Measuring intraocular pressure in selected species using tonometry

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When performing a complete ophthalmoscopic examination, assessment of intraocular pressure (IOP) is crucial as it contributes to the diagnosis of severe ocular diseases, such as glaucoma or uveitis (Di Girolamo et al, 2013).

However, IOP may vary depending on the instrument model used, the examiner's experience, species studied and time of day (Pereira et al, 2011). IOP can be indirectly measured by means of tonometry via indentation (Miller and Pickett, 1992a and 1992b), applanation (Miller et al, 1990 and 1991; Dziezyc et al, 1992; Moore et al, 1993) or rebound techniques, which are particularly suited to the measurement of IOP in species with small ocular globes (such as rats and mice; Munkwitz et al, 2008; Goldblum et al, 2002; Danias et al, 2003).

This article's purpose is to review literature on this topic. For in-depth information, readers are advised to refer to the reference material.

IOP in healthy ferrets

In one study, Di Girolamo et al (2013) determined normal IOP values in 52 conscious, clinically healthy ferrets (30 females and 22 males) by means of rebound tonometry and compared the readings with those obtained via applanation tonometry after application of topical anaesthesia.

Ferrets underwent a complete physical and ophthalmoscopic examination, including slit lamp biomicroscopy and indirect ophthalmoscopy with a 30-diopter or 60-diopter lens. The ferrets were immobilised with gentle physical restraint to prevent iatrogenic IOP alterations, taking care to avoid putting pressure against the globe, eyelids or jugular veins (Klein et al, 2011).

IOP measurements were taken in each eye by means of rebound tonometry first, between 4pm and 7pm, to avoid any aqueous massage by applanation tonometry. The non-species-specific setting was used in this study as the rebound tonometer does not have an internal calibration table for measuring IOP in ferrets.

The rebound tonometer was held near the ferret's eye at an estimated distance of 5mm to 8mm from the central cornea and three readings were performed for each eye, alternatively. Each

reading was the average the instrument automatically performs on six preliminary measurements.

The measurements with the applanation tonometer were performed from 15 to 20 minutes after the rebound tonometry and 1 minute after the application of one drop of topical anaesthetic. IOP measurements were reported in tonometer units (TU), due to the lack of manometric validation of ocular tonometry in ferrets.

Only after manometric calibration can the TUs be related to the millimetres of mercury. In dogs and rabbits, the rebound tonometer proved to be more accurate than the applanation tonometer as a means of measuring IOP (Görig et al, 2006; Kalesnykas and Uusitalo, 2007), whereas, in guinea pigs, a high level of disagreement was present between the two techniques (Coster et al, 2008).

In the present study, rebound tonometry presented a higher repeatability, was better tolerated by ferrets and easier to perform than applanation tonometry. Furthermore, due to the light and rapid contact with the cornea, rebound tonometry obviates the need for topical anaesthesia.

Mean IOPs obtained with the rebound tonometer were 14.07TU ± 0.35TU. The IOP was significantly higher in males than in females. A significant difference in IOP during the 24-hour measurements was also found, with the lowest IOP recorded at 10pm. Mean IOP measured by applanation tonometry was 15.44TU ± 1.11TU.

The two types of tonometers presented poor agreement, and IOP values were not correlated. The difference in IOP estimation increased with the magnitude of the measurements. Applanation tonometry presented a significant higher frequency of per-eye IOP values exceeding 25TU and 30TU, and a significantly lower repeatability compared with rebound tonometry.

IOP in healthy rabbits

In a different study, Pereira et al (2011) measured IOP values in adult healthy rabbits (38 New Zealand white rabbits: 20 males and 18 females) with an applanation tonometer and rebound tonometer, and compared the results obtained with the two devices (**Figures 1 and 2**).

A complete ophthalmoscopic examination was performed and included the Schirmer tear test, slit lamp biomicroscopy, direct ophthalmoscopy and fluorescein staining.

Using minimal head and neck restraint to avoid excessive pressure on eyelids and neck, and without use of systemic anaesthetics or tranquillisers, IOP was measured throughout the day (at 6am, 9am, noon, 3pm and 6pm) on both eyes in each animal using both tonometers.

