

Results of selected ophthalmic diagnostic tests for clinically normal Syrian hamsters (*Mesocricetus auratus*)

Seyed Mehdi Rajaei DVM, DVSC

Maneli Ansari Mood DVM, DVSC

Reza Sadjadi DVM

David L. Williams MA, VetMD, PhD

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From the Department of Clinical Sciences, Faculty of Specialized Veterinary Sciences, Science and Research Branch, Islamic Azad University, Tehran, Iran (Rajaei, Ansari Mood, Sadjadi); and the Department of Veterinary Medicine, University of Cambridge, Cambridge, CB3 0ES, England (Williams). Dr. Rajaei's present address is Department of Clinical Sciences, College of Veterinary Medicine, Karaj Branch, Islamic Azad University, Alborz, Iran.

Address correspondence to Dr. Rajaei (mehdi_13r@hotmail.com).

OBJECTIVE

To determine values for tear production, horizontal palpebral fissure length (HPFL), eye blink frequency, and intraocular pressure (IOP) in healthy Syrian hamsters (*Mesocricetus auratus*).

ANIMALS

40 healthy adult Syrian hamsters (80 eyes).

PROCEDURES

Tear production was measured with the phenol red thread test (PRTT), modified Schirmer tear test (mSTT), and endodontic absorbent paper points tear test (EAPPTT). The IOP was measured by use of rebound tonometry. Correlations between test results and body weight were evaluated.

RESULTS

Mean \pm SD values for the IOP, PRTT, EAPPTT, mSTT, HPFL, and blink frequency for all 80 eyes were 4.55 ± 1.33 mm Hg, 5.57 ± 1.51 mm/15 s, 4.52 ± 1.55 mm/min, 2.07 ± 0.97 mm/min, 5.84 ± 0.45 mm, and 1.68 ± 0.43 blinks/min, respectively. For all variables, values did not differ significantly between the right and left eyes or between males and females. There was no correlation between measured variables and body weight.

CONCLUSIONS AND CLINICAL RELEVANCE

Results for this study provided information on values for the IOP, PRTT, mSTT, EAPPTT, HPFL, and eye blink frequency in healthy Syrian hamsters. It was important to determine reference intervals for this species because they commonly are kept as pets or used as research animals. (*Am J Vet Res* 2016;77:72–76)

The tear film is vital to the physiologic function of eyes and is essential for the maintenance of corneal clarity. It serves as the cranial refracting surface of the eye and provides nutrition for the corneal surface.^{1,2}

The importance of tear film evaluation during assessment of ocular health has long been recognized. Tear film tests are categorized as quantitative tests that are used to evaluate the volume of tear film or qualitative tests that are used to assess quality of tear film. Quantitative tests for the evaluation of tear film include the STT, PRTT, and EAPPTT.

In clinical veterinary practice, quantitative clinical evaluation of the precorneal tear film is most frequently limited to use of the STT because published standard values for the STT in domestic species are accepted and clinically useful for the identification of

quantitative tear film deficiencies.² Small domestic, wild, and exotic animals have a small palpebral fissure length; thus, narrow (2.5 and 4 mm wide) mSTT strips have been recommended for measurement of tear production in these animals.³

The PRTT was developed for use because of variable results, poor repeatability, and low sensitivity of the STT for detecting inadequate tear production in humans.⁴ It is performed by placing a 75-mm-long cotton thread impregnated with pH-sensitive phenol dye (which changes from yellow to red when it absorbs tears that are slightly alkaline) in the ventral fornix of an eye for 15 seconds.²

The EAPPTT was proposed in 2012 as a new method for tear film assessment.⁵ Standardized endodontic absorbent paper points are commonly used in dentistry because their highly absorptive properties promote drying after irrigation, allow carriage of medicants (eg, antiseptics and disinfectants), and assist in collection of samples for microbiological culture.^{5,6} They also can be used as an alternative method for tear film measurement. For those measurements, 1 standardized absorbent paper point is inserted in the ventral conjunctival fornix of an eye

ABBREVIATIONS

EAPPTT	Endodontic absorbent paper points tear test
HPFL	Horizontal palpebral fissure length
IOP	Intraocular pressure
mSTT	Modified Schirmer tear test
PRTT	Phenol red thread test
STT	Schirmer tear test

and allowed to remain there for 1 minute; the paper point is then removed, and the wet portion is measured by use of a digital calipers graduated in millimeters.

