A survey of ocular ultrasound abnormalities in horse: 145 cases

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Abstract

Purpose To describe the association of clinical and ultrasonographic (US) findings in horses affected by visual impairments, to estimate the most frequent ultrasonographic alteration as well importance and limits of US as a part of ophthalmic evaluation in equine patients.

Methods One-hundred-forty-five horses referred to the Veterinary Teaching Hospitals of the University of Perugia and Camerino for ocular problems were submitted to ophthalmic examination and ocular ultrasound. The following group of abnormalities was established: corneal alteration, cataract, synechiae, iris prolapse, anterior chamber alterations, vitreous opacities, globe reduction, globe enlargement, retinal detachment, lens subluxation/luxation, lens rupture, intraocular masses, retrobulbar masses. Specificity, sensitivity, positive and negative predictive value and related 95% confidence interval were calculated. Kappa value was estimated for concordance evaluation.

Results A total of 384 clinical alterations were observed during ophthalmological examination, while 357 were found by ultrasound investigation. A very good agreement was found for lens subluxation/luxation, intraocular masses, iris prolapse, globe enlargement, lens rupture, vitreous opacities and cataract. Moderate agreement was found for retinal detachment, anterior chamber alterations and synechiae. Corneal alteration and globe reduction resulted in a fair and poor agreement, respectively.

Conclusions Ultrasonography affords the benefit of providing a complete cross-sectional view of the eyeball, facilitating the identification of ocular diseases in cases of loss of transparency of ocular media. It also represents an indispensable aid whenever anterior opacification precludes the use of ophthalmoscopic or biomicroscopic examination techniques.

Keywords Horse · Ultrasound · Ophthalmology · Ocular diseases

Sommario

Obiettivi Descrivere l'associazione tra reperti clinici ed ultrasonografici in cavalli affetti da alterazioni della visione, valutare i più frequenti reperti ultrasonografici e l'importanza ed i limiti dell'ultrasonografia come parte della valutazione oftalmologica nel cavallo.

Metodi Centoquarantacinque cavalli riferiti all'ospedale Veterinario Didattico dell'Università di Perugia e di Camerino per patologie oculari sono stati sottoposti a valutazione clinica e a ultrasonografia oculare. Le alterazioni sono state suddivise nelle seguenti categorie: lesioni corneali, cataratta, sinechie, prolasso dell'iride, alterazioni della camera anteriore, opacità vitreali, riduzione dimensioni globo, aumento dimensioni globo, distacco retinico, lussazione/sublussazione del cristallino, rottura della lente, masse intraoculari, masse retrobulbari. Sono stati calcolati specificità, sensibilità, valore predittivo positivo (VPP) e negativo (VPN) con i relativi intervalli di confidenza (95%). La concordanza è stata valutata per mezzo del k-value.

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Risultati Sono state riscontrate un totale di 384 lesioni all'esame clinico e 357 a quello ultrasonografico. Concorrenza eccellente è stata riscontrata per lussazione/sublussazione del cristallino, masse intraoculari, prolasso dell'iride, aumento di volume del globo, rottura della lente, opacità vitreali e cataratta. Concorrenza moderata per distacco retinico, alterazioni della camera anteriore e sinechie. Le alterazioni corneali e la riduzione delle dimensioni del globo avevano concordanza rispettivamente pari a modesta e scarsa.

Conclusioni L'ultrasonografia ha il vantaggio di fornire una visione completa della sezione dell'occhio facilitando l'identificazione di patologie causanti perdita di trasparenza delle strutture oculari. Rappresenta quindi un ausilio indispensabile nel caso di opacizzazione delle strutture anteriori che impediscono l'esecuzione di un corretto esame oftalmoscopico o biomicroscopico.

Introduction

Equine ocular ultrasonography (US) is a feasible and easy-to-perform procedure that provides a complete image of the structures of the globe, regardless of opacities in the ocular media and eyelid swelling [1–5]. The technique is safe and practical and it can be performed in the standing horse, and only in some cases sedation or local nerve block are required [1, 4].

