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SHORT COMMUNICATION

The effect of cuff size on accuracy of high-definition oscillometry in laterally recumbent horses

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Q7 **Tanya Duke-Novakovski[a], Barbara Ambros[a], Cindy Feng[b] & Anthony P Carr[a]**

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Abstract

Objective To determine the accuracy of high-definition oscillometry (HDO) for arterial pressure measurement during injectable or inhalation anesthesia in horses.

Study design Prospective, clinical study.

Animals Twenty-four horses anesthetized for procedures requiring lateral recumbency.

Methods Horses were premedicated with xylazine, and anesthesia was induced with diazepam−ketamine. Anesthesia was maintained with xylazine−ketamine−guaifenesin combination [TripleDrip (TD; *n* = 12) or isoflurane (ISO; *n* = 12)]. HDO was used to obtain systolic (SAP), mean (MAP) and diastolic (DAP) arterial pressures, and heart rate (HR) using an 8-cm-wide cuff around the proximal tail. Invasive blood pressure (IBP), SAP, MAP, DAP and HR were recorded during HDO cycling. Bland−Altman analysis for repeated measures was used to compare HDO and IBP for all measurements. The generalized additive model was used to determine if means in the differences between HDO and IBP were similar between anesthetic protocols for all measurements.

Results There were >110 paired samples for each variable. There was no effect of anesthetic choice on HDO performance, but more variability was present in TD compared with ISO. Skewed data required log-transformation for statistical comparison. Using raw data and standard Bland−Altman analysis, HDO overestimated SAP (TD, 3.8 ± 28.3 mmHg; ISO, 3.5 ± 13.6 mmHg), MAP (TD, 4.0 ± 23.3 mmHg; ISO, 6.3 ± 10.0 mmHg) and DAP (TD, 4.0 ± 21.2 mmHg; ISO, 7.8 ± 13.6 mmHg). In TD, 26−40% HDO measurements were within 10 mmHg of IBP, compared with 60−74% in ISO. Differences between HDO and IBP for all measurements were similar between anesthetic protocols. The numerical difference between IBP and HDO measurements for SAP, MAP and DAP significantly decreased as cuff width/tail girth ratio increased toward 40%.

Conclusion and clinical relevance More variability in HDO occurred during TD. The cuff width/tail girth ratio is important for accuracy of HDO.

Keywords blood pressure, horse, isoflurane, oscillometry, TripleDrip.

Introduction

Noninvasive blood pressure (NIBP) measurement can be performed in anesthetized horses using high-definition oscillometry (HDO) with a commercially available device and a cuff placed around the tail (Tünsmeyer et al. 2015). In awake cats, HDO has been found to have improved accuracy because of increased sensitivity at low signal amplitudes, a short cycling time, better recognition of artefacts at high and low heart rates (HRs), and using computer processing to deflate the cuff according to pulse rate (Martel et al. 2013). However, HDO was not accurate in anesthetized dogs and was unreliable during hypo- and hypertension in horses (Rysnik et al. 2013; Tünsmeyer et al. 2015).

Anesthetic agents can affect the vasomotor tone of blood vessels, and α_2-adrenergic agonists can increase vasomotor tone through stimulation of peripheral α_1 and postsynaptic α_2-adrenergic receptors (Greene et al. 1986). Conversely, volatile anesthetics can induce vasodilation, which alters vessel stiffness and reflects the wave characteristics within the extremity where the cuff is placed (Yamanaka et al. 2001). The effect of arterial wall stiffness due to atherosclerosis was found to influence the accuracy of NIBP measurement in humans (Ochiai et al. 1997). It was speculated that the NIBP method overestimated the blood pressure because more pressure is required to compress an artery with reduced compliance.

The hypothesis for this study stated that there would be no difference in accuracy of HDO using the manufacturer's tail cuff when different drugs are used to anesthetize laterally recumbent horses.

