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RESEARCH PAPER

Ultrasound-guided retrobulbar nerve block in horses: a cadaveric study

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Abstract

Objective To develop an ultrasound-guided technique for retrobulbar nerve block in horses, and to compare the distribution of three different volumes of injected contrast medium (CM) (4, 8 and 12 mL), with the hypothesis that successful placement of the needle within the retractor bulbi muscle cone would lead to the most effective dispersal of CM towards the nerves leaving the orbital fissure.

Study design Prospective experimental cadaver study.

Animals Twenty equine cadavers.

Methods Ultrasound-guided retrobulbar injections were performed in 40 cadaver orbits. Ultrasound visualization of needle placement within the retractor bulbi muscle cone and spread of injected CM towards the orbital fissure were scored. Needle position and destination of CM were then assessed using computerized tomography (CT), and comparisons performed between ultrasonographic visualization of orbital structures and success rate of injections (intraconal needle placement, CM reaching the orbital fissure).

Results Higher scores for ultrasound visualization resulted in a higher success rate for intraconal CM injection, as documented on the CT images. Successful intraconal placement of the needle (22/34 orbits) resulted in CM always reaching the orbital fissure. CM also reached the orbital fissure in six orbits where needle placement was extraconal. With 4, 8 and 12 mL CM, the orbital fissure was reached in 16/34, 23/34 and 28/34 injections, respectively.

Conclusion and clinical relevance The present study demonstrates the use of ultrasound for visualization of anatomical structures and needle placement during retrobulbar injections in equine orbits. However, this approach needs to be repeated in controlled clinical trials to assess practicability and effectiveness in clinical practice.

Keywords horse, local anaesthesia, nerve block, retrobulbar, ultrasonography.

Introduction

Retrobulbar nerve block (RNB), commonly used in cattle, has become increasingly popular in equine medicine. Akinesia and anaesthesia of the eyeball are achieved by blockade of the optic, oculomotor, abducens and trochlear nerves, and the maxillary and ophthalmic branches of the trigeminal nerve (Miller Michau 2005). Benefits during ocular surgeries include impedance of enophthalmus, reduced anaesthetic requirement, and prevention of the oculocardiac reflex during eye manipulation (Raffe et al. 1986). The use of RNB for standing procedures is therefore recommended by some authors to avoid unnecessary general anaesthesia in horses (Gilger & Davidson 2002; Tóth et al. 2008).

Several techniques for the retrobulbar administration of local anaesthetics have been described in horses, including the four-point block, direct injection into the orbital muscle cone above or below the zygomatic arch, and the modified Peterson block (Miller Michau 2005; Brooks 2006). In each case, a needle is blindly inserted into the orbital cavity behind the globe. Complications include penetration of the eyeball (which may be deleterious for procedures other than enucleation), orbital haemorrhage, direct damage to the optic nerve, and intrameningeal injection of local anaesthetic, leading to epidural or subarachnoid anaesthesia (Robertson 2004; Skarda & Tranquilli 2007). Real-time visualization of both needle passage and local anaesthetic spread may improve the safety of these techniques.

Ultrasound-guided nerve blocks have been used with increasing frequency in humans (Eichenberger et al. 2006; Luyet et al. 2008, 2009) and small animals (Bagshaw et al. 2009; Costa-Farre et al. 2009; Echeverry et al. 2009). Ultrasound (US) guidance might improve the quality and safety of RNB in horses by visualizing the position of the needle and injected fluid. If the pattern of spread of the injected fluid is inappropriate for RNB, the needle can be repositioned until the ideal site of injection is located. Placing the needle tip for optimal spread of local anaesthetic to the orbital fissure, where the nerves exit the skull, may reduce the total volume of injected agent required for successful local anaesthesia.

For these reasons, the first aim of the current study was to develop and describe an US-guided technique for RNB in horses. Based on preliminary investigations, we hypothesized that positioning of the needle tip within the cone formed by the retractor bulbi muscle (=intraconal position) would produce the most effective spread of fluid towards the orbital fissure and around the nerves that exit the skull in this region. As a second aim, the spread of three different injection volumes of contrast medium (CM) (4, 8 and 12 mL) towards the orbital fissure were compared by computerized tomography (CT) imaging, to determine the most appropriate volume for this technique.

Materials and methods

Twenty Warmblood horses recently euthanized by either lethal injection or bolt shot and exsanguination were used for this study. Heads were removed from the trunk immediately after death and cooled for an average of 24 hours (20–31 hours) until the retrobulbar injections were performed.

