Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(3): 1131-1134

Received: 04-03-2018
Accepted: 05-04-2018

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B-mode ultrasonographic evaluation of lens equatorial length in canine cataractous eye

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Abstract
B-mode ultrasonography is one of the non-invasive, real time, rapid diagnostic imaging technique which allows evaluation of internal structures of the eye. Twenty-one dogs (35 eyes) of both sex and various breeds with the history of cataract and loss of visual acuity were scanned over this study period. The eyes were scanned under topical anaesthesia using 6-18 MHz transducer. The mean ± S.E. of lens equatorial length was 11.42±0.13 mm. There was a high degree of positive correlation between the Mean lens equatorial length and the axial length of the globe and between the Mean lens equatorial length and Axial lens thickness. The lens equatorial length could be measured using conventional ultrasound machine and the measurement could help to determine the desired haptic to haptic length of intraocular lens and appropriate size of capsular tension ring in order to prevent potential adverse effects during cataract surgery in dogs.

Keywords: Eye, dog, ultrasound, lens equatorial length, B-mode, cataract

Introduction
Cataract in dogs are caused by oxidative stress and age related changes on the crystalline lens. B-mode ultrasonography is one of the non-invasive, real time, rapid diagnostic imaging technique which allows 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 cornea and lens which leads to futile Ophthalmoscopic examination of posterior segment of the eye [2]. Ocular ultrasonography has become one of the essential pre-operative diagnostic and prognostic tool to predict the visual outcome of pets having cataracts, based on the structural integrity of intraocular tissues. Many ultrasonographic studies were done in dogs but very few of them have explained the importance of lens equatorial length / diameter (LEL). This study focus on ultrasonographic changes observed in the cataractous lens, biometry, especially LEL of the canine eye, pre-operatively using a conventional ultrasound machine.

Materials and Methods
This study was conducted over a period of one year from March, 2017 – February, 2018 at Small Animal Ophthalmology Unit, Department of Veterinary Surgery and Radiology. Twenty-one dogs (35 eyes) of both sex and various breeds with the history of cataract and loss of visual acuity were scanned over this study period. All the dogs were scanned without sedation.

Topical anaesthesia of the eye to be scanned was achieved by instilling a drop of 0.5% Proparacaine at three instances with an interval of 5 minutes between each drop. Then sterile 2% hydroxypropyl methyl cellulose (HPMC) gel was applied over the eye to be scanned as coupling medium to reduce artefacts [2]. The dog’s face was positioned rostro-caudally, and the eyelids were held open using one hand of the examiner and other hand was used to scan the eye using the ultrasound transducer. Prior to scanning the transducer head was cleaned with isopropyl alcohol and rinsed with sterile distilled water. The eyes were scanned by “Esaote Mylab Class C” ultrasound machine using 6 – 18 MHz linear transducer and the frequency band was set to maximum. The eye is one of the sensitive tissue which differs other structures of the body in terms of vasculature. Hence, according to the guidelines of British Medical Ultrasound Society parameters such as Thermal Index (TI) and Mechanical Index (MI) were maintained at the recommended level (TI < 1.0 and MI < 0.3) to avoid thermal hazard and cavitation produced by diagnostic ultrasound, respectively [3, 4]. Different views of the eyes were recorded such as transverse view, longitudinal view and temporal view [2].

The probe marker was positioned medially, dorsally and rostrally (cranially) for transverse, longitudinal and temporal view, respectively. The transcorneal method of scanning was adopted [1, 2] for viewing transverse and longitudinal plane images of the eye and the probe was kept in direct contact with sclera, laterally to obtain the temporal view images. During scanning, care was taken not to exert direct pressure over cornea or sclera by the transducer.

