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# Ultrasonographic and Biometric Evaluation of the Eyes of Horses and Cattle

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# 말과 소에서 눈의 초음파측정과 생체측정의 평가

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**요　　약 : 말과 소의 정상 안구내의 구조와 크기를 알아보기 위하여 10마리의 말과 14두의 Holstein 안구를 적출하여 생리식염수내에서 초음파상으로 안구내의 구조를 확인하였으며 각막의 두께, 전방의 깊이, 수정체의 두께, 초자체의 깊이 및 안구축을 측정하였다. 초음파로 측정한 안구를 -30°C로 동결한 후 Diamond cutter로 절단하여 caliper로 측정하고 Student-t test로 처리하여 수치를 비교하였다. 초음파상에서 말은 암컷(35.99±1.97)과 숫컷(35.94±3.36), 좌측(36.26±2.82)과 우측(35.67±2.65)눈의 크기가 비슷하였으며, 소에서도 좌측(29.06±3.36)과 우측(28.53±3.36)눈의 크기가 비슷하여 통계학적 유의차는 없었다. 본 연구에서는 7.5 MHz 초음파기의 B-Mode 방식을 이용하여 말과 소의 안구의 구조를 확인하고 측정하였는데 임상적으로 매우 유용하여 수의안과학에서 적용할수 있는 가치있는 진단법이다.**

*Key word :* Ultrasonographic, ocular biometric, horse, cattle

## Introduction

Ocular biometry was one of the early uses of ultrasound in human ophthalmology[4]. The first use of ultrasonic techniques in ophthalmology occured in 1956 when Mundt and Hughs demonstrated the application of the A-scan[11]. In 1958 Baum and Greenwood developed the first B-scan ultrasonoscope for evaluation of ocular and orbital structures[7]. Ultrasonic measurment of the eye is very important to the ophthalmologist. It provides a relatively safe and painless means to study intraocular structures that may be obscured by certain pathologic conditions and undetectable disease using ordinary light sources or radiography[1]. In ophthalmic ultrasonography a short pulse of sound is directed into the eye using a piezoelectric crystal transducer[2]. In B-mode ultrasonography, echos are displayed as cross sectional images of the reflecting tissue interfaces[1,3,6,10]. This application resulted from ultrasound unique ability to measure the axial dimensions of the eye and determine the position of intraocular components without compression or other artifacts. Knowledge of the ultrasonographic appearance of intraocular structures of horses and cattle would serve as a basic from which clinical examinations of eyes horses and cattle eye might be done.

The purposes of this study were: 1) To present the B-mode ultrasonographic appearance of the globe and intraocular structures of the horse and cattle eye. 2) To present the ultrasonographic measurements of the globe of the eye and the anterior-posterior diameters of the intraocular structures. 3) To compare these ultrasonographic measurements with physical measurements of the same eyes after freezing. This information should serve as a basis for further clinical

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investigations of ocular abnormalities in horses and cattle.

## Materials and Methods

A total of 48 normal eyes, 10 eyes of horses and 14 eyes of cattle were evaluated ultrasonically. The eyes were collected from the abattoir immediately after autopsy. The globes were immersed in 0.9% sodium chloride solution until scanning was accomplished. All eyes were evaluated sonographically within 2 hours of collection.

A gauze 2 cm thick was fixed to the base of the water bath 10 cm in depth and the eye were submerged. The cornea was visible below the surface of the water and the optic nerve was adjacent to the sponge.

A commercially available ultrasound mechine with a 7.5 MHz mechanical liner transducer was used and the echos were received, processed and a display generated in a standard B-mode ultrasound system. An electronic cursor was used for all ultrasound measurements. After the ultrasound measurements were made the eyes were frozen -30°C, cut along a dorsal plane and measured with calipers. The globes were examined in a dorsal plane. Optimal B-scan images representing were identified and recorded; corneal thickness, aqueous chamber depth, lens diameter, vitreous chamber depth and the axis bulbi were recorded for each image using electronic cursor. After the ultrasound measurements were made eyes were frozen -30°C, cut along a dorsal plane using a diamond cutter. Direct measurements were made using a mechanical caliper, B-mode measurement and direct measurements of the frozen globes were then compared. The mean, ranges and standard deviations for each set of measurements were calculated. A student T-test was used to determine whether difference between measurements were significant.

