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B-mode ultra-sonographic evaluations of intraocular structures of the normal and cataractous eye in dogs

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Abstract
The B-mode ultra-sonographic evaluations of intraocular structures of the normal and cataractous eye were performed on clinically 20 normal and 20 cataractous eyes in dogs of different breeds of mesocephalic skull group using a linear transducer of 13 MHz at 4 cm scanning depth with suitable gain by trans corneal approach.

Keywords: B-mode ultra-sonographic, intraocular structures, trans corneal

Introduction

B-mode ultrasonography is a non-invasive, real time, rapid diagnostic imaging technique used for the qualitative and quantitative evaluation of intraocular and orbital lesions (Mason *et al*., 2001) [29]. Two-dimensional (2D) ultrasonography (USG) is the most common mode used clinically in veterinary ophthalmology (Scotty, 2004) [44]. It allows assessment of intraocular structures, for example cornea, anterior chamber, iris, ciliary body, lens, vitreous chamber and posterior section of the bulbar wall (Nautrup and Tobias, 2007) [32].

The ultrasonographic study is used for an inside view of inner ocular structures during the course of certain eye diseases such as corneal pigmentation, hypopyon, stromal abscesses, anterior uveitis, infectious keratoconjunctivitis (IKC) and cataract (El-Tookhy and Tharwat, 2013) [12]. The presence of cataracts prevents an adequate evaluation of the vitreous and ocular ultrasound can be an important tool for evaluating these structures (Gonzalez *et al*., 2001) [17].

The presence of cataracts prevents an adequate evaluation of the vitreous and ocular ultrasound can be an important tool for evaluating these structures (Gonzalez *et al*., 2001) [17]. In case of mature and diffuse cataract where visualization of the posterior segment of the eye is not possible, ultrasonography is a valuable tool to evaluate vitreous and retinal conditions, as well as the stage of cataracts (Van der Woerdt *et al*., 1993) [50].

The lens is made up of protein concentration of 33% of its total weight with most of those proteins being transparent and water-soluble (Shahzad *et al*., 2012) [45]. The lens depends on the aqueous humor and vitreous for nutrition and elimination of waste products (Martin, 2010) [27].

Cataract is the loss of transparency of the lens and has been one of the most common causes of loss of vision in dogs (Park *et al*., 2009) [34] and humans (Santosh *et al.*, 2019) [42]. The opacities may be of varying extent, shapes, location within the lens, causes, age of onset and rate of progression (Ofri, 2013) [33].

Materials and Methods

In the present study, evaluation of B-mode ultrasound echo morphometry of normal and cataractous eyes in dogs was conducted on 40 eyes of clinically 20 normal and 20 cataractous eyes of dogs which were brought for clinical check-up to Veterinary Clinical Complex (VCC) Department of Veterinary Surgery and Radiology, Post Graduate Institute of Veterinary Education and Research (PGIVER) Jaipur.

History of vision changes, age, any injury, time elapsed since occurrence of problem, recent medications use and presence of diabetes was obtained from the dog owner. The eyes were examined for cataract, conjunctival appearance, conjunctival vascularity, discharge, and corneal clarity.

Ultrasonographic evaluation of the normal and cataractous eyes of dogs was performed with the help of My Lab Seven (make-Esaote) ultrasound machine (Fig. 1) using a linear array probe (3-13 MHz) at 13 MHz (Fig. 2).

The dogs were examined in awaked condition. Manual restraint was sufficient for ophthalmic ultrasonographic examination. Dogs were scanned in either right or left lateral recumbency according to the right or left eye examined.

The probe directly placed on the cornea. This technique was suitable for visualization of ocular structures in dogs in which cornea was intact. (Fig. 4). Trans-corneal ultrasonography helps to evaluate normal intraocular morphology, echo biometric indices, and to diagnose the disease conditions as previously done by Singh *et al*., (2015) [46] in bovine and Tavana and Peighambarzadeh (2014) [48] in dogs.