Ocular ultrasound biometry such as axial length, lens or axial lens thickness and lens equatorial diameter / length (LEL) (as shown in Fig.1) from transverse, longitudinal and temporal views were measured using electronic callipers in millimetres [5-7]. The observed ocular biometry data was subjected for statistical analyses such as mean ± standard error (S.E.), range of axial length, lens thickness and LEL and correlation between age, body weight of the dogs with their ocular biometry data were tried to be established. Log transformation of data was done when the sample size of different groups was not equal and one-way ANOVA was calculated using IBM, SPSS software version 23.0.

Results and Discussion

The study comprised of 21 dogs of various breeds such as Labrador Retriever (N = 7), Mongrel (N = 2), Spitz (N= 6) and Dachshund, Terrier Crossbred, Yorkshire Terrier, Golden Retriever, Beagle, Lhasa Apso (N = One each). The age of the dogs ranged from 1 year to 14 years. The body weight of these dogs ranged from 3.7 – 48.5 kg. Among the 21 dogs eleven were male and ten were female. Among the twenty-one dogs presented fourteen had bilateral cataract and seven dogs had unilateral (only left eye was affected) cataract. A total of twenty-one left eyes and fourteen right eyes were scanned. The cataractous lens appeared hyperechoic in echogenicity at the cortical, nuclear or in both regions (as shown in Fig. 2 & 3).

The mean ± S.E. of ocular biometry values of the 35 eyes were axial globe length 19.95 ± 0.15 mm, axial Lens thickness 6.85 ± 0.18 mm, LEL Transverse view 11.52 ± 0.14 mm, LEL Longitudinal view 11.50 ± 0.14 mm, LEL Temporal view 11.24 ± 0.15 mm and Mean LEL from the above three views 11.42 ± 0.13 mm. The minimum and maximum range of ocular biometry of these 35 eyes were axial length 18.33 – 21.77 mm, axial lens thickness 4.81 – 10.48 mm, LEL Transverse view 10.04 – 13.17 mm, LEL Longitudinal view 9.77 – 13.32 mm, LEL Temporal view 9.71 – 13.25 mm and Mean LEL from the three views 10.10 – 13.24 mm. LEL ocular biometry value of this study was found to be similar to another study [7] but they had measured LEL from only two views Though ocular biometry could be evaluated using A-scan but earlier studies reported that there was no statistical significant difference between A-mode and B-mode ultrasonography measurements [8, 9]. However, no literature support was available regarding lens equatorial length measured using A-mode ultrasonography which was an added advantage of using B-mode ultrasonography imaging for eye. Another Study [10] reported that the use of high resolution ultrasound transducer (20 MHz) produced intra- and interobserver variation in measurements of eye and this might be due to thin slices of imaged tissue and it made repositioning of the probe on the same area difficult. The mean LEL value from a recent study [11] was 11.2 and 11.3 mm using 35 MHz ultrasound biomicroscopy which was almost similar to the mean LEL value (11.42 mm) of this study. The difference could be due to higher frequency transducer which would produce better resolution.

There was a moderate degree of positive correlation between the Mean LEL and Body weight (r = 0.422, p-value = 0.012). There was high degree of positive correlation between the Mean LEL and the axial length of the globe (r = 0.722, p-value = 0.000), between the Mean LEL and Axial lens thickness (r = 0.552, p-value = 0.001).

There was no significant difference [6, 7] of axial length, axial lens thickness, LEL of different views and Mean LEL between the left and the right eye (as shown in Table 1). There was no significant difference of ocular biometry value between gender.