The rebound tonometer was used first. Ten minutes later, anaesthetic eye drops (proparacaine hydrochloride 0.5%) were instilled and, after 30 seconds, tonometry was performed with the applanation tonometer. The mean IOP was 9.51mmHg ± 2.62mmHg with the rebound tonometer,

and 15.44mmHg ± 2.16mmHg with the applanation tonometer.

A significant difference was observed between measurements with the two tonometers, but the average IOPs from both devices were statistically similar throughout the day. No significant difference in IOP regarding gender was observed.

The authors concluded the applanation tonometer recorded consistently higher levels of IOP with greater variation compared to the rebound tonometer, and, generally, the IOP of rabbits was higher early in the day than later, regardless of tonometer used.

Tonometry on Hermann's tortoises

Ocular pathologies are commonly found in reptile species; therefore, complete ophthalmoscopic evaluation, including determination of IOP values, is of utmost importance to obtain a diagnosis.

Selleri et al (2012) determined IOP values in 26 healthy Hermann's tortoises (*Testudo hermanni*; 13 males and 13 females) with no use of topical anaesthetics. A preliminary ophthalmic evaluation, including slit lamp biomicroscopy and indirect ophthalmoscopy with a 90-diopter lens, did not reveal any ocular abnormalities in study animals. The tortoises were manually restrained in ventrodorsal recumbency and IOP measurements were obtained by means of rebound tonometry between 11am and 2pm to avoid any potential effects of diurnal variation.

A non-species-specific calibration table was used because the rebound tonometer did not have an internal calibration table for measurement of IOP in tortoises.

The rebound tonometer resulted faster and more feasible compared to applanation tonometry, due to the relatively small size of the ocular globe of these tortoises; therefore, the authors recommended the use of rebound tonometry for IOP determination in small to medium-sized tortoises, given the need to reduce manual restraints to prevent possible artefacts caused by pressure of the jugular veins.

The mean ± standard error of mean IOP was 15.74mmHg ± 0.2mmHg (range 9mmHg to 22mmHg). There were no significant differences in IOP between the right and left eyes or between males and females. However, a significant moderate negative correlation was found between IOP and bodyweight. These reference ranges could be extremely useful for clinicians to investigate ocular pathologies and IOP changes in chelonians, especially after hibernation.

Measuring IOP in bearded dragons

IOP has been measured in several reptilian species, but extrapolation from one species to another should be avoided due to interspecies anatomical variations.

Many reptilian species have small globes and ocular anatomical characteristics, such as striated iris musculature or the presence of scleral ossicles, which can cause altered rigidity and form stability that may result in pressure-related ophthalmic disorders and represent a challenge for ophthalmic examination (Williams, 2012).

Schuster et al (2015) evaluated the feasibility of the use of rebound and applanation tonometry for the measurement of IOP in 56 (27 females and 29 males) healthy inland bearded dragons (*Pogona vitticeps*) and assessed the effects of diurnal variation and topical anaesthesia on the IOP in that species.

A complete physical examination, serum biochemical analysis and radiographic examination of the body and skull was performed and animals were deemed healthy.

A complete ophthalmic examination included slit lamp biomicroscopy and fluorescein staining.

Clinical examination of the posterior ocular segment was not possible because of the small size of the pupil, presence of the striated muscles of the iris allowing voluntary control of the pupil size and apparent resistance of this species to conventional mydriatics.

The IOP of both eyes was measured by rebound tonometry (with the animals unrestrained in sternal recumbency and in the evening two to three minutes after one drop of local anaesthetic had been applied to the eyes) and applanation tonometry (two to three minutes after one drop of local anaesthetic had been applied to the eyes and after gentle manual restraint of body and head) between 9am and 10am, 1pm and 2pm, and 5pm and 7pm.

Applanation tonometry was not well tolerated even following topical anaesthesia, did not allow collection of adequate readings and is, therefore, not recommended. Rebound tonometry allows easy, quick measurement without the need for retraining animals.

Median daily IOP as determined by rebound tonometry was 6.16mmHg (range 4.89mmHg to 7.72mmHg) and measurements did not differ significantly between the right and left eyes or between sexes.

The IOP was highest in the morning, which indicates the IOP in this species undergoes diurnal variations, likely affected by environmental temperature rather than dark-to-light alterations.

Topical anaesthesia did not significantly affect IOP, but it did improve the compliance and the tolerance for all subjects.

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