Tutorial Article

Practical ultrasonography of the equine eye

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Introduction

Ultrasoundography is a useful diagnostic tool for assessing the equine eye. It is indicated when the cornea or anterior segment of the eye is opaque or where severe eyelid swelling precludes ocular visualisation, and for the evaluation of changes in globe size or position (for example to distinguish between glaucoma and retrobulbar masses). It is noninvasive and can be performed in conscious animals using nonspecialist ultrasound equipment that is readily available to equine veterinarians. The purpose of this paper is to present the normal appearance and dimensions of the equine eye and provide examples of abnormalities that can be detected using this technique and how they would appear different.

Equipment

While a range of ultrasound transducers can be used to image the eye, the required depth of penetration means that a high-frequency linear transducer (7.5–10 MHz) operating at a depth of 4–5 cm is ideally suited to ocular ultrasonography in the horse. A standoff, supplied for these transducers, can be useful for improving the ability to visualise the superficial structures such as the cornea and anterior chamber, although if a standoff is not available, then a water-filled glove can be used as an alternative (Miller 1991). A lower frequency transducer can also be used for examination of the eyes. These transducers will provide greater penetration to enable deeper structures, such as those in the retrobulbar space to be visualised, but will give less detailed images of the globe itself. If available, higher frequency transducers (13 MHz or higher) can be used to obtain superior images of the anterior segment.

Technique

There are 2 methods of obtaining images of the equine globe: transpalpebral and transcorneal techniques. Transpalpebral ultrasonography can easily be performed in the standing unsedated horse through closed eyelids (Fig 1) and has the advantage that the horse cannot observe the ultrasound transducer approaching, thus allowing this procedure to be performed with minimal restraint. If there is a corneal defect, this technique minimises the risk of causing any further damage. However, there is an increase in the occurrence of ultrasonographic artefacts with transpalpebral compared to transcorneal ultrasonography. Transcorneal ultrasonography involves placement of the probe directly onto the cornea and results in improved image quality, although orientation of the transducer in a vertical plane can be limited by the eyelids. This technique is less well tolerated even with the use of topical local anaesthetic agents and chemical restraint is usually required.

Irrespective of the technique used, it is advantageous to perform auriculopalpebral perineural akinesia, using approximately 2 ml of local anaesthetic solution placed...
subcutaneously at the site where the neurovascular bundle can be palpated in its superficial location, approximately halfway along the zygomatic arch. This provides motor blockade of the upper eyelid and prevents reflex blinking induced by pressure on the globe. In addition, topical local anaesthetic agents such as tetracaine (amethocaine) can be applied for transcorneal ultrasound.

Ultrasound contact gel should be applied to the upper and lower eyelids, but should be used with care on the cornea due to risks associated with bacterial contamination. Usually other water-based media (e.g. KY Jelly) are used and should be thoroughly washed from the eye at the end of the examination. Cellulose-based gels should be avoided as they can cause corneal irritation and alcohol should be avoided near the eye.

A systematic approach to ocular ultrasound should be adopted. The globe should be thoroughly evaluated with the probe orientated in both the horizontal and vertical imaging planes. Oblique planes can also be performed in order to further investigate abnormal findings. The authors begin with the transducer orientated horizontally and start dorsally and gradually move the transducer in a ventral direction. The eye is imaged through both upper and lower eyelids. The transducer is then held vertically and the eye examined from medially to laterally.

Care must be taken when ultrasound is being used to evaluate the globe post trauma or when swollen eyelids or conjunctiva of unknown aetiology preclude visualisation of the globe; excess pressure on the globe or unexpected movement by the patient may result in extrusion of intraocular contents if the cornea or sclera are damaged.

**Artefacts**

Several artefacts can be seen when examining the equine eye with ultrasound. Reverberation artefacts (reduplication or multiple-signal echoes) are commonly seen. These most commonly occur due to a lack of ultrasound gel resulting in air becoming trapped between the hairs. They are seen as bright hyperechoic flecks over the ultrasound image and if the problem persists despite the use of contact gel, it may be necessary to clip the hair on the eyelids or to premoisten them with water before gel is applied. In addition, this artefact can be seen in the near field for other reasons and is often minimised by the use of a standoff on closed lids (Fig 1). Shadowing or attenuation can be seen as anechoic ‘shadows’ beneath the structure causing them. In the eye this is usually seen with cataracts and intraocular foreign bodies and behind the eye this is seen with the optic nerve head and sometimes the bony orbital wall (Fig 2). Perpendicular parallel lines are sometimes seen in the anterior, or more commonly the posterior segment; these are known as range ambiguity artefacts or ‘Herbies’ (Fig 2). These are caused by machine factors, such as frame rate and in some cases these artefacts cannot be resolved.