A vertical image of the globe was created by placing the transducer at the limbus and scanning done across the globe. Eye globe was divided into right and left halves by placing the probe on the vertical plane. Radial views of the globe were achieved by moving the transducer around the globe. (Fig. 4)

No pre-examination drug or medication was used during the B-mode ultrasonographic evaluations of internal structures of the normal and cataractous eyes in dogs. The dogs were properly restrained manually without any sedation or local anaesthetic application. The dogs were positioned in lateral recumbency with head facing toward the ultrasound machine. (Fig. 4)

Dogs were kept in lateral recumbency during the examination Lee *et al*. (2003) [25] and Bentley (2015) [2]. Eye lids were held open manually. In present study use of the conductive gel acting as a standoff pad (photo-x-1001, Fig. 3). Transducer (Linear probe 3-13 MHz, Fig. 2) was directly placed on the cornea after application of coupling gel. Scanning depth was kept 4 cm while frequency was set to 13 MHz Care was taken not to put undue pressure on cornea to avoid any possible changes in biometric measurements. The globes were examined in a vertical plane. In present study, all the dogs under study were having normal and cataractous eyes and ultrasonography provided a complete cross-sectional view of the globe (Scotty *et al*., 2004) [44] beyond the opaque ocular media (Gonzalez *et al*., 2001) [17].

In the end, excess sterile coupling gel was wiped off with cotton from surrounding eyelids and margins and gently each eye was flushed with sterile saline solution to remove the coupling gel and associated debris.

Good quality echo-morphometric sonograms were obtained in normal and cataractous eyes of all groups. Optimal B-scan sonogram along the central optic axis enabled visualisation of the cornea, aqueous chamber, anterior lens capsule, posterior lens capsule, vitreous chamber and posterior ocular wall.

Results and Discussion

Ultrasonography is indicated in diagnostic variations that are not identified in the routine ophthalmic examination, especially when there is opacification of the transparent media of the eye (e.g., cornea, aqueous humor, lens and vitreous humor (Gonçalves *et al*., 2000; Scotty *et al*., 2004) [16, 44].

Two dimensions B-scan ultrasound can be one of the diagnostic tools for the detection of hidden posterior segment lesions and can be performed routinely in preoperative cataract patients, as this would help in surgical planning (Qureshi and Laghari, 2010) [38].

Ocular sonography is a good diagnostic tool for a routine ophthalmic examination (Görig *et al*., 2006) [18]. In present study, all the dogs under study were having normal and cataractous eyes and ultrasonography provided a complete cross-sectional view of the globe (Scotty *et al*., 2004) [44] beyond the opaque ocular media (Gonzalez *et al*., 2001) [17]. The B-mode probe used in the present study operated at a frequency of 3-13 MHz, allowed complete evaluation of the globe which was similar to Ribeiro *et al.*, (2010) [39] and Martin *et al.,* (2010) [27]. The scanning depth was kept 4 cm which allowed excellent evaluation of the intraocular structure and was in agreement with Whitecomb (2002) [51].

Transpalpebral and transcorneal ultrasonographic techniques are useful to evaluate the normo echoic ocular pattern. However, transcorneal technique has some risk of corneal damage but outweighed by the enhanced image quality (Hillyer, 1993) [21]. In present study, transcorneal ocular ultrasonography revealed good quality sonogram and biometric study of normal and cataractous eyes of dogs. Trans-corneal ultrasonography helps to evaluate normal intraocular morphology, echo biometric indices and to diagnose the disease conditions as previously done by Singh *et al.,* (2015) [46] in bovine and Tavana and Peighambarzadeh (2014) [48] in dogs.

The present study was conducted in lateral recumbency by manual restrain and blepharoptosis on unsedated dogs similar to Lee *et al.,* (2003) [25] and Bentley (2015) [2]. This allowed adequate evaluation of the eye globe, avoided rotation of eye ball and upward movement of third eyelid which were reported as the common problem faced in sedated or general anesthetised and closed eyelids by Penninck *et al.,* (2001) [36], Mustafa (2005) [31] and Dar *et al.,* (2014) [8]. Thus, sedation and general anaesthesia proposed previously by Schiffer *et al*., (1982) [43], Hager *et al.,* (1987) [19] and Gonçalves *et al.*, (2009) [15] did not appear necessary and with these techniques, risks inherent in anaesthesia, as well as extra costs, were eliminated in present study.