US should be always included as part of an ophthalmologic examination, especially when the development of ocular opacities in conditions such as corneal disease, uveitis, cataracts or trauma can preclude adequate evaluation of posterior structures using ophthalmoscopy and slit-lamp biomicroscopy [1].

US becomes crucial both in human and in veterinary medicine for the investigation of ocular opacities in conditions such as corneal disease, uveitis, cataracts or trauma [6]. It becomes essential in the process of screening candidates for cataract surgery and for the diagnosis of posterior segment diseases [1, 7, 8].

In addition, US in veterinary medicine is a very useful diagnostic tool for many other ophthalmic conditions as enophthalmos, buphthalmos or exophthalmos and in cases of ocular protrusion and suspicion of disparity in globe size [9, 10].

In human beings, ocular US is remarkably important in emergency cases of acute vision loss and acute posterior ocular disease [6, 11].

The Bedside Ocular Ultrasound is used by trained general physician to diagnose retinal detachment with a high degree of accuracy; moreover, its features such as speed, non invasive nature, and cost-effectiveness make it an ideal tool for busy emergency medicine clinicians [8].

US allows the visualization of intraocular structures in case of loss of transparency and enables to accurately differentiate between diseases that needs immediate ophthalmologic consultation (e.g. retinal detachment, vitreal hemorrhage, etc.) and those which can be followed up on an outpatient basis [7, 12].

Clinical examination represents the gold standard for diagnosis of eye abnormalities but in case of loss of transparency of ocular media, US becomes essential to the scope of diagnosis. Ocular surface and anterior segment pathologies (the ones regarding eyelids, cornea, anterior chamber and lens) as well as vitreous and retina are better recognized and diagnosed by clinical examination but, in case of loss of transparency of ocular media (i.e. diffuse corneal edema or cataract) ultrasonographic examination is more reliable and becomes crucial for the diagnosis.

The aim of this retrospective survey was to describe the association of clinical and ultrasonographic findings in horses affected by visual impairments, to estimate the most frequent ultrasonographic alteration as well importance and limits of US as a part of ophthalmic evaluation in equine patients. We evaluated the accuracy of ocular ultrasound for the diagnosis of ocular pathology in the routinely clinical activity.

Materials and methods

Medical records of one-hundred-forty-five horses referred to the Veterinary Teaching Hospitals of the University of Perugia ($n = 120$) and Camerino ($n = 25$) for ocular problems, between January 2015 and December 2016, were included in this study.

Cases were included if information about complete ophthalmic examination, including slit-lamp biomicroscopy, tonometry and indirect ophthalmoscopy on both eyes, and ocular ultrasonography was present.

Ultrasound was performed by the same operator at the two facilities, US were performed using a Logiq C5 Premium ultrasonograph (GE Healthcare Italia, Milan, Italy) with a multi-frequency linear transducer (4–12 MHz), using trans-palpebral approach after instillation of oxibuprocaine eye drops 0.4% (Novesina[®], Novartis Pharma spa, Origgio, Italy).

Ultrasonographic evaluation was carried out by systematically examining the cornea, anterior chamber, lens, iris and ciliary body, vitreous humour, ocular fundus, and retrobulbar space.

Longitudinal, transverse, and radial scans were acquired as well as measurement of the total globe, anterior chamber depth and vitreous chamber depth. For ocular biometry, considered parameters were those described by McMullen and Gilger [13].

Ultrasonographic examination of the retrobulbar space was performed by positioning the transducer over the supraorbital fossa and examining the structures behind the eye [9]. At the completion of the procedure the eye was washed with sterile saline solution, followed by the application of artificial tears.

For the purpose of the research, the following group of findings was established: corneal alteration, cataract, synechiae, iris prolapse, anterior chamber alterations, vitreous opacities, globe reduction, globe enlargement, retinal detachment, lens subluxation/luxation, lens rupture, intraocular masses, retrobulbar masses.