Intraocular pressure is controlled and regulated by the CNS, which maintains a balance between aqueous humor production and outflow.^{7,8} Assessment of IOP is a critical component of a complete ophthalmic examination because an abnormally high or low IOP is evidence of ocular disease, such as glaucoma or uveitis.⁹

The purpose of the study reported here was to determine tear secretion by use of the mSTT, PRTT, and EAPPTT and to measure IOP by means of rebound tonometry in the eyes of healthy adult Syrian hamsters (*Mesocricetus auratus*). Additionally, HPFL and eye blink frequency were evaluated because these 2 variables could directly affect measurement of tear production and spread of the tear film.¹⁰

Materials and Methods

Animals

The study population consisted of 40 healthy adult Syrian hamsters (21 males and 19 females). Animals were housed indoors beginning 7 days before the first day of testing; Syrian hamsters were housed separately in labeled cages in an air-conditioned room with a constant temperature (20° to 22°C) and relative humidity (50% to 55%). The lighting cycle consisted of 12 hours of light and 12 hours of darkness. Animals were fed a commercial diet formulated for hamsters, and water was available ad libitum. The study was approved by the Iran Society for Prevention of Cruelty to Animals in accordance with the Iranian Ethical Code for Studies on Laboratory Animals.

Procedures

A complete physical examination and ophthalmoscopic examination that included direct and indirect ophthalmoscopy,^a fluorescein staining,^b and slit lamp biomicroscopy^c were performed. All the animals were included in the study on the basis that no abnormalities were detected during the physical and ophthalmic examinations.

A PRTT,^d EAPPTT,^e and STT^f were performed. Each test was produced by a single manufacturer and was from the same batch with a single lot number. A sequence of procedures was performed on each Syrian hamster. Eye blink frequency and IOP were assessed on day 1, the PRTT was performed on day 3, the EAPPTT was performed on day 5, and the mSTT and HPFL were assessed on day 7. On day 14, complete physical and ophthalmoscopic examinations were performed on all Syrian hamsters.

One investigator (SMR) conducted all ocular tests, examinations, and measurements. All tests were conducted between 4 PM and 6 PM to minimize possible variations associated with diurnal changes.

Eye blink frequency was counted. Each animal was placed in a cage that was made of clear plastic, which was intended to provide familiar surroundings. Syrian hamsters were not restrained or handled during counting. Two investigators (SMR, MAM), 1 located on each side of the cage, counted the number of eye blinks during a 5-minute period. The mean value for the 2 investigators was calculated and used for statistical analysis.

For IOP measurement, animals were physically restrained without any pressure applied to the eyelids or neck. One of the investigators grasped a Syrian hamster by the nape of the neck between a thumb and forefinger and simultaneously maintained a grip on the tail and supported the animal's body against the palm of the other hand; a second investigator then obtained IOP values. Protrusion of the eyeballs was not observed during tonometry. A tonometer^g with a disposable probe was held horizontally perpendicular at a distance of 4 to 5 mm from the central corneal surface. The device was calibrated by use of the p setting. Six consecutive measurements were obtained. The series of measurements was repeated until the tonometer indicated that there was an acceptable SD for the 6 measurements. The procedure then was repeated for the contralateral eye.

To measure the aqueous portion of the tear film, the ventral eyelid of each Syrian hamster was everted. A 3-mm folded head of a phenol red cotton thread was placed into the ventral conjunctival fornix and allowed to remain there for 15 seconds. The thread was then removed, and the portion of the thread that had changed from yellow to red was immediately measured.

To measure the aqueous tear volume with the EAPPTT, 1 absorbent paper point was inserted in the ventral conjunctival fornix of each eye and allowed to remain there for 1 minute. Each paper point was then removed, and the wet portion was immediately measured by use of a digital calipers.

The mSTT strips were obtained by longitudinal dividing standard (35 mm in length and 5 mm in width) commercial STT strips aseptically with a scalpel blade and stainless steel ruler to yield 2 strips that were 35 mm in length and 2.5 mm in width. Forceps were used to insert an mSTT strip in the ventral conjunctival fornix. Strips were allowed to remain in the fornix for 1 minute. Strips then were removed, and the wet portion was measured. Because of the small amount of tears in most of the eyes, the notch of the mSTT strip often was not reached; thus, the distance from the end of a strip to the point at which the strip was wet was measured, rather than measuring the length of the wet strip beginning at the notch as is conventional for other species.¹¹

