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Ocular ultrasonographic evaluation of cataractous and pseudophakic eyes in dogs

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Abstract: Ocular B-mode ultrasonography is one of the noninvasive, rapid diagnostic imaging techniques indicated in canine cataract patients to evaluate the posterior segment of the eye. This study was conducted on twelve eyes of dogs with a history of cataract, which were scanned under topical anesthesia. The preoperative and postoperative ultrasonographic biometry, and ultrasonographic features of the lens, intraocular lens (IOL), and posterior segment were recorded. There was a significant difference between pre- and postphacoemulsification mean value of the axial length of globe and anterior chamber depth. The normal ultrasonographic features of the 2-hydroxy-ethyl-methylacrylate IOL was observed in vitro by placing the IOL in a coupling gel bath; it appeared as a "flying saucer" with hyperechoic margins and a central anechoic optic area and similar findings were also observed in pseudophakic eyes. Posterior segment changes such as posterior vitreous detachment were noticed in two dogs and retinal detachment in one dog postoperatively. In conclusion, ocular B-mode ultrasonography could be used to locate the position of the IOL in canine pseudophakic eyes. Ocular ultrasound is still more a useful tool to locate the position of the IOL postoperatively, even in pseudophakic eyes with corneal edema or iris synechiae in dogs.

Key words: Eye, ultrasonography, dog, cataract, pseudophakic

1. Introduction

Ocular B-mode ultrasonography is one of the noninvasive, real-time, rapid diagnostic imaging techniques that allow evaluation of internal structures of the eye (1). This imaging technique is indicated when there is presence of opacity on the refractive ocular structures such as the cornea and lens, which leads to futile ophthalmoscopic examination of the posterior segment of the eye (2). Ocular ultrasonography has become one of the essential preoperative diagnostic and prognostic tools to predict the visual outcome of pets with cataracts, based on the structural integrity of intraocular tissues. Many ultrasonographic studies were done in dogs but very few of them have explained the position of the intraocular lens (IOL) and posterior segment changes in the pseudophakic eyes. This article focuses on ultrasonographic changes observed in the cataractous lens and the posterior segment of the canine eye preoperatively and the ultrasonographic features of the IOL and changes observed in the posterior segment postoperatively following phacoemulsification of cataract.

2. Materials and methods:

This study was conducted over a period of 8 months from March to December 2017 at the Department of Veterinary Surgery and Radiology. Fifty dogs of both sexes and various breeds with the history of cataract and loss of visual acuity were scanned in this study period. All the dogs were scanned without sedation.

2.1. Preoperative ultrasonography

Topical anesthesia of the eye to be scanned was achieved by instilling a drop of 0.5% proparacaine three times with an interval of 5 min between each drop. Then sterile 2% hydroxypropyl methyl cellulose gel was applied over the eye to be scanned as coupling medium to reduce artifacts (2). The dog's face was positioned rostrocaudally, and the eyelids were held open using one hand of the examiner while the other hand was used to scan the eye using the ultrasound transducer. Prior to scanning the transducer's head was cleaned with isopropyl alcohol and rinsed with sterile distilled water. The eyes were scanned with a Sonoscape S6V ultrasound machine using a 8–15 MHz linear transducer. Different views of the eyes were recorded, such as transverse view, longitudinal view, and temporal view. The probe marker was positioned medially, dorsally, and rostrally (cranially) for transverse, longitudinal, and temporal views, respectively. The transcorneal method of scanning was adopted (1,2) for viewing transverse and longitudinal plane images of the eye and the probe was

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kept in direct contact with the sclera, laterally, to obtain the temporal view images. During scanning, care was taken not to exert direct pressure over the cornea or sclera with the transducer.

Out of the 100 eyes scanned, 89 of the them were diagnosed as having cataracts, and among the cataractous eyes, 30 eyes had vitreous abnormalities. Twelve cataractous eye without any vitreous changes were randomly included in this study. These dogs had undergone routine hematobiochemical analysis and detailed ophthalmological examination.

