Determination of Intraocular Pressure in Clinically Healthy Turkish Eastern Anatolian Red Cattle of Different Age Groups Using Rebound Tonometry

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ABSTRACT

This study aims to determine the intraocular pressure (IOP) of healthy Turkish Eastern Anatolian Red (EAR) cattle eyes using the iCare® Rebound Tonometer (RT). In addition, we aimed to evaluate whether there is a difference in the IOP values depending for the left or right eyes, time of day, gender, and age of animals. The research was carried out on 42 EAR cattle. The cattle were divided into 3 groups, group I (7 male, 7 female, n=14), group II (7 male, 7 female, n=14), and group III (7 male, 7 female, n=14) 6, 12, 24 months old, respectively. Measurements were performed, in the morning (6:00 a.m.), in the noon, and the evening (6:00 p.m.). The average IOP values for groups I, II and III was 24.51±0.91 mm Hg (*P*=0.520), 24.23±0.87 mm Hg (*P*=0.621) and 23.98±0.82 mmHg (*P*=0.772). According to the findings of this research for the values, the IOP of EAR cattle using the RT no statistically significant differences between right and left eyes, time of day, gender, and age were found for any of the results (*P*>0.05). In this study, the IOP reference value for EAR cattle was determined as 24.24±0.54 mm Hg using RT, regardless of any variable. In addition, this study is the first research article in which the intraocular pressure in Turkish Eastern Anatolian Red cattle was measured by the iCare® Rebound Tonometer.

Keywords: Intraocular pressure (IOP); Rebound tonometer; Cattle.

INTRODUCTION

The assessment of intraocular pressure (IOP) is fundamental in an eye examination and the diagnosis of ocular diseases, such as uveitis and glaucoma (1, 2). The measurement of IOP is made using two basic methods, manometry and tonometry (3, 4). Manometry is an invasive technique that needs anterior camera cannulation/paracentesis and general anesthesia and thus it is not practical for clinical use. Tonometry, noninvasive and indirect measurement of IOP, works on indentation, applanation, or rebound principle and nowadays it is a method of choice for the clinical setting (4, 5). Rebound Tonometer (RT), a recently developed technique, is suited to the measurement of IOP in various animal species. Additionally, the technique minimizes corneal injury as there is only light, short-lasting contact with the cornea during RT. Furthermore the technique prevents the risk of cross-infection due to the use of disposable probes and does not require sedation or topical anesthesia (3, 6-8). Values in IOP have been variable it may vary for the model of the device, researchers' experience, species, age of the animal, and period of the day at which the IOP is measured (2).

Turkish Eastern Anatolian Red (EAR) cattle are one of the native breeds bred in high altitude regions of Turkey, resistant to harsh winter conditions. The breed is an important source of milk and beef (9). In studies to determine the IOP in cattle as a whole, there are reference values of many

cattle breeds. However, the IOP of Turkey's most important cattle breed, the EAR cattle, no pressure reference value have been reported.

The purpose of the study was determination the IOP of healthy EAR cattle eyes using the RT. Futhermore, we aimed to evaluate whether there were differences in the values of IOP in connection to left or right eyes, the period of the day, gender, and age.

MATERIALS AND METHODS

Animals

The study material consisted of a total of 42 healthy Turkish EAR cattle situated at Yazıcı village in the city of Ağrı, Turkey. The cattle were randomly divided into 3 equal groups, a group I (7 male, 7 female, n=14), group II (7 male, 7 female, n=14), and group III (7 male, 7 female, n=14) 6, 12 and 24 months of age, respectively. Before the study, all cattle underwent hematology and clinical chemistry blood tests, ophthalmic examinations including direct and indirect ophthalmoscopy, assessments of the pupillary light reflex, slit-lamp biomicroscopy (Handy Slit Lamp XL-1®), the Schirmer Tear Test Tear Flo, (OASIS Medical, Inc., San Dimas, CA), and the fluorescein staining procedure was performed. Only cattle with healthy eyes were used for the study.

The study was approved by The Animal Experiments Center Ethics Committee at TURKEY (HADMEK 2018).