In present study use of the conductive gel acting as a standoff pad advocated by (Cottrill *et al.,* 1989) [6], allowed adequate visualization of intraocular structure, which is important for the obtainment of good quality images. It also provided adequate contact of the transducer with the surface of the cornea, with minimal pressure on the eye, which resulted in less discomfort for the patients (Williams, 2004; McMullen & Gilger, 2006; Wilkie *et al.*, 2006; Toni *et al.*, 2010) [53, 30, 52, 49]. After ultrasound examination, excess coupling gel was carefully wiped from the eyes as reported by El-Tookhy and Tharwat (2013) [12] and rinsed with sterile 0.9% sodium chloride solution as stated by Martin *et al*., (2010) [27] to prevent the corneal irritation (Hager *et al.*, 1987; Maggs *et al*., 2008; Martin *et al*., 2010; Assadnassab and Fartashvand, 2013 and Singh *et al*., 2015) [19, 26, 27, 1, 46]. Vertical plane was used in agreement with Gonclave *et al*., (2000) [16] Ribeiro *et al*., (2009) [40], Kassab (2012) [22]. Optimal B-scan images along the central optic enabled visualisation of the cornea, anterior chamber, anterior lens capsule, posterior lens capsule, vitreous chamber, posterior ocular wall and optic nerve.

In present study cornea was characterised by two parallel and convex hyperechoic lines near the contact area of transducer in normal and cataractous eye. The cornea generated two echoes the first one corresponded to its epithelium and the second to its Descemet's membrane which was in agreement with El-Tookhy *et al*., (2012) [11]. In normal and cataractous eye of dogs, the ultrasonographic appearance of anterior and posterior chambers of the aqueous as a single anechoic space was in agreement with Assadnassab and Fartashvand (2013)

[1]. Previous studies had reported inflammatory and pyogenic materials (hypopyon) as a hyperechoic mass in the anterior chamber (El-Tookhyl and Tharwat, 2013) [12] and inflammatory debris associated with anterior uveitis as an ill-defined area of increased echogenicity (Penninck *et al.,* 2001) [36]. However, no such abnormalities were recorded in present study.

The anterior and posterior margins of the lens were hyperechogenic creating a distinct delineation between the chambers and the lens. It was possible to identify the lens by identifying both anterior and posterior capsules. Anterior lens capsule appeared as convex hyperechoic line while posterior lens capsule appeared as concave hyperechoic line and the lens was identified as a hypoechoic area between two hyperechoic lines of the anterior and posterior lens capsules connected to zonules and ciliary body at its equator in normal and cataractous eyes of dog. In normal eye, the lens nucleus was visible as an anechoic part between two hyperechoic lines of the anterior and posterior lens capsules, was in agreement with Williams (2004) [53]. The hyper echogenicity of the anterior and posterior capsules detected independent of the developmental stage of the cataract was in agreement with Martins *et al.,* (2011) [28]. Cataracts are degenerative changes in the lens as detailed by Gelatt and Mackay, (2005) [13] which produce echogenicity at various locations within an anechoic lens. The type of cataract and its duration of occurrence can change the lens's echogenicity, size and shape. Changes within a cataract lens create acoustic inhomogeneities, as stated by Spaulding (2008) [47]. In present study in cataractous eyes, posterior sub luxation of lens was seen in two cases. As the intraocular pressure (lOP) constantly increases, ocular layers may be stretched and ocular globe may expand (hydrophthalmus). This condition may result in the occurrence of tears in the fibrils of the zonula (Curtis, 1990) [7].

There was significant increase in the echogenicity of the lens capsule with progression of stage of the cataract which was also observed by Lavanya *et al*., (2021) [24] and Diaz (2004) [9].

The vitreous chamber, filled with vitreous humour, was identified as anechoic area between the posterior lens capsule and posterior pole of the eye which appears hyperechoic in normal and cataractous eyes. These findings corroborate with previous studies by Williams (2004) [53] and Haraldsen (2014) [20]. Vitreous opacities imaged ultrasonographically as areas of increased echogenicity in the normally anechoic vitreous. Multiple areas with different echogenicity within the vitreous are seen ultrasonographically in cataractous eyes with vitreous degeneration due to variable degrees of liquefaction of the vitreous. Degeneration of vitreous had multicurved lines with different varying reflectors was found in 4 dogs. Vitreous degeneration is more frequent in older animals and can develop secondary to intraocular inflammation and with hypermature cataract formation reported by Diaz (2004) [9]. Presence of vitreous degeneration, and haemorrhage in cataractous eyes in dogs were reported by Dar *et al.,* (2014) [8], Qureshi and Laghari (2010) [38] in human in previous studies. Vitreous degeneration increased with the age of dog as reported earlier (Glenwood 1999; Coffee *et al.,* 2007; Boevé and Stades 2007) [14, 5, 3].