2.2. Surgical technique

These twelve eyes had undergone cataract surgery by phacoemulsification through a 2.8 mm clear corneal main incision using a keratome and a suitable 37–41 diopter multifocal plate haptic single-piece hydrophilic 2-hydroxy ethyl methacrylate (HEMA) IOL was implanted through the extended (3.5–4.0 mm) main incision into the capsular bag. Then the main incision was closed by two simple interrupted sutures using 8–0 silk suture material. These dogs were treated with postoperative medications to prevent postoperative infection and glaucoma and the intraocular pressure was monitored every 3 days.

2.3. Postoperative ultrasonography

Postoperatively, after 2 weeks ultrasonography was repeated similarly in all the pseudophakic eyes of dogs, as explained above.

2.4. IOL in vitro ultrasonography

To understand the true ultrasonographic property of the intraocular lens used in this study, the HEMA IOL was embedded in a coupling gel bath and it was scanned using a linear transducer with the same imaging parameters (3).

2.5. Parameters observed

Preoperative and postoperative ocular ultrasound biometrics such as axial length, lens or axial lens thickness, and anterior chamber depth measured using electronic calipers were recorded. Other ultrasonographic features such as echotexture, echogenicity of the cataractous lens, IOL, and posterior segment of cataractous and pseudophakic eye were also recorded. The echotexture was described as homogeneous or heterogeneous and the echogenicity was described as hypoechoic, hyperechoic, or anechoic. The area of echogenicity in the cataractous lens content was also recorded as capsular, cortical, nuclear, or complete. The position of the IOL in relation to capsular bag, anterior chamber, and vitreous were posteriorly recorded.

The observed ocular biometry data were subjected to statistical analyses such as mean ± standard error, range, ratio of axial lens thickness to axial length of globe, and mean value of axial length and further subjected to paired samples t-tests with confidence intervals of 95% using IBM SPSS Statistics 23.

3. Results

The study included various breeds of dogs such as Labrador retriever (n = 4), mongrel (n = 3), Spitz (n = 3), Cocker spaniel (n = 1), and Dachshund (n = 1). The age of the dogs ranged from 18 months to 11 years. The reports of hematobiochemical analysis were in normal ranges except for three dogs whose fasting serum glucose levels were high, suggestive of diabetes. These dogs were treated with parenteral insulin injection to bring the serum glucose level to the normal reference range to be considered for cataract surgery.

3.1. Preoperative ultrasonography

Preoperatively, the mean ± standard error (SE) of the axial length of the globe was 20.15 ± 0.29 mm and it ranged from 18.07 mm to 21.18 mm. The mean ± SE of axial lens thickness of cataractous lenses was 6.99 ± 0.45 mm and it ranged from 4.83 to 10.18 mm. The mean ± SE of anterior chamber depth (ACD) was 3.34 ± 0.19 mm and it ranged from 2.25 to 4.33 mm. The mean ± SE of the ratio of axial lens thickness to axial length of globe was 0.34 ± 0.02 and it ranged from 0.24 to 0.49.

The lens thickness was found to be >8 mm in the three diabetic dogs, where the lenses appeared swollen along with anterior chamber depth of <3 mm (as shown in Figure 1). The ratios of axial lens thickness to axial length of globe in the three diabetic dogs were 0.39, 0.45, and 0.48. Both anterior and posterior lens capsules were observed as curvilinear hyperechoic lines. The lens was observed as homogeneously hyperechoic only at the cortical region in four dogs (as shown in Figure 2) and only at the nucleus region in six dogs and homogeneously hyperechoic throughout the lens in two dogs. Other than the area of hyperechoic echogenicity the lens was anechoic in the above-mentioned eyes of ten dogs. In the posterior segment, the vitreous was observed as an anechoic

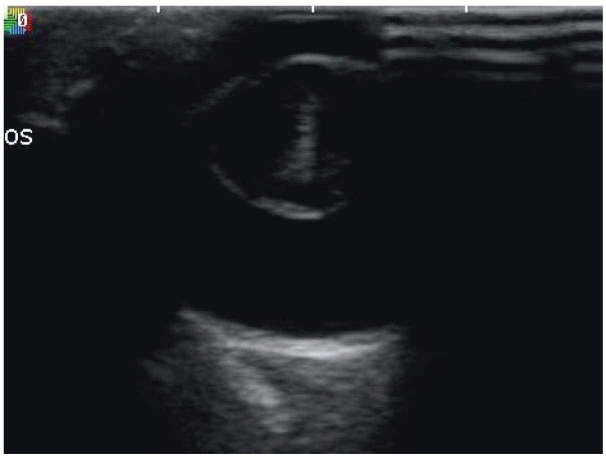

Figure 1. Intumescent cataract: swollen hyperechoic lens, shallow anterior chamber.

structure and the scleroretinal rim was observed as a thick curvilinear hyperechoic line.