Tonometry

IOP in both eyes of each cattle was measured with the rebound tonometer TonoVet® (iCare Finland Oy, Vantaa, Finalnd) calibrated in the "p" mode according to the manufacturer's recommended procedures. Cattle were not sedated or topically anesthetized. Measurements were performed randomly three times per day, in the morning (6:00 a.m.), in the noon, and the evening (6:00 p.m.) throughout 7 days by only one investigator (SY). First, the right eye and then the left eye was measured. Measurements were repeated 6 times in every measurement and arithmetic means were taken. The mean calculated IOP values were recorded for each eye.

Statistical analysis

The statistical analysis of the results is determined by SPSS 17,0 program. Comparison between two independent groups was determined by Independent Samples t-Test and comparison among more than two groups is determined by One-way ANOVA to ve Post-hoc Tukey test. Conclusions are presented as mean ± SE. $P<0.05$ was considered significant.

RESULTS

All Turkish EAR cattle were decided healthy based on ocular and physical examination findings and the results of blood tests, which were within reference values reported for the cattle. Statistically significant differences not apparent between mean IOP values of right and left eyes of all cattle and were determined to be 24.34±0.61 mm Hg and 24.15±0.79 mm Hg, respectively ($P=0.850$). The mean IOP values by day in the morning (6:00 a.m.), noon, evening (6:00 p.m) were measured 24.10±0.77 mmHg, 24.70±0.92 mm Hg, and 23.92±0.90 mm Hg, respectively. Although there was no statistical significance, mean IOP values observed decreased in the evening measurement ($P=0.805$). There was no statistically significant difference between the average IOP of males and females all cattle were determined 24.11±0.66 mm Hg and 24.54±0.73 mm Hg, respectively ($P=0.659$). The mean IOP values for groups I (6 months), II (12 months), and III (24 months) were 24.51±0.91 mm Hg, 24.23±0.87 mm Hg, and 23.98±0.82 mm Hg (Table 1), respectively. The mean IOP did not differ significantly for the age of the cattle ($P=0.913$). There was no statistically significant difference reported among IOP values for groups I ($P=0.520$), group II ($P=0.621$), and group III ($P=0.772$). No statistically significant differences between left and right eyes, time of day, gender, and age were found for any of the results (*Independent Samples T-Test*, $P>0.05$).

In this study, the reference IOP for EAR cattle were determined as 24.24±0.54 mmHg due to any variable without, using the iCare® Rebound Tonometer. Ocular problems were not found throughout measurements in the EAR cattle.

DISCUSSION

Reference IOP values measured widely using the iCare® Rebound Tonometer (RT) have been reported in various animal species (2,10,11). RT is a portable hand-held tonometer that does not require any topical anesthesia (7). It records the IOP by detecting the deceleration of a rod probe as it jumps from the cornea. As IOP increased, the rod probe jumped faster than the cornea. This movement is detected

Table 1. Distribution of IOP value (mean±SE) of groups according to the various variables: measurement eye sides, time of day, gender, and age.

Group	Time (Circadian Rhythm)	Gender	Eye Sides	IOP (mm Hg)	MEAN (Right and Left)	MEAN (Male and Female)	ALL TOTAL MEAN	*P*
I		Male	Right	24.28±3.50				
	Morning		Left	24.00±2.83	24.14±2.16			
		Female	Right	24.71±2.22		24.35±1.46		
			Left	24.42±3.63	24.57±2.04			
		Male	Right	25.42±3.92				
	Noon		Left	25.14±4.52	25.28±2.87			
		Female	Right	25.00±2.39		25.21±1.78	24.51±0.91	
			Left	25.28±3.95	25.14±2.22			
		Male	Right	24.14±1.50				
	Evening		Left	23.57±2.52	23.85±1.25			
		Female	Right	24.14±3.33		23.96±1.54		
			Left	24.00±1.00	24.07±2.88			0.520
ANOVA*								*P*
Eye Sides								0.908
Gender								0.928
Time								0.555
II		Male	Right	23.57±2.80				
	Morning		Left	23.71±2.75	23.64±1.88			
		Female	Right	24.71±2.22		24.10±1.36		
			Left	24.42±3.63	24.57±2.04			
		Male	Right	24.42±3.67				
	Noon		Left	24.57±4.70	24.50±2.86			
		Female	Right	25.00±2.39		24.64±1.65	24.23±0.87	
			Left	24.57±2.67	24.78±1.75			
		Male	Right	24.14±1.50				
	Evening		Left	23.57±2.12	23.85±1.25			
		Female	Right	24.14±3.33		23.96±1.54		
			Left	24.00±5.00	24.07±2.88			0.621
ANOVA*								*P*
Eye Sides								0.914
Gender								0.786
Time								0.947
III		Male	Right	23.71±2.49				
	Morning		Left	23.42±2.25	23.57±1.61			
		Female	Right	24.28±1.87		23.85±1.22		
			Left	24.00±3.47	24.14±1.89			
		Male	Right	24.14±3.71				
	Noon		Left	23.85±3.24	24.00±2.36			
		Female	Right	24.57±1.88		24.25±1.40	23.98±0.82	
			Left	24.42±2.75	24.50±1.60			
		Male	Right	23.57±1.73				
	Evening		Left	23.71±2.02	23.64±1.27			
		Female	Right	24.14±3.77		23.85±1.66		
			Left	24.00±5.32	24.07±3.13			0.772
ANOVA*								*P*
Eye Sides								0.920
Gender								0.763
Time								0.976