Stage of Cataract was categorized as intumescent (N=5), immature (N= 9 eyes) and mature (N=21). The dog which had intumescent cataract was found to be suffering diabetes. Descriptive statistics of ocular biometry based on stage of cataract was provided in table 2. There was a significant (p-value = 0.24) positive high degree of correlation (r = 0.926) between the axial lens thickness and the mean LEL of intumescent cataracts. The was significant (p-value = 0.000) positive high degree of correlation (r = 0.743) between the axial globe length and the mean LEL of Mature cataracts. The one - way ANOVA of log transformed ocular biometry data of different stage of cataract revealed that there was significant difference between the mean ocular biometry data value of intumescent cataract group when compared to the mean ocular biometry data of mature and immature cataract groups (p-value < 0.05) and these findings were similar to the findings of an earlier study [6]. The significant difference between the ocular biometry data of intumescent cataract and other mature and immature cataract could be attributed to the increased intralenticular pressure within the lens capsule due to osmotic diabetic cataract [12]. The presence of cataract allowed better demarcation of lens equator region [13]. The temporal view ultrasonography of the eye was possible in this study due to the presence of orbital ligament at the caudolateral aspect and the eyeball occupies the base of the orbit and projects a variable distance rostral to the orbital margin [14].

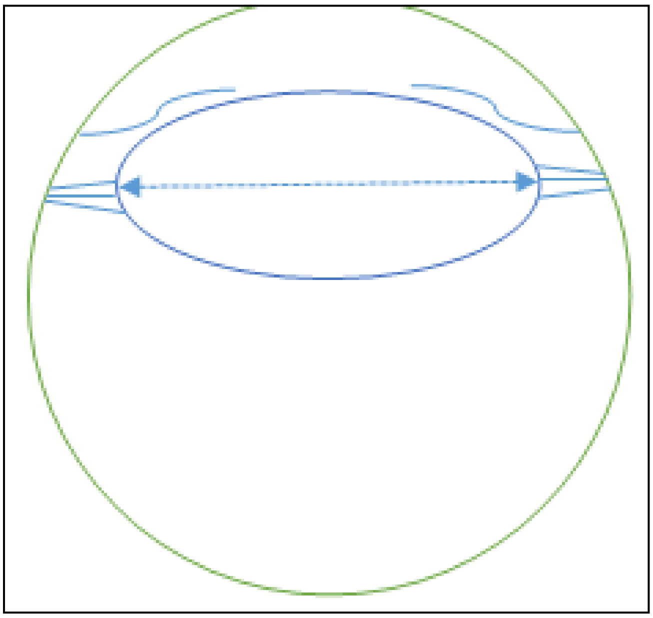

Fig 1: Schematic Diagram- Cross section of Canine eye; Dotted line represents Lens Equatorial Length; L -Lens; C- Cornea; V- Vitreous humour; A- Aqueous humour

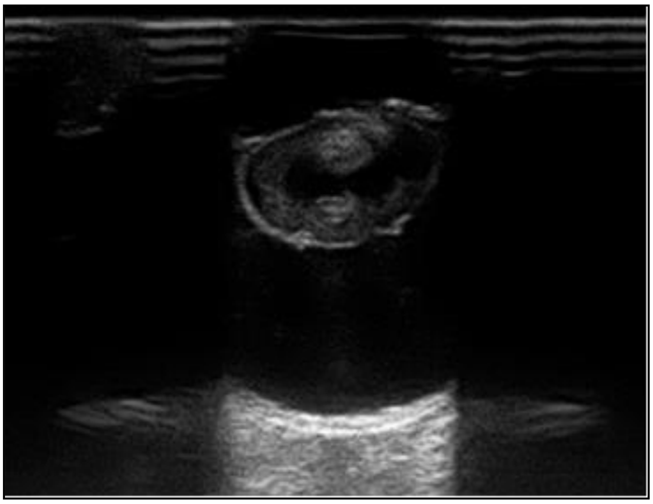

Fig 2: Ultrasound image of Cataractous eye- Transverse view; Note-Hyperechoic cortex and anechoic nucleus