3.2. Postoperative complication

Four dogs had developed corneal edema (as shown in Figure 3) after the 3rd postoperative day, but upon treatment the edema was resolved completely within a month. Two dogs had developed posterior synechiae (as shown in Figure 4), which caused irregular dilatation of pupil. The above-mentioned complications hindered further ophthalmoscopic examination of posterior segment.

3.3. In vitro IOL ultrasonography

The HEMA IOL was observed in the shape of a "flying saucer", where the border and haptic of the IOL had hyperechoic echogenicity with a central anechoic optic area (as shown in Figure 5).

3.4. Postoperative ultrasonography

The mean ± SE of axial length of the globe was 20.65 ± 0.41 mm and it ranged from 17.90 to 22.52 mm. The mean ± SE of ACD was 5.46 ± 0.40 mm and it ranged from 3.68 to 7.70 mm. In this study, there was a significant difference between the pre- and postoperative axial length of the globe and ACD ($P = 0.048$ and $P = 0.000$, respectively).

The optic area of the IOL was observed as a hyperechoic biconvex structure with a small central anechoic optic area, and haptics were observed as a single hyperechoic line overlying the posterior capsule in eight dogs. Reverberation artifacts could be noticed in the vitreous

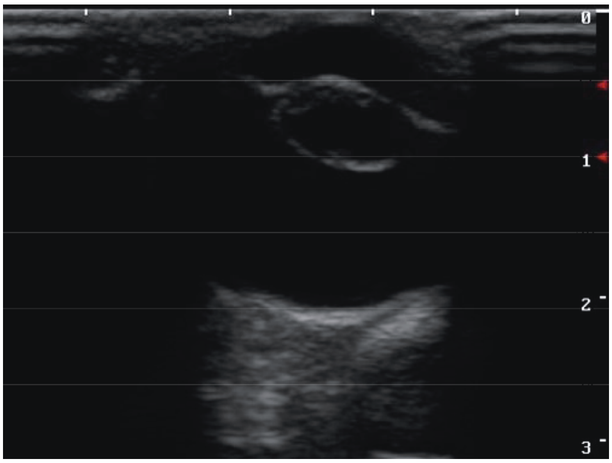

Figure 2. Cortical cataract: hyperechoic echogenicity at the lens cortex.

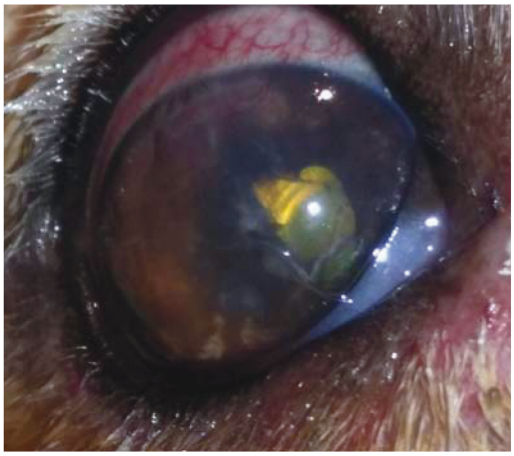

Figure 4. Posterior synechiae.

Figure 3. Corneal edema.