* There is no significant different between others at $P>0.05$.

by a solenoid inside the device. RT also minimizes corneal damage and prevents the risk of cross-infection by using single-use probes (3, 7, 12, 13).

In the present study, we measured IOP in Turkish EAR cattle using the TonoVet® the iCare® Rebound Tonometer findings a mean value of 24.24±0.50 mm Hg. This value is higher than that (18.8±1.7 mm Hg) of cattle reported with Perkins® by Andrade *et al.* (14), and is less than that (28.2±4.6 mm Hg) for Fresian, Jersey cattle and (27.5±4.8 mm Hg) of Holstein cattle reported with MacKay-Mar® by Gum *et al.* (15). The value is nearer to that (23.4±5.9 mm Hg) of cattle reported with MacKay-Marg® by Kotani (16) and that (26.9±6.7 mm Hg) of Holstein, Friesian, Jersey cattle reported with Tono-Pen XL® by Gum *et al.* (15).

IOP values can be influenced by many factors, such as the model of the measuring tool, the experience of the researchers, the animal species, stress, and the time of the day when the pressure was evaluated (2). In this study, all measurements were made by only one investigator to limit bias and to reduce the stress, the measurements were made *in situ*, and the same helper suitably limited the animals to the neck and eyelids for a short period with minimum pressure.

In studies conducted to determine IOP in different animal species, generally, no statistically significant differences have been reported between right and left eye measurement results (17-23). Unlike these results, in the study by Wang *et al.* (24), twenty-four hours of IOP measurements in rabbits using the RT revealed that the IOP in the right eyes was slightly higher than the left eyes ($F=45.96$, $P<0.001$). In our study mean IOP values of measured as 24.34±0.61 mm Hg in the right eyes and 24.15±0.79 mm Hg in the left eyes with a resultant lack of significant difference between them ($P>0.05$). Our findings supported the conclusion that there is no difference in the IOP values between the right and left eyes. It has been reported that IOP values can be influenced markedly by stress factors including abnormal pressure on the head and neck, disproportional physical constraints, and abnormal body posture during the measurement (2, 4, 25). As reported by the authors, in this present study, during the measurement, we paid great attention to these factors. To avoid individual diversity, all IOP measurement was performed by the same investigator.