Where the eye was collapsed, intraocular pressure was restored prior to US examination by injecting water into the eyeball; this injection was performed using a 20 gauge needle inserted underneath the third eyelid, until the globe felt plump to palpation.

The examination and injections were always performed by the same investigator (UM). US was performed using a Sonosite Turbo ultrasound machine (SonoSite Inc, WA) with an 8–5 MHz, 11 mm, broadband, curved array transducer (C11x; Sonosite Inc), positioned on the closed upper eyelid. First, visualization of the optic nerve was attempted in horizontal and vertical US planes. Next, a 21 gauge × 100 mm SonoPlex Stim cannula (Pajunk Medizintechnologie GmbH, Germany) was inserted at the rostral end of the supraorbital fossa, caudomedially to the posterior aspect of the zygomatic process, in a slightly craniomedial direction. The needle was advanced under US visualization, with the aim being to place its tip just behind the eyeball in the craniocentral part of the cone formed by the retractor bulbi muscle, as shown in Fig. 1. Whenever possible, the needle tip was positioned such that the needle and optic nerve could be visualized simultaneously within the same US image. A CT scan was then performed to record the initial position of the needle. Thereafter, CM (Telebrix 30M; Guerbet, Germany) was injected in 4 mL aliquots, up to a final volume of 12 mL in each orbit. To avoid movement of the cannula during syringe attachment, the contrast medium was injected through extension tubing connected to the needle before skin penetration. After each 4 mL injection CT scans were performed to assess the spread of CM. The investigator performing the ultrasound guided retrobulbar injection (URI) was unaware of the CT results.

US visualization of the optic nerve and direction of CM dispersal were scored according to the methods shown in Tables 1 & 2. If the spread during the first injection was considered unsatisfactory, the investigator had the option to interrupt the initial 4 mL injection and reposition the needle under US guidance. At this time, an additional CT

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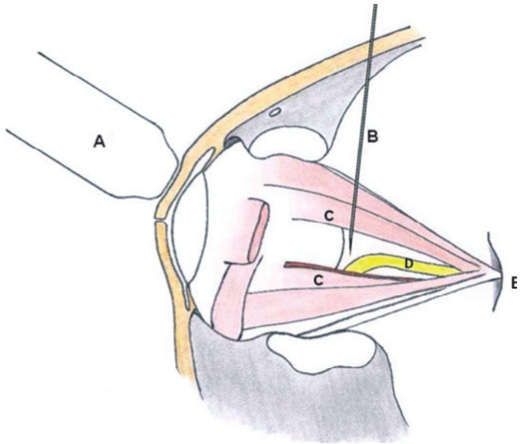

Figure 1 Lateral view of an equine orbit. The zygomatic process of the frontal bone and the lateral rectus muscle are sectioned. Note the position of the needle tip within the space formed by the subdivisions of the retractor bulbi muscle, which builds the innermost layer of the retrobulbar muscle cone. A: ultrasound transducer, B: needle with tip positioned within the cone of the retractor bulbi muscle, C: rectractor bulbi muscle, D: optic nerve, E: orbital fissure.

Table 1 Scoring system for ultrasound visualization of orbital structures and needle placement

Category	Criteria
Poor	Eyeball, retrobulbar muscle cone with intraconal space, optic nerve and bony shadow of the orbit, and the needle are not all clearly visualized
Good	All structures (listed above), and the needle, can be visualized, but the needle cannot be placed in the same ultrasound image as the optic nerve
Excellent	All structures (listed above), and the needle can be visualized, and the needle is visualized in the same ultrasound image as the optic nerve

Table 2 Scoring system for the spread of the initial 4 mL injection of contrast medium, as observed during ultrasound imaging

Category	Pattern of spread of injected contrast medium
Unsatisfactory	Greater than 50% cranial spread
Satisfactory	Both cranial and caudal spread, with >50% spreading caudally
Excellent	Only caudal spread

scan was performed to record the new needle position before the injection was completed.