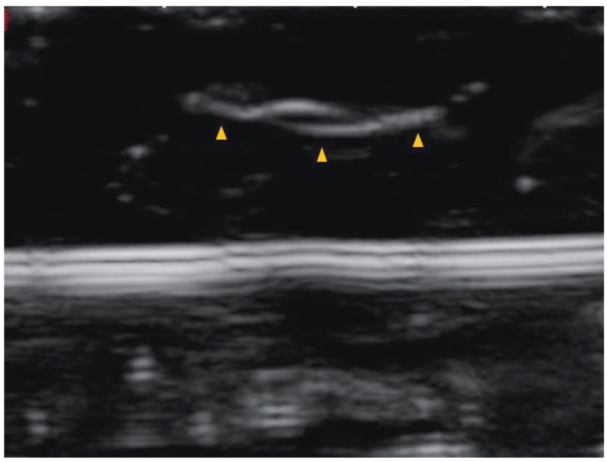

Figure 5. HEMA IOL: in vitro ultrasonography ("flying saucer" appearance: arrowheads). Note the hyperechogenic margin of the IOL with central anechoic optic area.

when the ultrasound beam was directed perpendicular to the IOL (as shown in Figure 6) in all the dogs. In the remaining four dogs the intraocular lens was found to be displaced from the capsular bag and observed in the vitreous (as shown in Figure 7). Partial posterior vitreous detachment was noticed in two dogs as a hypoechoic line that separated the vitreous from the anechoic retro-hyaloid space (as shown in Figure 8). Total retinal detachment was observed in a dog as a classic seagull wing-shaped hyperechoic undulating line extending from the optic disc.

All the dogs had regained vision except the dog with retinal detachment. Although posterior vitreous detachment was noticed in two dogs, the visual outcome was not affected during that time. After 3 months of follow-up, among the eleven dogs, one dog with posterior vitreous detachment subsequently developed vitreal hemorrhage and retinal detachment with loss of vision.

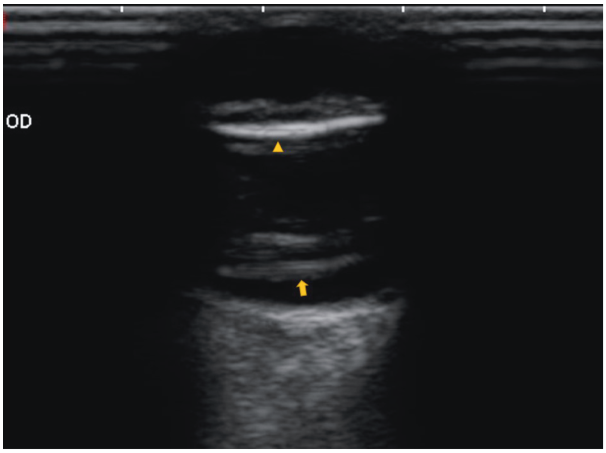

Figure 6. Pseudophakic eye: IOL (arrowhead), reverberation artifact (arrow).

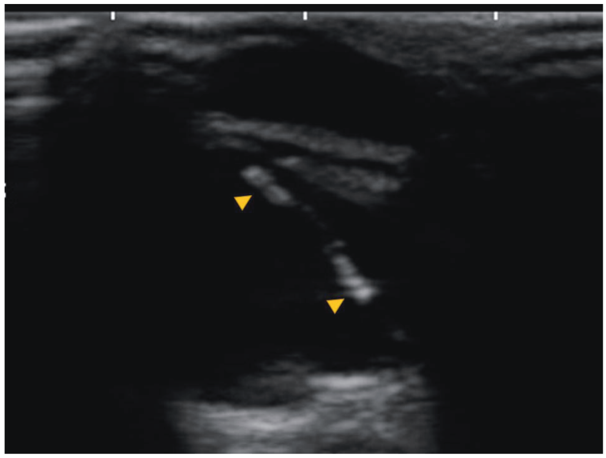

Figure 7. Pseudophakic eye: IOL displaced into the vitreous (arrowheads).

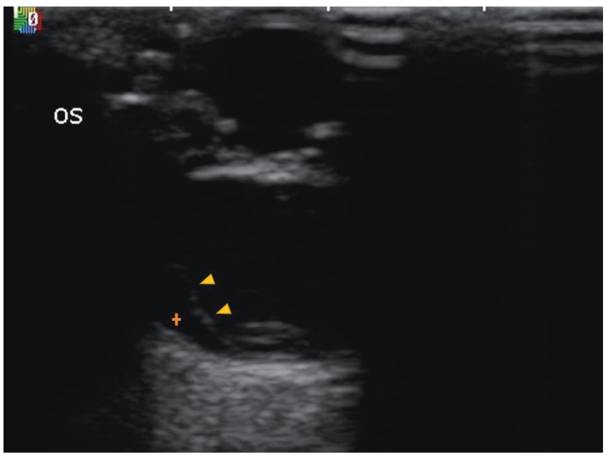

Figure 8. Pseudophakic eye: hypoechoic posterior vitreous detachment (PVD: arrowheads), +: anechoic retro-hyaloid space.