## Result and Discuss

On B-scan images, the eyes appeared as well-defined, ovid structures with mostly anechoic contents

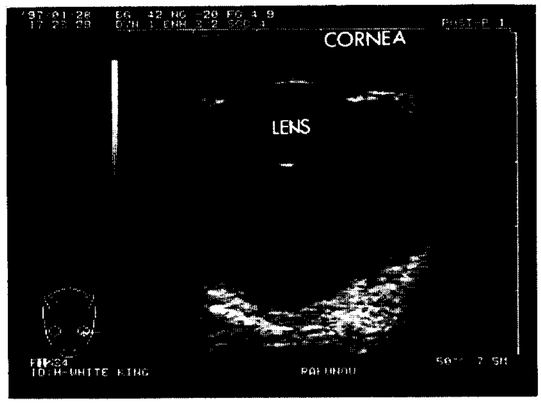


**Fig. 1.** Normal intraocular structure.

(Fig. 1). The cornea appeared as a convexly curved hypoechoic structure with both central and peripheral areas of hyperechogenicity.

The anterior chamber was a convexly curved anechoic area posterior to the cornea but the posterior chamber was not seen. This chamber was an anechoic area between the posterior surface of the iris and the anterior surface of the lens. The iris and ciliary body were seen as irregular hyperechoic structures posterior to the anterior chamber and anterior to the lens. They extended centrally from the margins of the globe and except at the pupillary opening could not be distinguished separately from the anterior lens. The lens appeared as two curvilinear echogenicities representing the anterior and posterior lens capsules. The internal appearance of the lens was anechoic. The vitreous chamber imaged as a

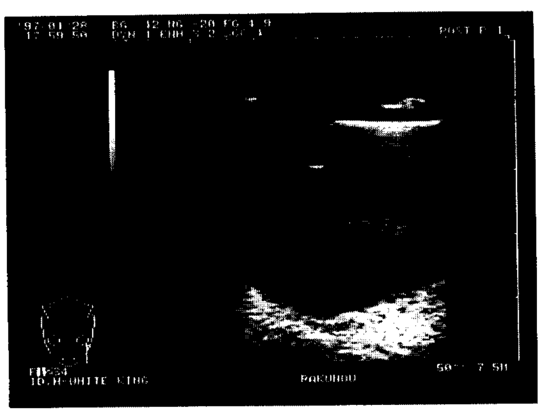

**Fig 2.** Insert of a needle in lens.

**Fig 3.** Insert of the needle in vitreous chamber.

homogenous, anechoic region between the posterior lens capsule and extended to the anterior inner surface of the posterior globe. The posterior ocular wall had the highest echogenicity encountered. It was not possible to identify individual retinal, choroidal or scleral layers in horse and cattle. A neddle was inserted to lens (Fig. 2) and vitrous chamber(Fig. 3) for confirmation of the intraocular structure in normal horse. Comparisons of the all measurements obtained by ultrasonography and by physical means, range and standard deviation of corneal thickness, aqueous chamber depth, lens diameter, vitreous chamber depth and axis bulbi are presented from Table 1 to 7. Knowledge of the normal dimension of the intraocular structures using ultrasonography is helpful in assessing a disease.

However the corneal hyperechogenicity attributed to increased corneal stiffness or density toward the cornea scleral junction. The slightly echoic appearance beneath the cornea seen in this study was thought to represent a reverberation artifact. It is important to remember that we measured corneal thickness along the central ocular axis and the cornea is thinner at the periphery. In these studies, we could not separate the anterior and posterior chambers of the aqueous sonographically. This may be due to postmortem mydriasis of the iris[8]. Images of the iris, ciliary body, lens and the vitreous were similar to that reported for humans[5], dogs[5,9] and horses[8]. The weak echoes identified between the anterior and posterior lens capsule in some case was observed as reverberation artifacts. The retina/choroid/sclera complex was hyperechoic and individual layers could not be consistantly separated in B-mode images. The optic nerve was recognized on B-mode image as a hypoechoic structure with parallel margins coursing posteriorly from the globe.