Materials and methods

Twenty-four anesthetized client-owned horses undergoing clinical procedures in lateral recumbency were used for this study. Xylazine hydrochloride (1 mg kg^{-1}; Rompun; Bayer Healthcare, ON, Canada) was administered intravenously (IV) for premedication, and anesthesia was induced with ketamine hydrochloride (2 mg kg^{-1}, IV; Vetalar; Bioniche Animal Health, ON, Canada) and diazepam (0.1 mg kg^{-1}, IV; Diazepam Injection USP; Sandoz Canada Inc., QC, Canada). Maintenance of anesthesia, either injectable or inhalation anesthesia, was chosen by the attending anesthesia clinician. In 12 horses [group TripleDrip (TD)], anesthesia was maintained by IV infusion of ketamine (1000 mg) and xylazine (500 mg) in 1 L of 5% guaifenesin (Guaifenesin USP; Medisca, QC, Canada) in 5% dextrose (Dextrose USP Anhydrous; Galenova, QC, Canada) administered at a rate to maintain a suitable anesthetic depth. Oxygen was administered by tracheal insufflation or using a demand valve. Isoflurane (ISO) in oxygen was administered to another 12 horses (group ISO) via an endotracheal tube using a large animal anesthetic rebreathing system (Model 2800C-P; Mallard Medical, CA, USA). The depth of anesthesia in both groups was determined using eye reflexes and response to surgical stimulation. Dobutamine and fluid therapy were administered to achieve a mean arterial pressure (MAP) of >70 mmHg.

The manufacturer's 8-cm-wide cuff for horses was placed around the proximal part of the tail approximately 2 cm from the perineum (Equine Model HDO; MemoDiagnostics, S+B MedVET GmbH, Germany). The tail girth was measured at the point of cuff placement for each horse, and the percentage cuff width/tail girth ratio was recorded. A 20-gauge, 48-mm catheter (BD Insyte; Becton Dickinson Infusion Therapy Systems Inc., UT, USA) was aseptically placed into a facial artery and connected to low compliance tubing flushed with heparinized saline (Heparin Sodium Injection USP; Fresenius Kabi Canada Ltd., ON, Canada). The systolic (SAP), MAP and diastolic (DAP) arterial pressures were measured using a silicon chip strain gauge transducer (Truwave Disposable Pressure Transducer; Edwards Lifesciences LLC, CA, USA), and the results were displayed on a monitor (GE Datex-Ohmeda Cardiocap/5; GE Healthcare, Technologies Datex-Ohmeda Inc., WI, USA). The transducer was renewed after anesthesia of three horses and zeroed at the sternum manubrium as the external reference point for the right atrium. Visual assessment of a square-wave flush waveform was used to examine excessive damping of the arterial pressure wave. The monitor calculated HR from the arterial pressure waveform and displayed the electrocardiogram (GE Datex-Ohmeda Cardiocap/5).

Paired data for SAP, MAP, DAP, and HR were obtained every 5 minutes throughout anesthesia from the HDO device and the invasive blood pressure (IBP). IBP and HR were recorded midway during the 20-second HDO cycling time.

Statistical analysis

Body weight, age, tail girth, and cuff width/tail girth ratio between groups were compared using an unpaired Student *t* test. The number of NIBP data points lying ≤10 mmHg of the corresponding IBP were expressed as a percentage of the total number of data points for SAP, MAP and DAP for each group (Brown et al. 2007).

Accuracy of the measurements within each group and between groups was assessed via comparison of the HDO and IBP (reference) values in each group using Bland–Altman analysis (Bland & Altman 1999) for repeated measures based on the linear mixed effect (LME) models using the R package MethComp (Carstensen et al. 2008) (see Supplementary information). To detect if the means in the differences between HDO and IBP for all measurements were similar between anesthetic protocols, a generalized additive model was developed using the R package *mgcv* (Wood 2001). All statistical tests were two-sided, and p values < 0.05 were considered