CT imaging was performed using a helical, six-slice CT scanner (Somatom Emotion 6; Siemens Medical Solutions, Germany) with typical raw data acquisition at 110 kV, 160 mAs, and 6 × 1 mm collimation. CT image reconstruction was performed with a slice thickness of 1.25 mm in increments of 0.7 mm, using soft tissue and bone weighted tissue kernels. Image interpretation was performed by a board-certified diagnostic and forensic radiologist, using an open source picture archiving and communication system (OsiriX; Pixmeo, Switzerland). The CT findings were described as follows: precontrast needle position (intraconal: yes or no), distance from the needle tip to the optic nerve (needle tip to nerve in mm), needle depth (skin surface to needle tip in mm), location of CM (intraconal: yes or no), and distance of leading edge of CM to the orbital fissure (distance in mm to the crista pterygoideus, an easily identifiable osseous landmark at the opening of the fissure). For analytical reasons the distance of the leading edge of the CM to the orbital fissure was categorized as CM that reached the fissure (distance of 0 mm, or spread more caudal than the orbital fissure) and CM that did not reach the fissure (distance >0 mm).

Statistical analysis

All statistics were performed using commercially available software (NCSS 2007 and SigmaStat, Version 3.0; Systat Software, IL, USA). Numerical data were tested for normality of distribution by the Shapiro Wilk test. Normally distributed data are presented as mean ± SD, while non-normally distributed data are given as median (IQR). Comparisons of the depths of intraconal and extraconal needles were performed using a Student *t*-test. The Fisher‘s Exact test was used to compare results for needle position and outcome of the injection, as well as for comparison of the spread towards the orbital fissure for intraconal and extraconal needle placement, in the left and right orbit and during left- and right-handed US guidance. The spread of the three different CM volumes (4, 8 and 12 mL) was compared using the Cochrane‘s *Q* test. Values of $p \leq 0.05$ were considered significant.

Results

In total, 40 URI were performed. In all but one case the anatomical structures of the retrobulbar space (the retrobulbar muscle cone attached to the eyeball, the optic nerve and the bony shadow of the orbital walls) could all be visualized during US. In all cases the needle could be observed entering the retrobulbar muscle cone. Example CT images after needle placement and CM injection are shown in Figs 2 & 3. There was no significant difference for success of needle placement or CM dispersal (as observed on CT images) between the left and right orbit or between left- or right-handed guidance.

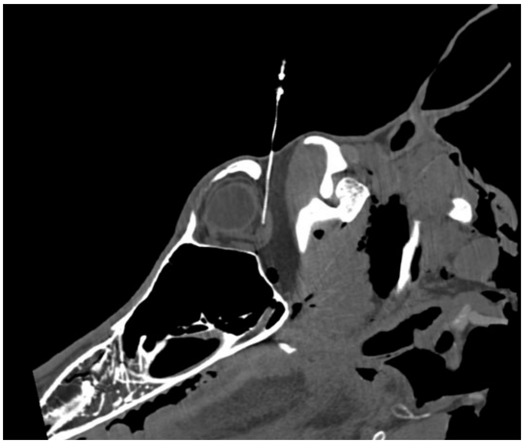

Figure 2 CT image showing a lateral view of the equine orbit with the needle inserted behind the eyeball.

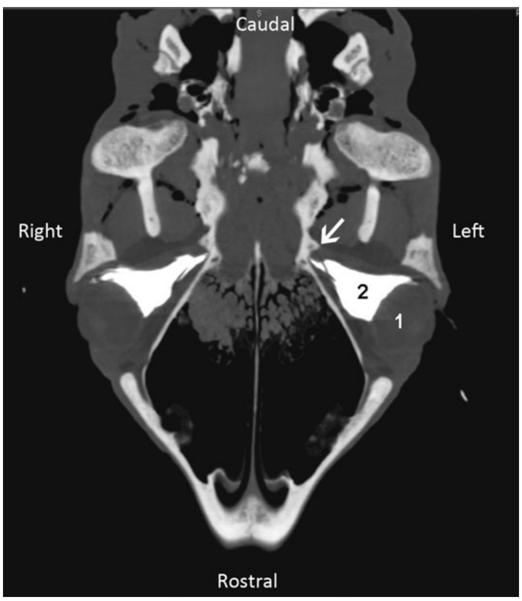

Figure 3 CT image showing a dorsal view of both orbits after retrobulbar injection of 4 mL of contrast medium. In both orbits the contrast medium has reached the orbital fissure. 1: Eyeball, 2: CM spread out in retrobulbar muscle cone, Arrow: Crista pterigoideus.

In all but six cases, significant caudal spread could be observed during injection via US. In these six cases the spread of the injected CM was scored as unsatisfactory and the needle was repositioned to accomplish the injection. In these cases, the new needle position could not be assessed precisely as the small amount of CM (1–2 mL) already injected altered the US and CT images causing loss of details and precluding orientation. Therefore, these six orbits were excluded from further analysis, so that finally only 34 orbits underwent thorough evaluation of needle position and contrast spread. Hence, the data presented in the following paragraphs were obtained from the ultrasound-guided retrobulbar injections performed in 34 orbits.