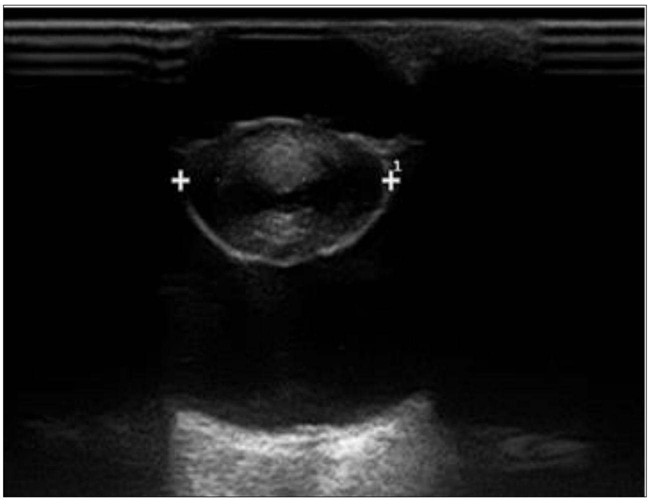

Fig 3: Ultrasound image of Cataractous eye- Transverse view; Note-"+ - +" – indicates lens equatorial length

Table 1: Descriptive Statistics of Ocular biometry of Left and Right eye

Ocular Biometry		Left Eye^{NS} (N=21)	Right Eye^{NS} (N=14)
Axial length (mm)	Mean ± S.E.	19.97 ± 0.18	19.94 ± 0.28
	Min - Max	18.33 – 21.20	18.40 – 21.77
Axial lens thickness (mm)	Mean ± S.E.	6.77 ± 0.28	6.97 ± 0.19
	Min - Max	4.81 - 10.48	5.90 - 8.84
LEL –Transverse (mm)	Mean ± S.E.	11.61 ± 0.19	11.38 ± 0.20
	Min - Max	10.04 – 13.17	10.24 – 12.46
LEL – Longitudinal (mm)	Mean ± S.E.	11.51 ± 0.18	11.49 ± 0.24
	Min - Max	9.77 – 13.32	10.05 – 13.07
LEL - Temporal (mm)	Mean ± S.E.	11.26 ± 0.18	11.20 ± 0.27
	Min - Max	9.82 – 13.25	9.71 – 12.61
Mean LEL (mm)	Mean ± S.E.	11.46 ± 0.17	11.36 ± 0.23
	Min - Max	10.10 – 13.24	10.13 – 12.71

NS- No significance between left and right eye ($\alpha = 0.05$)

Table 2: Descriptive Statistics of Ocular biometry of different stage of cataract

Cataract Stage	Statistics	Axial Length (mm)	Axial Lens Thickness (mm)	Mean LEL (mm)
Immature	Mean ± S.E.	19.32 ± 0.28	6.63 ± 0.20	10.99 ± 0.19
	Min - Max	18.33 – 20.49	5.20 – 7.28	10.51 – 11.97
Intumescent	Mean ± S.E.	20.54 ± 0.17	8.34 ± 0.66	12.35 ± 0.27
	Min - Max	19.90 – 20.80	6.60 – 10.48	11.87 – 13.24
Mature	Mean ± S.E.	20.08 ± 0.19	6.59 ± 0.19	11.38 ± 0.17
	Min - Max	18.4 – 21.77	4.81 – 8.71	10.10 – 12.49

Conclusions

In our study, the conventional ultrasound was found to be useful to determine the lens equatorial length (LEL) of the dog eye from three different views to reduce error during LEL measurement. However, ultrasound biosafety parameters should be considered to avoid any potential hazards to the eye when using a conventional ultrasound machine. The LEL measurement could help to determine the desired haptic to haptic length of intraocular lens (IOL) and to decide upon the use of appropriate size of intraocular devices like capsular tension ring in order to prevent potential adverse effects such as capsular tear, IOL vaulting into the anterior chamber during cataract surgery in dogs.

Acknowledgement

The authors would like to thank Indian council of Agricultural Research (ICAR) for the financial support and The Dean, Director of Clinics, Madras Veterinary College and Head of the Department, Department of Veterinary Surgery and Radiology for the facilities provided during this study.

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