Data analysis was carried out by means of the computer software program WINPEPI (PEPI-for-Windows) [14]. Specificity, sensitivity, positive (PPV) and negative

predictive value (NPV) and related 95% confidence interval (CI) for US in comparison with clinical examination were calculated. Kappa value was estimated for concordance evaluation and agreement was interpreted according to Landis and Koch [15] as follows: no agreement = < 0.01; poor = 0.01 to 0.20; fair = 0.21 to 0.40; moderate = 0.41 to 0.60; good = 0.61 to 0.80; very good = 0.81 to 1.00 [15].

Results

Horses included in the study aged between 1 month and 28 years (Mean 10.8, SD 6.3), 68 were female, 24 stallion and 53 Gelding.

The number of diagnosis and related frequency are reported in Table 1.

A total of 384 clinical alterations were observed during ophthalmological examination while 357 were found by ultrasonographic investigation. Their distribution among the considered categories is reported in Fig. 1.

US abnormalities were detected in all but one horse, which was affected by optical neuritis and presented at the Veterinary hospital with a history of visual impairment without other clinical alterations.

The most frequent ultrasound findings were those involving the anterior chamber ($n = 78$) followed by cataract ($n = 70$), globe reduction ($n = 50$) synechiae (38) and vitreous hyperechogenicity ($n = 36$) (Figs. 2, 3, 4 and 5).

All horses ($n = 61$) with diagnosis consistent with uveitis, keratouveitis and endophthalmitis had more than one lesion recognized.

Table 2 shows the calculated value of sensitivity, specificity, PPV, NPV and k values as accuracy diagnostic parameters of ocular findings. A very good agreement was found for lens subluxation/luxation, intraocular masses, iris prolapse, globe enlargement, lens rupture, vitreous

Table 1 Number and percentage of diagnosis achieved after clinical and ultrasound evaluation

Diagnosis	<i>N</i>	% (<i>n</i> = 145)
Recurrent uveitis	33	22.8
Keratitis/Keratouveitis	26	18.6
Corneal ulceration/perforation	20	13.8
Senile cataract	11	7.6
Lens sub/luxation	10	6.9
Congenital cataract	9	6.2
Stromal abscess	9	6.2
Uveitis	6	4.1
Glaucoma	5	3.4
Iris melanomas	5	3.4
Irideal cysts	3	2.1
Micro-phakia	3	2.1
Endophthalmitis	2	1.4
Corneal edema	1	0.7
Optical nerve neuritis	1	0.7
Retrobulbar mass	1	0.7

Fig. 1 Different findings detected at clinical and ultrasonographic examination

Fig. 2 Corneal alteration: please note the enlarged part of the cornea (near the limbus) representing a stromal abscess

Fig. 4 Decrease in anterior chamber depth, cataract and detached retina

Fig. 3 Corneal alteration: keratitis. Please also note the presence of synchia between corneal endothelium and anterior capsule of the lens

Fig. 5 Retinal detachment. Note the characteristic appearance of detached retina, described as “seagull” sign

opacities and cataract. Moderate agreement was found for retinal detachment, anterior chamber alterations and synchia. Corneal alteration and globe reduction resulted in

a fair and poor agreement, respectively. The unique case of retro bulbar mass was not enough to permit an estimation of k value and sensitivity.

Table 2 Diagnostic accuracy parameters of ocular ultrasound for different conditions