The hypoechogenicity is presumably due to orientation of the beam parallel to the nerve fibers and the highly organized, homogenous structure of the optic nerve compared to adjacent fat. The axis bulbi in horse is 30.03±2.02. The results of the compared ultrasound measurements between right and left, between male and female eyes are almost same (Table 1, 2 and 3). Also in cattle axis bulbi is 29.06±3.36, In the result of the compared ultrasound measurements between right and left eyes, there is no significant differences (Table 5 and 6), except aqueous chamber depth.

This experiment found that differences between B-

**Table 1.** B-mode ultrasonic measurements eyes of horses (mm)

| Intraocular Structures | Measurements | | |
|---|---|---|---|
| | Mean | S.D.* | Range |
| Corneal thickness | 0.65 | 0.12 | 0.5-1.3 |
| Aqueous chamber depth | 3.25 | 1.96 | 1.5-6.0 |
| Lens diameter | 11.10 | 0.90 | 9.8-13.1 |
| Vitreous chamber depth | 15.35 | 1.31 | 18.3-22.1 |
| Axis bulbi | 30.03 | 2.02 | 30.9-41.9 |

S.D.*=Standard deviation

**Table 2.** Comparison of the ultrasonic measurements right and left eyes of horses (mm)

| Intraocular Structures | | Measurements | | |
|---|---|---|---|---|
| | | Mean | S.D.* | Range |
| Corneal thickness | R | 0.83 | 0.25 | 0.5-1.3 |
| | L | 0.83 | 0.25 | 0.5-1.3 |
| Aqueous chamber depth | R | 3.31 | 1.19 | 1.6-5.5 |
| | L | 3.58 | 1.44 | 1.5-6.0 |
| Lens diameter | R | 11.92 | 0.97 | 9.8-13.1 |
| | L | 11.87 | 0.95 | 10-12.8 |
| Vitreous chamber depth | R | 20.18 | 1.09 | 18.3-22.0 |
| | L | 20.59 | 1.16 | 18.3-22.1 |
| Axis bulbi | R | 35.67 | 2.65 | 30.9-40.3 |
| | L | 36.26 | 2.82 | 32.1-42.9 |

S.D.*=Standard deviation

**Table 3.** Comparison of the ultrasonic measurement eyes of male and female horses (mm)

| Intraocular Structures | | Measurements | | |
|---|---|---|---|---|
| | | Mean | S.D.* | Range |
| Corneal thickness | M | 0.87 | 0.34 | 0.5-1.3 |
| | F | 0.79 | 0.07 | 0.7-0.9 |
| Aqueous chamber depth | M | 3.83 | 1.43 | 1.6-6.0 |
| | F | 3.06 | 1.07 | 1.5-4.5 |
| Lens diameter | M | 11.45 | 1.12 | 9.8-13.1 |
| | F | 12.34 | 0.38 | 11.6-12.8 |
| Vitreous chamber depth | M | 20.49 | 0.93 | 19.3-22.0 |
| | F | 20.28 | 1.32 | 18.3-21.7 |
| Axis bulbi | M | 35.94 | 3.36 | 30.9-41.9 |
| | F | 35.99 | 1.97 | 32.7-38.2 |

S.D.*=Standard deviation

**Table 4.** Comparison of ultrasonic and physical measurements eyes of horses (mm)

| Intraocular Structures | | Measurements | | |
|---|---|---|---|---|
| | | Mean | S.D.* | Range |
| Corneal thickness | U | 0.65 | 0.12 | 0.5-1.3 |
| | P | 0.93 | 0.32 | 0.6-1.6 |
| Aqueous chamber depth | U | 3.25 | 1.96 | 1.5-6.0 |
| | P | 3.18 | 1.34 | 1.1-5.0 |
| Lens diameter | U | 11.10 | 0.90 | 9.8-13.1 |
| | P | 12.36 | 1.07 | 10.3-14.0 |
| Vitreous chamber depth | U | 15.35 | 1.31 | 18.3-22.1 |
| | P | 21.53 | 1.28 | 19.0-23.1 |
| Axis bulbi | U | 30.03 | 2.02 | 30.9-41.9 |
| | P | 37.01 | 3.16 | 31.2-43.1 |

