Veterinary Anaesthesia and Analgesia 2017, **xxx**, 1–7 http://dx.doi.org/10.1016/j.vaa.2016.10.001

RESEARCH PAPER

Measurement of intraocular pressure in healthy anesthetized horses during hoisting

Caroline S Monk[a], Dennis E Brooks[a,b], Tiffany Granone[b], Fernando L Garcia-Pereira[b], Alexander Melesko[c] & Caryn E Plummer[a,b]

[a]Department of Small Animal Clinical Sciences, College of Veterinary Medicine, University of Florida, Gainesville, FL, USA

[b]Department of Large Animal Clinical Sciences, College of Veterinary Medicine, University of Florida, Gainesville, FL, USA

[c]Federated Investors, New York, NY, USA

Correspondence: Caryn E Plummer, College of Veterinary Medicine, University of Florida, 2089 SW 16th Avenue, Gainesville, FL 32610, USA. Email: PlummerC@ufl.edu

Abstract

Objective To measure intraocular pressure (IOP) in horses during hoisting after induction of anesthesia.

Study design Prospective nonrandomized clinical study.

Animals Eighteen healthy adult horses aged [mean ± standard deviation (SD)] 10 ± 4.2 years and weighing 491 ± 110 kg anesthetized for elective procedures.

Methods IOP was measured in the superior eye of each horse based on planned recumbency after induction of anesthesia. Measurements were taken directly after premedication with xylazine or detomidine with butorphanol, after induction with diazepam–ketamine, after intubation, when suspended by the hoist and on the operating table. During hoisting, the head was supported and the eye–heart height was measured to account for variations in head positioning among patients. IOPs were compared across time points using repeated-measures analysis of variance. Regression was used to compare IOP outcome with potential cofactors.

Results Compared with measurements after premedication (17.5 ± 2.5 mmHg) (mean ± SD), hoisting significantly increased IOP (32.4 ± 15.3 mmHg) ($p < 0.01$). The highest recorded IOP in the hoist was 80.0 (range, 16.0–80.0) mmHg. The difference in IOP between premedication and hoisting was 15.0 ± 16.2 (range, −1.0 to 68.0) mmHg. Body weight had a significant effect on absolute IOP and change in IOP in the hoist ($p < 0.01$).

Conclusions and clinical relevance Hoist IOP was significantly higher than post-premedication IOP with heavier horses having higher hoist IOPs and greater increases in IOP. The clinician should take this relationship into account when anesthetizing and hoisting larger horses where an increase in IOP could be detrimental.

Keywords alpha$_2$-adrenergic agonist, body weight, equine, general anesthesia, ophthalmic.

Introduction

Intraocular pressure (IOP) is defined by aqueous humor formation, uveoscleral outflow and episcleral venous pressure in the Goldmann equation as follows:

$$\mathrm{IOP} = [F/C] + \mathrm{PV}$$

where F denotes the aqueous fluid formation rate, C is the aqueous fluid outflow rate and PV is the episcleral venous pressure.

IOP is most commonly estimated indirectly using tonometry. The reference range for horses using tonometry is reported as 15–37 mmHg (Miller et al. 1990; Smith et al. 1990; van der Woerdt et al. 1995, 1998; Ramsey et al. 1999; Knollinger et al. 2005; Komáromy et al. 2006; Stine et al. 2014). Maintenance of IOP within a physiologic range is vital for intraocular health, especially that of the optic nerve,

Please cite this article in press as: Monk CS, Brooks DE, Granone T et al. Measurement of intraocular pressure in healthy anesthetized horses during hoisting, Veterinary Anaesthesia and Analgesia (2017), http://dx.doi.org/10.1016/j.vaa.2016.10.001

which is particularly susceptible to the pathophysiologic impact of glaucoma.

The effect of head position on IOP has been previously documented in horses and humans (Kergoat & Lovasik 2005; Komáromy et al. 2006; Prata et al. 2010; Malihi & Sit 2012). When the head is inverted relative to the heart, the position changes the brain-to-heart hydrostatic gradient. When the head position was lowered below heart level in 30 horses administered detomidine, IOP increased in 52 out of 60 eyes (Komáromy et al. 2006). This change likely results from increases in intracranial pressure (ICP), cerebral perfusion pressure (CPP) and episcleral venous pressure as the head-down position increases the hydrostatic gradient of blood flow to the head (Brosnan et al. 2008). Additional factors that may also raise IOP are congestion of orbital content compressing the globe and an increase in the ocular blood volume within the uveal tract (Linder et al. 1988; Komáromy et al. 2006).