Finding	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Kappa value
Corneal alteration	22.9 (16.5–30.7)	96.8 (92.0–98.9)	90.5 (84.2–94.5)	48.4 (40.1–56.8)	0.11
Cataract	97.2 (92.6–99.1)	98.6 (94.6–99.8)	98.6 (94.5–99.78)	97.3 (92.8–99.2)	0.95
Synechiae	61.3 (52.8–69.2)	100 (96.8–100)	100 (96.8–100)	77.6 (69.7–83.9)	0.48
Anterior Chamber alt.	100 (96.8–100)	69.8 (61.5–77.0)	62.8 (54.4–70.6)	100 (96.8–100)	0.44
Vitreous opacity	85.0 (77.9–90.2)	98.1 (93.8–99.5)	94.4 (89.0–97.4)	94.5 (89.1–97.4)	0.83
Globe reduction	100 (96.8–100)	78.5 (70.8–84.7)	48.0 (39.7–56.4)	100 (96.8–100)	0.38
Retinal detachment	100 (96.8–100)	93.8 (88.1–96.9)	68.0 (59.7–75.4)	100 (96.8–100)	0.41
Lens sub/luxation	100 (96.8–100)	100 (96.8–100)	100 (96.8–100)	100 (96.8–100)	1.00
Intraocular masses	100 (96.8–100)	100 (96.8–100)	100 (96.8–100)	100 (96.8–100)	1.00
Iris prolapse	100 (96.8–100)	100 (96.8–100)	100 (96.8–100)	100 (96.8–100)	1.00
Globe enlargement	100 (96.8–100)	100 (96.8–100)	100 (96.8–100)	100 (96.8–100)	1.00
Lens rupture	100 (96.8–100)	100 (96.8–100)	100 (96.8–100)	100 (96.8–100)	1.00
Retrobulbar mass	NE	99.3 (95.6–100)	0	100 (96.8–100)	NE

PPV positive predictive value, NPV negative predictive value, NE not evaluable

Discussion

Analysis of the final diagnosis showed that recurrent uveitis, keratitis/keratouveitis and corneal ulceration/perforation were the most common diseases affecting 33, 26 and 20 horses, respectively, according to the literature [1, 16–19].

Corneal alterations such as keratitis, keratouveitis, ulceration, perforation and stromal abscess showed a poor agreement ($k = 0.1$), corresponding to a significant lack in diagnostic capability of ultrasound, compared to the clinical assessment, despite sonography was performed setting the transducer to the highest frequency available (12 MHz). A limit of the present study was the lack of a high-resolution ultrasound probe for the evaluation of the cornea. Low frequencies US does not represent a valid diagnostic tool to detect corneal alteration, even if performed within the use of a standoff pad [1, 17] and the results of the present study confirmed such observation. However, ultrasound can be useful to evaluate corneal integrity in horses with severe eyelid swelling [9]. Recently, high-frequency ultrasound probes were used for ocular ultrasonographic examination in horses [20]. Transducers have frequencies ranging from 20 MHz (high-resolution ultrasound) to 60 MHz (ultrasound biomicroscopy) and have been developed allowing imaging at resolutions comparable to low-power microscopic views (20–80 μm), introducing a substantial improvement in corneal examination, compared with conventional 10-MHz probes that have resolutions of 300–400 μm [21, 22]. High-resolution ultrasounds were used in human ophthalmology allowing evaluation of tumors and cysts in the anterior segment, scleral diseases, intraocular assessment of the lens, trauma, and differentiation of various forms of glaucoma [23–25]. This innovative technique could cover

the deficiency of surface structures ultrasound as the cornea, filling a niche in veterinary ophthalmology [20].

As reported in literature [26], diagnosis of iris prolapse, lens subluxation/luxation, lens rupture, globe enlargement and intraocular masses is based on clinical presentation; in the present study, for those pathologies, ultrasound examination confirmed the clinical observation ($k = 1$).

Synechiae were found both clinically and ultrasonographically in several conditions, especially in advanced stage of recurrent uveitis. These types of lesion consist of adhesions of the iris to the cornea (anterior synechiae) or to the anterior lens capsule (posterior synechiae). Twenty of the cases reported as synechiae at clinical examination were found to be negative at ultrasound. This could be due to the inability of low-frequency probe to differentiate appropriately tiny intraocular alterations from artifacts during examination [1, 17]. Anyway, ultrasound should be always performed to detect any other ocular abnormalities that might be posterior to the synechiae, such as cataracts or retinal detachments.