S.D.*=Standard deviation

**Table 5.** B-mode ultrasonic measurements eyes of cattle (mm)

| Intraocular Structures | Measurements | | |
|---|---|---|---|
| | Mean | S.D.* | Range |
| Corneal thickness | 0.69 | 0.22 | 0.5-1.3 |
| Aqueous chamber depth | 3.11 | 1.48 | 1.1-6.5 |
| Lens diameter | 10.66 | 1.39 | 8.2-12.3 |
| Vitreous chamber depth | 14.85 | 1.31 | 13.0-17.3 |
| Axis bulbi | 29.06 | 3.36 | 23.1-33.2 |

S.D.*=Standard deviation

mode ultrasonic and physical measurements were noticed (Table 4 and 7), although the difference was not statistically significant. Previously published measurements have not provided enough information for a statistical comparision.

**Table 6.** Comparison of the ultrasonic measurement right and left eyes of cattle (mm)

| Intraocular Structures | | Measurements | | |
|---|---|---|---|---|
| | | Mean | S.D.* | Range |
| Corneal thickness | R | 0.69 | 0.24 | 0.5-1.3 |
| | L | 0.69 | 0.22 | 0.5-1.3 |
| Aqueous chamber depth | R | 2.82 | 1.43 | 1.1-6.5 |
| | L | 3.11 | 1.48 | 1.1-4.5 |
| Lens diameter | R | 10.70 | 1.42 | 8.2-12.2 |
| | L | 10.66 | 1.39 | 8.2-12.3 |
| Vitreous chamber depth | R | 14.63 | 1.46 | 13.0-17.3 |
| | L | 14.85 | 1.31 | 13.0-17.3 |
| Axis bulbi | R | 28.53 | 3.36 | 23.1-32.4 |
| | L | 29.06 | 3.36 | 23.2-33.2 |

S.D.*=Standard deviation

**Table 7.** Comparison of ultrasonic and physical measurements eyes of cattle (mm)

| Intraocular Structures | | Measurements | | |
|---|---|---|---|---|
| | | Mean | S.D.* | Range |
| Corneal thickness | U | 0.69 | 0.22 | 0.5-1.3 |
| | P | 0.88 | 0.21 | 0.6-1.2 |
| Aqueous chamber depth | U | 3.11 | 1.48 | 1.1-6.5 |
| | P | 2.88 | 1.55 | 1.0-5.8 |
| Lens diameter | U | 10.66 | 1.39 | 8.2-12.3 |
| | P | 11.47 | 1.10 | 9.7-12.9 |
| Vitreous chamber depth | U | 14.85 | 1.31 | 13.0-17.3 |
| | P | 15.73 | 1.60 | 12.1-18.0 |
| Axis bulbi | U | 29.06 | 3.36 | 23.1-33.2 |
| | P | 30.67 | 3.16 | 24.0-33.2 |

S.D.*=Standard deviation

In our study, the smaller B-scan values compared with physical measurements in horse and cattle. All ocular measurements were probably affected by freezing to some degree in our study. This may be due to expansion of water during freezing[5]. The physical measurements were consistently larger than the ultrasonic ones except for aqueous chamber depth, which decreased. This may be due to expansion of the lens during freezing which reduces the depth of the aqueous chamber.

This study was to characterize the normal ultrasound appearance and ocular biometry of eyes of horses and cattle by using a widely available, geneal purpose scanner. This study will provide baseline information for the study of pathologic conditions affecting the eyes of horses and cattle with an ultrasound unit commonly available to the veterinarians.

## Summary

The normal ultrasonographic intraocular structures and biometry of eyes of 10 horses and 14 cattle were evaluated by saline immersion technique. Five intraocular dimensions were taken; corneal thickness, aqueous chamber depth, lens diameter, vitreous chamber depth and axis bulbi. The eyes were then frozen, sectioned in a dorsal plane and the same measurements were made using calipers. Ultrasonic and physical measurements were compared statistically. There was no difference between rigth and left eye of horses and cattle. In this study, the smaller B-scan values compared with physical measurements in horse and cattle were observed. The use of B-mode ultrasonography at a frequency of 7.5 MHz to examine the intraocular structures of the horse and cattle eyes are suggested as a valuable clinical equipment.

This investigation will provide baseline information for the study of pathologic conditions affecting the eyes of horses and cattle with an ultrasound commonly available to the veterinarian

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