The posterior pole of the eye, which includes the retina, the choroid and the sclera, was identified as a hyperechogenic and concave structure in normal and cataractous eye. It was hard to differentiate retina choroid and sclera and was collectively termed as scleroretinal rim in agreement with Ribeiro *et al*., (2009) [40]. The optic disc appeared as a slightly brighter region that may be either raised or depressed relative to the posterior globe, in normal and cataractous eyes. The ultrasonographic appearance of the optic nerve and extra-ocular muscles in the present study was in agreement with El-Maghraby *et al.,* (1995) [10], Haraldsen (2014) [20] and Kumar *et al.,* (2018) [23]. No abnormalities were found at sclero-retinal rim and optic nerve in the present study. However, presence of retinal detachment and optic nerve avulsion in cataractous eyes of dogs had been reported by Dar *et al*., (2014) [8], Van der Woerdt *et al.,* (1993) [50] in dogs and Qureshi and Laghari (2010) [38] in human.

It was concluded that B-mode ultrasound can be used to study the normal echogenicity of the intraocular structures of normal and cataractous eye.

Fig 1: Showing MyLabSeven (make-Esaote) ultrasonography machine

Fig 2: Showing Linear Array Probe 3-13 MHz

Fig 3: Showing sterile coupling gel for Ultrasound (Photo- X-1001)

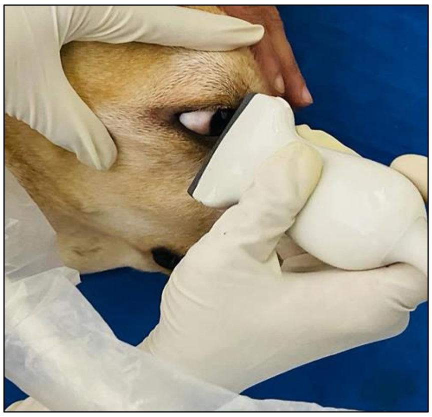

Fig 4: A Labrador retriever adult male in lateral recumbency during ultrasonographic examination. Probe position in vertical plane in trans corneal approach

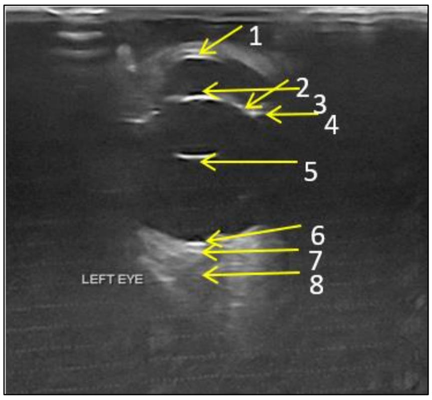

Fig 5: B-Mode ultrasonogram of left normal eye of 3-year-old female golden retriever

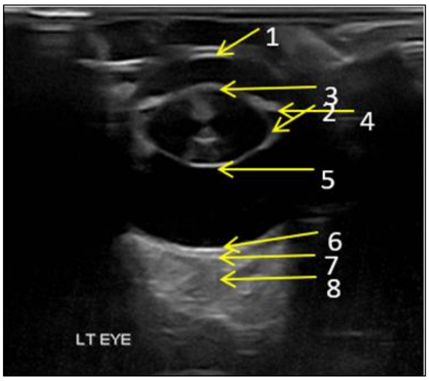

Fig 6: B-Mode ultrasonogram of left cataractous eye of 3-year-old female beagle

1: Cornea, 2: Iris, 3: Anterior lens capsule, 4: Ciliary body, 5: Posterior lens capsule, 6: Sclero-retinal rim, 7: Optic disc and, 8: Optic nerve.

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