Regarding the anterior chamber, ultrasound was able to detect a greater number of abnormalities than the clinical evaluation (78 vs 49). Specifically, in 11 cases ultrasound detected slight opacities (e.g. particles) and 18 were reported as slight depth changes in comparison with the contralateral eye that is difficult to evaluate at clinical assessment. This explanation could also account for the 26 cases reported as globe reduction at ultrasound, but not detected at clinical examination. Due to the impossibility to perform measurement of anterior chamber depth during clinical examination, US becomes crucial for this evaluation, especially in condition as uveitis and glaucoma, which affect this part of the eye.

US was employed to evaluate the entire globe, thus permitting a more accurate measurement of parameters such

as globe axial length and anterior chamber depth, during glaucoma or uveitis [17, 18].

As expected, the agreement between evaluations was very good in case of cataract, as reported for the other diseases involving the lens (e.g. lens luxation, subluxation and rupture). Ultrasound was able to detect two cases more than clinical examination because the corneal opacity prevented visualization of the posterior structures.

Regarding retinal detachment, the low agreement is to be interpreted as a greater sensitivity of ultrasound compared with clinical direct evaluation, since it was able to detect eight cases where the presence of severe cataract prevented visualization of the eye fundus, confirming the high value of this examination in such disease.

Ultrasound confirmed 34 cases out of 40 clinically diagnosed as vitreous opacities and recognized 2 more cases. These discrepancies could be due to the presence of cataract in the two more cases, and to the low accuracy of low ultrasound frequencies to differentiate artefacts from initial, small caliper, vitreous fiber changes as in course of asteroid hyalosis. This is a form of vitreal degeneration in which round to oval, gray to white opacities (asteroid bodies), possible lipid and calcium deposits of different dimensions, are suspended within the vitreous gel, appearing as point-like echogenicities when present in a certain number. In these cases, ophthalmoscopy and biomicroscopy are essential to differentiate the nature of opacities but in cases of loss of transparency, high-frequency US becomes crucial for this purpose [1, 3].

Although it was not possible to carry out an assessment of the accuracy parameters for the only case of retrobulbar mass, this alteration was detected at ultrasound but not at clinical evaluation, where only a suspicious was stated for it.

Conclusion

Ultrasonography was a useful add-on in the evaluation of the cataracts and lens luxation or subluxation, particularly for those horses where clinical evaluation did not allow a proper identification of the extension of cataract or lens luxation. In the former cases, apart from the greater or lesser evaluation accuracy, it should be highlighted that US enabled better verification of the stage and location of many cataracts, and contributed to the expectation of technical difficulty regarding phacoemulsification, as reported in literature [1].

In the present survey, the majority (53%) of the cataracts diagnosed in adult horses were correlated to uveitic etiology and these cases presented with advanced cataract and chronic ocular disease in agreement with previous studies [1, 16].

Ultrasonography is commonly used as diagnostic tool to evaluate the retina in cases of suspected retinal detachment

and when the posterior segment cannot be examined with a routine ophthalmological examination, such as in case of corneal edema, anterior chamber hemorrhage, cataract, uveitis and vitreal hemorrhage [16–18].

When performing US for detection of retinal detachment, the operator should be aware of the several artifacts described both for the vitreous chamber and the retinal surface which may be confused with ocular diseases [17].

In conclusion, ultrasonography affords the benefit of providing a complete cross-sectional view of the globe, facilitating the identification of ocular diseases in cases of loss of transparency of ocular media or in case of intense palpebral swelling. It also represents an indispensable aid whenever anterior opacification precludes the use of ophthalmoscopic or biomicroscopic examination techniques.

Further studies are needed for the assessment of diagnostic and prognostic value of high-resolution ultrasound in cases of corneal damage such as edema, neovascularization, and stromal abscesses since the probes used in clinical practice could not allow an appropriate evaluation.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All the described animal-related procedures were conducted according to Directive 2010/63/EU of the European Parliament and of the Council of 22nd September 2010 on the protection of animals used for scientific purposes (Article 1, Paragraph 1, Letter b), the Italian legislation (D. Lgs. n. 26/2014, Article 2, Paragraph 1, Letter b), which does not require any approval by the competent Authorities.

Informed consent Informed consent form was obtained from all the owners participating in the study.

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