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**Fig 2:** Common ultrasonographic artefacts seen when undertaking ultrasonographic examination of the equine eye in a normal horse demonstrating reverberation artefact within the anterior chamber due to poor contact and also a range ambiguity artefact within the posterior chamber. A standoff device has been used to obtain these images.

**Fig 3:** Normal ocular structures visible using transpalpebral ultrasound demonstrating normal ultrasonographic appearance of the entire globe (A) and the corresponding appearance of these structures in a sectioned extirpated eye (B).
Normal ocular structures

Using ultrasound imaging of the eye, the cornea, aqueous humour, lens, iris, ciliary body, vitreous humour, retina and retrobulbar space can be examined and dimensions obtained (Fig 3). Ocular disease is frequently unilateral enabling the contralateral eye to be used for comparison of lesions and diameters. However, where bilateral disease is suspected reference can be made to the range of diameters of the normal equine eye that have been determined ultrasonographically using extirpated eyes (Rogers et al. 1986). The mean anterior to posterior diameter of the eye is approximately 40 mm (39.4 ± 2.3 mm) and is slightly larger in the vertical imaging plane (42.5 ± 3.6 mm).

Cornea

The cornea can only be effectively visualised using either the transpalpebral technique or using a standoff with a transcorneal approach. The normal cornea is a thin homogeneously echogenic structure (Fig 4a). Corneal measurements from the extirpated eye revealed it to be approximately 900 µm (Andrew et al. 2001) to 2 mm thick (2.33 ± 0.39 mm) (Rogers et al. 1986). Other studies using ultrasonic pachymetry in live horses have shown the cornea to be slightly less at between 770 µm (Ramsey et al. 1999) to 793 µm (van der Woerdt et al. 1995) with the peripheral cornea being thicker than the periphery. Although rarely required for the diagnosis of a stromal abscess, with

Fig 4: Transpalpebral ultrasound image of the anterior segment demonstrating the normal appearance (A) and the presence of hypoechoic material within the anterior and posterior chambers in a horse with anterior uveitis (B) representing the presence of inflammatory debris in these chambers. The lens is not visible in B since the animal has a posterior luxation of the lens. The arrow points to an irregular cornea.

Fig 5: Transpalpebral ultrasound images of the lens and iris demonstrating the normal appearance (A) with both the hyperechoic anterior and posterior lens capsule visible around the hypoechoic centre of the lens compared to the presence of a large cataract (B) appearing as hyperechoic material within the borders of the lens capsule.
ultrasound this abnormality appears as thickened, irregular, often hypoechoic areas within the cornea and may reveal foreign bodies within these (Reef 1998; J.D. Slater, personal communication).

**Aqueous humour**

In order to view the anterior segment clearly, care must be taken to ensure the chamber is not compressed by excessive pressure from the transducer. The aqueous humour should be uniformly anechoic (Fig 4a), and has a mean depth of 3–5 mm (4.22 ± 1.29 mm) (Rogers et al. 1986). The presence of disease in the anterior chamber can be identified in the presence of severe corneal opacification and includes the presence of blood, fibrin and purulent material, which appear as increased echogenic material within this chamber (Fig 4b). Blood appears as hyperechoic heterogeneous material that swirls, particularly when the globe or head moves. Fibrin appears as hypoechoic material that initially forms ventrally; it may have a ‘spider’s web’ appearance within the anterior chamber in some cases. A change in the depth of the anterior chamber may occur in the presence of anterior and posterior lenticular luxations. Changes in the horizontal, vertical or both dimensions are also seen with lens subluxations. Anterior uveitis causes the anterior chamber to increase in size and due to inflammatory changes the anterior chamber may appear hypoechoic. Penetrating ocular images will also affect anterior chamber dimensions; acutely the chamber size may decrease and then will increase with time.