Ultrasound visualization of the anatomical structures and needle placement was judged as good (17) or excellent (10) in 27 cases (Table 1). In the seven cases where visualization was categorized as poor this was either because not all of the anatomical structures could be observed (one case) or because all were observed, but with a loss of clarity (six cases). Of the 10 'excellent' cases (where the needle and optic nerve could be imaged simultaneously), CT showed intraconal needle placement in 8, and in all 10 CM reached the orbital fissure. Of the 17 orbits described during US as 'good' visualization, 13 were confirmed during CT as having intraconal needle placement, and in 15 CM reached the orbital fissure. In the two cases where the CM did not reach this target, extraconal needle position was revealed on the CT images. When the US image was judged as poor, needle placement was not as easy as in the other cases. In six of those cases, the CT scans demonstrated extraconal needle position. However, three of these injections (two extraconal and one intraconal), resulted in spread of CM that reached the orbital fissure.

In 20 out of 34 orbits, the examiner evaluated the spread of injected CM, as observed by US, as being excellent (i.e. dispersing in a caudal direction, towards the orbital fissure) (Table 2). For these injections, the presence of intraconal CM, as confirmed by CT imaging, was significantly higher than when the spread was evaluated during US as satisfactory (14/34) ($p = 0.036$).

The median distance of the needle tip to the optic nerve measured by CT imaging was 3 mm (1–7 mm). In one case, the optic nerve sheath was punctured. In this orbit, placement of the needle within the same ultrasonographic plane as the optic nerve was not possible, i.e. the optic nerve was not visualized during insertion of the needle and injection of the CM. CT images revealed circular and caudal spread around the optic nerve, indicating a possible injection within the nerve sheath. However, tracking toward cerebral structures was not apparent.

The mean needle insertion depth as determined by CT was 50.8 ± 5.3 mm. There was no significant difference between the depth of needles that were placed outside of the cone formed by the retractor bulbi muscle (mean depth 52.5 ± 4.4 mm) and needles placed intraconally (mean depth 49.8 ± 5.6 mm).

CT scans showed that in 28 of 34 injections, the CM reached the orbital fissure, and further caudal spread was found in 27 of these. Tracking along the optic canal or the canal of the orbital fissure toward cerebral structures was not observed. CM reached the orbital fissure in all 22 of the orbits where CT showed intraconal needle placement, as well as in 6 where needle placement was extraconal. In the remaining six orbits where the needle was placed outside the retractor bulbi muscle cone, CM failed to reach the orbital fissure. In these cases, the mean distance from the most caudal spread of CM to the crista pterygoideus was 14.3 ± 9.9 mm after 12 mL CM had been injected. When CM reached the orbital fissure, this was achieved with 4, 8 and 12 mL CM in 16, 23 and 28 cases, respectively (Fig. 4). There was a statistically significant effect of injection volume on outcome ($p < 0.001$) when injection of 4 mL was compared with higher volumes, but there was no difference in final CM destination between injection of 8 and 12 mL.

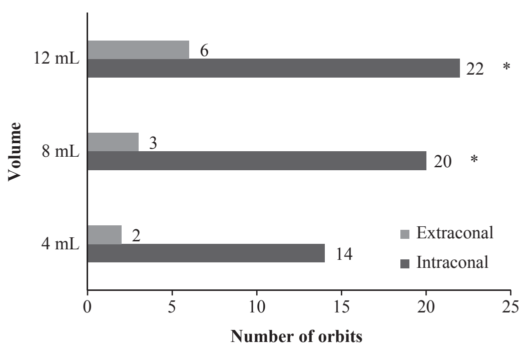

Figure 4 Number of orbits where injected contrast medium reached the orbital fissure with different injection volumes, and when the needle tip is within (intraconal) or outside (extraconal) of the cone formed by the retractor bulbi muscle. *Indicates statistically significant differences between the groups (significantly different from 4 mL).

Discussion

To our knowledge this is the first description of an US guided technique for retrobulbar needle placement in horses and the first where distribution of three different injection volumes has been compared. The results of our study show that it is often possible to use US to visualize the intraorbital anatomical structures and to guide a needle into the retrobulbar space, in order to perform a retrobulbar nerve block.