There is no consensus on the effect of circadian rhythm on IOP values in animals which may vary according to different times of the day as a result of the circadian rhythm. The β-adrenergic system and circadian rhythms affect the regulation and formation of aqueous humor and thus have been shown to regulate IOP (2, 4). In a study by Ziółkowska *et al.* (26), IOP in goats kept in 12 hours light and 12 hours dark is higher in the morning than in the evening, and that IOP changes from morning to evening were reduced in 24 hours light and 0 hours dark with 24 hours dark and 0 hour light. In the study by Liu *et al.* (7) in Tibetan monkeys, circadian IOP wave was detected. IOP measurements were performed at 9 in the morning, 3 in the evening, and 6 in the evening (just before the lights go out) and at 9 o'clock on the same day. Three days later, IOP values of the same animals were measured at 9 a.m., at midnight, 3 a.m., 6 p.m. (just before switching on the lights) and at 9 a.m., yielding a 24-hour IOP. According to their findings, the IOP values of Tibetan monkeys were usually higher throughout the day and lower at night. They were recorded between 20 and 24 mm Hg. However, a significant IOP increase was reported at noon (29.3±0.9 mm Hg, mean ± SEM, n=12). The lowest IOP value was (19.6±0.8 mm Hg). In a study conducted in New Zealand white rabbits of Wang *et al.* (24) in daylight (7 am to 7 pm), IOP was less in the dark period (8 p.m. to 6 a.m.). In the same way, in another study in rabbits, IOP was recorded to be higher in the morning (27). In contrast, in a study conducted in mice, when they were exposed 12 hours after each of the light and darkness, the IOP fell at noon and then gradually increased from the early hours of the evening to 21:00 (28). Similarly, in marmosets, it was demonstrated that IOP was higher throughout the unlighted phase and lower during the light phase (29). In our research, no statistically significant difference was observed at different times of the day, higher than the average IOP's in times of daylight measurement, including in morning 6:00 a.m. (24.10±0.77 mm Hg), in the noon (24.70±0.92 mm Hg) to compare in evening 6:00 p.m. (23.92±0.90 mm Hg). Contrary to the results of the researchers mentioned above, the reason why we did not see differences between circadian rhythms in our findings may be that the study was conducted in the autumn season. There are 4 seasons in Turkey and the temperature values of the day and the intensities of sunlight change according to the seasons. In the autumn season, there are no obvious differences between daytime air temperature and sunlight intensity. As a result, we believe that there was a lack of significant difference between IOP values between 6 a.m., 12 noon, and 6:00 p.m.

The effects of gender on IOP are debatable. In studies conducted by some authors, it was shown that there was no important statistical difference between IOP values of male and female animals in ferret, lions, apes, and calves (22, 30-33). In another study on lions, gender-related differences in IOP were reported Ofri *et al.* (34). In the study of Wu *et al.* (35), studies on humans have reported higher IOP value in males as compared to females. The present research results in males (24.11±0.66 mm Hg) and females (24.54±0.73 mm Hg) demonstrated no statistical difference ($P>0.05$), following the judgement of most other research studies.

Age-dependent differences in IOP have been reported. Previous studies that investigated the correlation between age and IOP is reported different conclusions. In a study conducted by Ofri *et al.* (34), to investigate the relationship between age and IOP in lions, IOP was measured 33 lions in 5 to 80 months using tonometry. Age was found significantly related to IOP ($P<0.005$). The mean IOP was reported to be 12.8 +/- and 23.9 +/- 4.1 mm Hg in lions aged less than 1 year and greater than 1 year of age respectively. In the first 20 months of life, IOP increased linearly with age, decreasing gradually for about 40 months (r=0.85). Age-based changes in IOP, intraocular dimensions (r> or=0.72) are highly correlated with ultrasonographic measurements and may be a determining factor in developmental ocular growth. Similarly, in the study, Bito *et al*. (30) the mean IOP of *Rhesus* monkeys were found significantly higher of infants and juveniles (7 months to 3 years, 15.7 +/- 2.0 mm Hg; n=33) than that of young adult and adult (less than or equal to 6 years, 14.5 +/- 2.0; n=69). In another study, in two different studies investigating the correlation between age and IOP in *Saanen* goats, IOP was reported to increase with age (1, 36). Similar to the results of *Saanen* goats, the study of Pamuk *et al.* (37), in *Anatolian Buffalo* IOP values are increasing in the parallel of age. On the contrary, research by Gelatt and MacKay (38) in dogs demonstrated a decrease in IOP with increasing age. No statistical difference was reported between different age groups studies in chinchillas and Turkish *awassi* sheep (2, 4). Our study measured IOP values of EAR cattle 6 months (24.51±0.91 mm Hg), 12 months (24.23±0.87 mm Hg), 24 months (23.98±0.82 mm Hg) age with no significant differences ($P>0.05$). We attribute the fact that we did not find any age-related differences in our study, as the study was conducted in a more limited age range.

CONCLUSION

The outcome of this study indicates that no differences in the values of IOP in connection to Turkish EAR cattle left or right eyes, time of day, gender and age. According to the results of this research, the reference IOP for EAR cattle was determined as 24.24±0.54 mm Hg, using the iCare® Rebound Tonometer. Lastly, the iCare® Rebound tonometer was also proven to be a safe diagnostic tool for IOP measurement in EAR cattle.

CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest.

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