Horses anesthetized for surgical or diagnostic procedures are often hoisted with the limbs supporting the body in an inverted position. In this position, the head commonly is carried below the level of the heart, and the thoracic cavity and large abdominal vessels are compressed by the weight of the colon. Additionally, a more pronounced effect of body position on ICP and CPP than in a conscious horse is induced by anesthetic drugs that interfere with normal cerebrovascular autoregulation (Brosnan et al. 2008, 2011). Increases in ICP and CPP during hoisting for general anesthesia may have an impact and increase IOP.

Deep corneal ulcers, descemetoceles and penetrating foreign bodies of the eye may involve fragile corneal lesions that may rupture if IOP increases. In cases of pre-existing glaucoma, an even greater increase in IOP may further damage retinal ganglion cells (RGC). In a rat model study on glaucoma, slowly rising pressure was not overtly damaging to RGCs, but rapid, high-pressure pulses injured these cells almost immediately after insult (Resta et al. 2007). The effects of hoisting on the IOP of horses have not been published, and this effect should be determined to enable risk assessment of anesthesia for ophthalmic procedures.

The aims of this study were to determine the IOP in normal horse eyes during hoisting after induction of anesthesia and to evaluate factors that had potential to influence IOP. We hypothesized that IOP would be increased during the hoisting position compared with the standing position.

Materials and methods

This study was approved by the Institutional Animal Care and Use Committee of the University of Florida (no. 201408375). Owner consent was obtained before each horse was enrolled in the study. Eighteen horses were considered to be healthy, with no cardiovascular or respiratory abnormalities, based on a physical examination and results of laboratory tests within the normal reference ranges for the laboratory (complete blood cell count and serum biochemistry profile). Within 5 minutes after administration of drugs for premedication, an anterior segment ophthalmic examination without pharmacologic mydriasis was performed using a portable slit-lamp (Kowa SL-14; Kowa Company, CA, USA). The horse was included in the study if the anterior segment of the measured eye was free of detectable disease on direct examination.

Anesthesia

The anesthesia protocol was formulated for each horse by the anesthesiologist on duty on the day of the procedure. The horses were administered intravenously (IV) [mean ± standard deviation (SD)] either xylazine (0.54 ± 0.09 mg kg^{-1}; AnaSed; Lloyd Inc., IA, USA; $n = 9$) or detomidine (0.01 ± 0.00 mg kg^{-1}; Domosedan; Orion Pharma, Finland; $n = 9$) for premedication with butorphanol (0.02 mg kg^{-1}; Torbugesic; Zoetis Inc., MI, USA; $n = 14$, seven horses with xylazine and seven with detomidine). Induction of anesthesia was achieved by administration of diazepam (0.07 ± 0.01 mg kg^{-1}; Diazepam hydrochloride USP; Hospira Inc., IL, USA) and ketamine (2.50 ± 0.24 mg kg^{-1}; Ketamine hydrochloride USP; Putney Inc., ME, USA) IV in direct succession. During induction, the horse was supported against the wall by personnel until the horse assumed sternal recumbency. The horse was turned to lateral recumbency and the trachea intubated with a cuffed endotracheal tube with an internal diameter 18−26 mm (SurgiVet, OH, USA).

IOP measurements

IOP was measured in one eye in each horse using the uppermost eye for the planned lateral recumbency during anesthesia. Within 5 minutes after administration of drugs for premedication, 0.5% tetracaine ophthalmic solution (Bausch & Lomb, NY, USA) was instilled into the eye. IOP was measured in the standing horse with the head in a position such that

Please cite this article in press as: Monk CS, Brooks DE, Granone T et al. Measurement of intraocular pressure in healthy anesthetized horses during hoisting, Veterinary Anaesthesia and Analgesia (2017), http://dx.doi.org/10.1016/j.vaa.2016.10.001