4. Discussion

Topical anesthesia was found to be adequate for ocular ultrasonography in dogs in this study, as reported in earlier studies (1,2).

Cataracts could be categorized based on the area of echogenicity in the crystalline lens (2,4). One author (4) opined that in diabetic cataracts, an increased axial thickness of the lens could be noticed. The preoperative biometry of the lens in diabetic cataracts with lens thickness >8 mm and shallow anterior chamber <3 mm (5) was consistent with our findings from this study. The ratio of axial lens thickness and axial length of globe in diabetic cataracts of this study were similar to the findings of another study on lens morphometry in cataractous dogs (5).

In an earlier study on human cataract phacoemulsification, the ACD was found significantly increased after phacoemulsification, which was consistent with this study (6).

Corneal edema and posterior synechiae were observed as the few complications following phacoemulsification surgery in dogs, but corneal edema could be successfully treated by hypertonic topical solutions (7). In this study, for eyes with corneal edema and posterior synechiae ocular ultrasonography was found to be helpful in evaluating the position of the IOL and any posterior segment abnormality.

In the present study, ultrasonography of pseudophakic eyes revealed the presence of reverberation artifacts in the vitreous, which might be due to the inherent property of the HEMA IOL. Reverberation artifacts were produced when the angle of incidence of the ultrasound beam was perpendicular to the IOL (2,8). To differentiate the vitreous abnormalities from artifacts produced by the IOL, changing the angle of incidence of the ultrasound beam would reduce or eliminate the artifacts (8).

However, in another in vitro study with ultrasound biomicroscopy, single-piece acrylic IOL made up of phenyl-ethyl-methacrylate did not not produce any reverberation artifact and the shorter scanning depth of the ultrasound biomicroscopy could be a limitation (3).

Total retinal detachment was visualized as "seagull wings" or a V-shaped hyperechoic structure in the vitreous chamber in the present study, which was similar to findings mentioned in other studies of dogs (2,4). Posterior vitreal detachment appeared as a curvilinear convex echo in the posterior portion of the vitreous chamber (2,8,9).

Postoperatively, vitreous detachment was noticed in two dogs in this study; this could be due to leakage of irrigation fluid during phacoemulsification into the vitreous chamber as the permeability of the zonules increased with age (10). In studies of human cataract extraction, the incidence of postoperative retinal detachment was high following postoperative posterior vitreous detachment (PVD) without any preoperative change in the vitreous (11,12).

An ultrasound biomicroscopy study on human pseudophakic patients reported that the faulty haptic positioning of the IOL led to chronic inflammation of the iris (13), but in this study on dogs, no such abnormalities or complications were noticed.

Although many ultrasound biomicroscopy studies suggested that it would be easy to precisely identify IOL position and anterior chamber changes because of the high frequency (14), ultrasound biomicroscopy could not penetrate beyond the depth of 5 mm from the contact surface. Hence, it could not replace conventional ultrasound imaging of the posterior segment and orbit after IOL implantation (15).

The probable limitation of conventional ultrasound machines for scanning the eye lies in the use of linear transducers with longer contact surfaces. Hence, the complete cross-sectional image of the globe cannot be seen in a single acoustic window. This can be overcome by comparing a series of images of different planes or slices through fanning of the transducer.

In conclusion, pre- and postoperative ocular B-mode ultrasonography should be performed routinely to rule out PVD and retinal detachment. If PVD is observed postoperatively, periodic evaluation should be carried out to predict retinal detachment in dogs. Ocular B-mode ultrasonography could be used to locate the position of the IOL in canine pseudophakic eyes. Reverberation artifacts due to the IOL should not be mistaken for vitreous changes in pseudophakic eyes of dogs. Ocular ultrasound is a definite tool to locate the position of the IOL postoperatively in eyes with corneal edema or iris synechiae in dogs.

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