 48, 7-12.
21. *Steffey EP, Kelly AB, Hodgson DS, Grandy JL, Woliner MJ, Willits N*, 1990, Effect of body posture on cardiopulmonary function in horses during five hours of constant-dose halotane anesthesia, *Am J Vet Res*, 51, 11-6.
22. *Swanson RC, Muir WW, Bednarski RM, Skarda RT, Hubbell JAE*, 1985, Hemodynamic responses in halotane-anesthetized horses given infusions of dopamine or dobutamine, *Am J Vet Res*, 46, 365-70.
23. *Umar MA, Yamashita K, Kushiro T, Muir WW*, 2007, Evaluation of cardiovascular effects of total intravenous anesthesia with propofol or a combination of ketamine-medetomidine-propofol in horses, *Am J Vet Res*, 68, 121-7.
24. *Valverde A, Giguere S, Morey TE, Sanchez LC, Shih A*, 2007, Comparision of noninvasive cardiac output measured by use of partial carbon dioxide rebreathing or the lithium dilution method in anesthetized foals, *Am J Vet Res*, 68, 141-7.
25. *Valverde A, Rickey E, Sinclair M, Rioja E, Pedernera J, Hathway A, et al*. 2010, Comparison of cardiovascular function and quality of recovery in isoflurane-anaesthetised horses administered a constant rate infusion of lidocaine or lidocaine and medetomidine during elective surgery, *Equine Vet J*, 42, 192-9.
26. *Wagner AE*, 2000, Focused supportive care: blood pressure and blood flow during equine anesthesia, In: Steffey EP, editor, Recent advances in anesthetic management of large domestic animals, International Veterinary Information Service (www.ivis.org).

UČINAK PREANESTETIČKE PRIMJENE RASTVORA RINGEROVOG LAKTATA NA KRVNI PRITISAK KOD KONJA ANESTEZIRANIH IZOFLURANOM

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SADRŽAJ

Hipotenzija uzrokovana inhalacionim anesteticima je odavno poznata u konja te je verovatno jedan od glavnih uzroka visokog rizika anestezije u ove vrste. U ovom radu ispitan je uticaj 10 ml/kg rastvora Ringerovog laktata, apliciranog pre indukcije anestezije, na vrednosti krvnog pritiska za vreme elektivnog hirurškog zahvata. Cilj je bio utvrditi da li se takvom terapijom smanjuje rizik razvoja hipotenzije. Korišćeno je devet konja podeljenih u dve grupe. Svi konji su podvrgnuti istom protokolu anestezije. Drugoj grupi konja je u periodu od 15 minuta pre indukcije anestezije aplicirano 10 ml/kg rastvora Ringerovog laktata. Efekat rastvora Ringerovog laktata uočen je na početku anestezije. Statistički značajne razlike među grupama uočene su samo kod prvog merenja. Dobiveni rezultati ukazuju da predložena metoda predstavlja vrlo jednostavan način potpore kardiovaskularnog sistema barem u početku hirurškog zahvata.