US-guided nerve blocks have become increasingly popular, not only in human but also in veterinary medicine. Needle orientation is no longer based on surface landmarks that may differ between individuals, but can be based on US visualization of the internal anatomical structures. Needles can be guided, accurately placed and moved into an optimal position even during injection, making it easier to reach and block the target nerves. In our study, CT scans demonstrated desirable distribution of CM in 28 out of 34 orbits when using this technique.

The subjective evaluation of US performance correlated well with the results of the CT images, showing that higher scoring at US corresponded with intraconal spread of CM and CM reaching the orbital fissure. In six cases where the CT revealed extraconal needle placement, the examiner evaluated the needle placement via ultrasound as moderate. Should this occur in a clinical setting, the needle may be moved until a sufficient caudal spread of local anaesthetic is achieved. In the six excluded cases where needles needed to be repositioned because of unsatisfactory spread of the CM, we realized that the sonographic image was blurred and visualization of the anatomical structures as well as of the needle was strongly impaired. Such changes were not observed in pilot trials when local anaesthetic was injected and this may be due to the high viscosity of the CM compared to local anaesthetics.

Our hypothesis that a needle placed within the cone formed by the retractor bulbi muscle would lead to a more effective spread of the injected fluid towards the orbital fissure was confirmed by the results of this study, even though this optimal needle position could not be achieved in all cases. From experience in humans, it is known that inserting the needle close to the ultrasound probe on the eyelid helps to place it in the same ultrasonographic plane as the optic nerve, thus allowing both structures to be observed simultaneously. In our study, a supraorbital approach for needle insertion was chosen as it was considered to be safer (to avoid eyeball penetration) and because it is routinely used for blind RNB in horses. The US transducer was placed on the eyelid to obtain the best possible visualization of the orbital anatomy, however this combination did not always allow needle placement in the same ultrasonographic plane as the optic nerve, possibly impairing the performance of the technique.

In one case optic nerve sheath puncture could not be excluded, but the CM did not spread towards the brain stem. However, local anaesthetic solutions are much less viscous than CM, and therefore may spread differently to CM *in vivo*, possibly resulting in spread towards cerebral structures if the optic nerve sheath is punctured. When performing this injection in this study, the examiner was unable to place the needle so that it could be visualized simultaneously with the optic nerve, which may have contributed to inadvertent puncture. Therefore, refinement of this technique to insert the needle only if the optic nerve can be visualized may increase the safety of the technique. It is possible that optic nerve sheath puncture occurs frequently with the blind approach, but goes unnoticed as this block is used most frequently for enucleations (Hewes et al. 2007; Pollock et al. 2008; Tóth et al. 2008). In other procedures, puncture of the optic nerve sheath may result in neuritis or permanent damage to the optic nerve.

Several alternate injection techniques for RNB have been described, however we propose that performing the block under US guidance has advantages compared to these. For enucleation, Tóth et al. describe the four-point block combined with a retrobulbar injection through the supraorbital fossa. Bacteria can be transmitted into the orbit during needle insertion (Gilger & Davidson 2002) and this risk increases with the number of injections. By performing a single injection under US guidance, thereby blocking all relevant neural structures at once, infection risk may be reduced.

Lichtenstern (1911) described the first use of RNB, and reported haematoma formation after injection close to the orbital fissure. Tremaine (2007) describes haematoma formation caused by puncture of the maxillary artery or veins because of placement of the needle too far ventrally within the orbit. Real-time imaging of the orbital structures during RNB may prevent puncture of major vessels as the needle can be visualized and located close to the eyeball, away from larger vessels.

Ocular surgery can result in cardiac dysrhythmias or cardiac arrest due to the oculocardiac reflex. Robertson (2004) states that in theory, this reflex can be blocked on the afferent side by retrobulbar injection of a local anaesthetic. However, Robertson also mentions that RNB may itself initiate the oculucardiac reflex and suggests that it is therefore not recommended to perform this technique in standing horses. Reducing the injection volume may decrease the risk of vagal stimulation by minimizing the additional pressure in the retrobulbar space, however increased injection volumes were associated with increasing success rate in our study. On the basis of our results, an injection volume of 8 mL may represent a compromise between minimizing injection volume and optimizing success rate, and additional studies are warranted to investigate this further.