**Lens**

The lens has a single echogenic line on the anterior and posterior portions, with an anechoic centre. Measurements show that the mean anterior-posterior dimensions of the lens is 11–13 mm (11.93 ± 1.1 mm) (Rogers et al. 1986) and the diameter of the lens to be approximately 20 mm (Martin and Anderson 1981). The lens may be enlarged (for example with cataracts) or reduced in size (such as during lens resorption, after traumatic rupture or in some cataract cases), displaced from its normal position (Fig 5a) or may contain cataracts, which appear as an increased echogenicity within the lens with a more prominent lens capsule (Fig 5b). In addition it may be possible to identify lenticular rupture with a change in size and an irregular appearance of the lens capsule.

**Iris and ciliary body**

The iris and ciliary body lie posterior to the anterior chamber and anterior to the lens, at the equator. The ciliary body lies peripheral to and surrounds the lens. The iris can be visualised between the ciliary body and the lens and is smooth in texture (Figs 3a and 4a). The corpora nigra (iridic granules; Fig 2) can be seen as hyperechoic irregular structures that are localised at the edge of the pupil. The iris is approximately 2–3 mm thick (2.5 ± 0.66 mm) and the ciliary body 3–5 mm (3.99 ± 1.13 mm; Rogers et al. 1986).

**Vitreous humour**

The vitreous is an anechoic structure (Fig 6a) and has a mean depth of 15–19 mm (17.37 ± 1.98 mm; Rogers et al. 1986). This depth will change with luxation of the lens and with chronic glaucoma. Changes in the posterior segment can arise as a result of trauma (blood) or infection (inflammatory exudate; Fig 6b). Blood has increased echogenicity that swirls, particularly if the globe or head moves and inflammatory exudate appears as variable hypo- to hyperechoic particles; generally these are much ‘brighter’ and individual particles larger than the changes seen with blood. Vitreal ‘floaters’ can be seen in older horses as an incidental finding. These are the result of degenerative changes to the vitreal proteins and appear as bright white, regular hyperechoic ‘flecks’ within the vitreous. Neoplasms that have also been reported within the
vitreous include teratoid medulloepitheliomas in young horses (Ueda et al. 1993), choroidal melanomas (Rebhun 1998) and metastatic lymphosarcoma (Rebhun and Del Piero 1998). These masses will appear variably hypo- to hyperechoic within the vitreous fluid.

**Retina**

The retina is a thin hyperechoic structure caudal to the posterior chamber that is indistinguishable from the choroid and sclera (Reef 1998) except with high resolution ultrasound (Fig 7a). The mean retino-choroid-scleral thickness reported in extirpated eyes is approximately 2 mm (2.2 ± 0.48 mm; Rogers et al. 1986). Ultrasound can be used to identify retinal detachment. This modality is particularly useful when corneal oedema is present. Care must be taken to differentiate the appearance of retinal detachment as a hyperechoic structure floating within the vitreous, with the appearance of 2 wings attached at the optic nerve head (‘seagull sign’) within this space (Fig 7b) from that of vascular remnants, vitreal ‘floaters’ and inflammatory debris. Vascular remnants are rare in the horse, but when present can be seen as a hypoechoic ‘line’ from the optic nerve head to the posterior surface of the lens. The appearance of some of the other abnormalities is described above.

**Retrobulbar space**

Several structures can be visualised in the retrobulbar space, including the optic nerve, retrobulbar fat pad, extraocular muscles and bony orbit (Fig 6a). The optic nerve is hypoechoic and the retrobulbar fat is heterogeneous in texture but relatively hypoechoic, whereas the extraocular muscles are hypoechoic with hyperechoic flecks. The orbital bone is hyperechoic and a shadow is cast from it. Abscesses, haemorrhage and neoplasms can be identified in this space with ultrasound and their characterisation can be useful for evaluation of horses with exophthalmus (Reef 1998; van den Top et al. 2007). Retrobulbar abnormalities should be suspected in exophthalmic and frequently painful eyes. Abscesses appear as variably hypoechoic areas lying either between the bony orbit and the extraocular muscles or between the muscles and fat. They usually cause a markedly abnormal asymmetric appearance of this area ultrasonographically. Neoplasms will have a similar appearance, but are usually more hyperechoic; however, they may have a necrotic centre - this part of the neoplasm will appear like an abscess. Both of these structures may have a recognisable, thickened capsule. Haemorrhage will usually be seen as relatively heterogeneous hypoechoic material surrounding the muscles and fat within the orbital bone and is usually accompanied by other evidence of trauma.

**Summary**

Ultrasoundography of the globe and surrounding structures is an easily performed procedure in practice and can provide valuable information on degree and prognosis of ocular damage. In addition it can be used to monitor response to therapy or changes in disease states.

**References**