Limitations of our study include the restriction to cadaveric cases as well as the use of CM instead of local anaesthetic solution. Developing this US guided technique in cadavers excluded important *in vivo* factors such as movement of the patient during injection, and the effect of tissue perfusion and normal body temperature, which might change the outcome and performance of the RNB. Movements during injection might impair accurate sonographic visualization and might increase the risk of damaging orbital structures like the optic nerve or the globe. Nevertheless, in anaesthetized or well sedated and restrained horses movement is abolished or decreased, and visualizing the needle may improve the safety of RNB compared to blind needle passage. The CM used in our study has a higher viscosity than the commonly used local anaesthetics, and this was likely exacerbated by the low temperature of the cadaver tissue. Therefore, the distribution of the CM might not represent the spread that will occur with a local anaesthetic *in vivo*.

This study demonstrates the feasibility of using US to visualize anatomical structures and needle placement during retrobulbar injections in equine cadavers. The initial hypothesis that injections within the cone formed by the retractor bulbi muscle would lead to effective spread towards the orbital fissure was confirmed by CT imaging. Further trials are needed to assess the efficacy and safety of this technique in clinical patients, and to compare US guided RNB to classical blind techniques.

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References

Bagshaw HS, Larenza MP, Seiler GS (2009) A technique for ultrasound-guided paravertebral brachial plexus injections in dogs. Vet Radiol Ultrasound 50, 649–654.

Brooks DE (2006) Orbit. In: Equine Surgery (3rd edn). Fathman L, Gower J (eds). Saunders, St. Louis, MO, USA. p. 757.

Costa-Farre C, Blanch XS, Cruz JI et al. (2009) Ultrasound guidance for the performance of sciatic and saphenous nerve blocks in dogs. Vet J 187, 221–224.

Echeverry DF, Gil F, Laredo F et al. (2009) Ultrasound-guided block of the sciatic and femoral nerves in dogs: a descriptive study. Vet J 186, 210–215.

Eichenberger U, Greher M, Kirchmair L et al. (2006) Ultrasound-guided blocks of the ilioinguinal and iliohypogastric nerve: accuracy of a selective new technique confirmed by anatomical dissection. Br J Anaesth 97, 238–243.

Gilger BC, Davidson MG (2002) How to prepare for ocular surgery in the standing horse. Proceedings of the 48th Annual Convention of the American Association of Equine Practitioners, Orlando, FL, pp. 266–271.

Hewes CA, Keoughan GC, Gutierrez-Nibeyro S (2007) Standing enucleation in the horse: a report of 5 cases. Can Vet J 48, 512–514.

Lichtenstern G (1911) Die Verwendung von Tropokain in der tierärztlichen Chirurgie mit besonderer Berücksichtigung hinsichtlich seiner Verwendbarkeit in der Augapfelinfiltration beim Pferde II. Munch Tierarztl Wochenschr 22, 358–359.

Luyet C, Eichenberger U, Moriggl B et al. (2008) Real-time visualization of ultrasound-guided retrobulbar blockade: an imaging study. Br J Anaesth 101, 855–859.

Luyet C, Eichenberger U, Greif R et al. (2009) Ultrasound-guided paravertebral puncture and placement of catheters in human cadavers: an imaging study. Br J Anaesth 102, 534–539.

Miller Michau T (2005) Equine ocular examination: basic and advanced diagnostic techniques. In: Equine Ophthalmology. Fathman L, Gower L (eds). Elsevier Saunders, St. Louis, MO, USA. pp. 21–24.

Pollock PJ, Russell T, Hughes TK et al. (2008) Transpalpebral eye enucleation in 40 standing horses. Vet Surg 37, 306–309.

Raffe MR, Bistner SI, Crimi AJ et al. (1986) Retrobulbar block in combination with general anesthesia for equine ophthalmic surgery. Vet Surg 15, 139–141.

Robertson SA (2004) Standing sedation and pain management for ophthalmic patients. Vet Clin North Am Equine Pract 20, 485–497.

Skarda RT, Tranquilli WJ (2007) Local and regional anesthetic and analgesic techniques: ruminants and Swine. In: Lumb and Jones' Veterinary Anesthesia and Analgesia (4th edn). Tranquilli WJ, Thurmon JC, Grimm KA (eds). Blackwell, Oxford, UK. pp. 646–648.

Tóth J, Hollerrieder J, van der Geer C et al. (2008) Transpalpebrale Bulbusentfernung am stehenden Pferd. Tierarztl Prax Ausg G Grosstiere Nutztiere 36, 119–123.

Tremaine WH (2007) Local analgesic techniques for the equine head. Equine vet Educ 19, 495–503.

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