For measuring HPFL, the distance between the inner end of the ocular caruncle and the temporal canthus (termed the palpebral fissure length) was measured. Measurements were obtained by use of a waterproof digital caliper with a liquid-crystal display screen.^h

Statistical analysis

Statistical analysis was performed by use of a statistical software program.¹ A 1-sample Kolmogorov-Smirnov test was used to assess data normality. Paired sample *t* tests were used to compare IOP, PRTT, EAPPTT, mSTT, and HPFL values obtained for the right and left eyes. Mean and SD were calculated for all the eyes and for right and left eyes separately. An independent sample *t* test was used to compare mean IOP, PRTT, EAPPTT, and mSTT values for sex and body weight. A Pearson correlation analysis was used to evaluate the relationship between body weight and mean IOP, PRTT, EAPPTT, mSTT, and HPFL. Values were considered significant at $P < 0.05$.

Results

Ocular discomfort was not observed in any of the Syrian hamsters for up to 7 hours after measurements were obtained during the study. No signs of conjunctivitis, keratitis, blepharitis, corneal ulcers, or intraocular disease were detected in any of the Syrian hamsters.

All the continuous numeric data obtained for the study were normally distributed as determined by use of the 1-sample Kolmogorov-Smirnov test ($P > 0.2$). Mean \pm SD body weight for all Syrian hamsters was 83.40 ± 18.20 g (range, 42.2 to 122.0 g). Mean body weight of females and males was 83.13 ± 15.61 g and 83.81 ± 20.76 g, respectively (Table 1). Mean values for IOP, PRTT, EAPPTT, and mSTT for all 80 eyes were 4.55 ± 1.33 mm Hg, 5.57 ± 1.51 mm/15 seconds, 4.52 ± 1.55 mm/min, and 2.07 ± 0.97 mm/min, respectively. We did not detect significant differences in values between the right and left eyes or between males and females.

A correlation ($r = 0.541$; $P = 0.014$) was detected between PRTT and EAPPTT values but not between PRTT and mSTT values or between EAPPTT and mSTT values. Moreover, there was no correlation between the measured variables and body weight of the Syrian hamsters.

Discussion

A paucity of information exists on ocular variables for wild and exotic animals because of the large number of species involved.¹⁰ Some wild and exotic species

are maintained as pets, whereas others are used as research animals. Regardless of their use, good veterinary care must be provided for each species, and reference intervals need to be determined for physiologic variables before diagnosis of abnormal conditions is possible. This is particularly true for ophthalmic examination.

Syrian hamsters are desert-dwelling species. Low tear production may be a fluid conservation mechanism for animals living in arid areas.¹² Nevertheless, low tear production by Syrian hamsters is adequate to protect the ocular surface.¹³ In contrast to results of a previous study¹³ on tear production by Syrian hamsters in which investigators found a significantly increased PRTT value for male animals, compared with results for female animals, no significant difference was found between PRTT values of the males and females in the present study.

The mean \pm SD EAPPTT for Wistar rats (*Rattus norvegicus*) and Swiss Webster mice (*Mus musculus*) is 6.18 ± 2.06 mm/min and 4.39 ± 1.45 mm/min, respectively.¹⁰ The mean EAPPTT for Syrian hamsters in the present study was slightly higher, compared with values for the mice of that other study.¹⁰

Another alternative quantitative tear test is the mSTT, which has been used in dogs,^{14,15} birds,¹⁶ rhesus monkeys (*Macaca mulatta*),¹⁷ black-tufted marmosets (*Callithrix penicillata*),⁵ and red-ear sliders (*Trachemys scripta elegans*).¹⁸ In the present study, STT values for Syrian hamsters were exceptionally low, which made it difficult to evaluate tear production by use of this method. A more precise measurement was possible with the mSTT. The mSTT has been used in birds¹⁶; however, the strips used in that study¹⁶ were only 2 mm wide.

During STT measurement, the filter paper strip absorbs all the tears produced as well as those comprising the tear film. Once the tear film has been absorbed, tear uptake by the test strip equals tear production by the lacrimal and Harderian glands.¹⁹

In the present study, results for the PRTT and EAPPTT were positively correlated, and volume of fluid measured by use of the PRTT and EAPPTT was small. We postulate that the PRTT and EAPPTT were measuring tear volume in the conjunctival sac rather

Table 1—Mean \pm SD and range for ophthalmic variables measured in both eyes of each of 40 Syrian hamsters (*Mesocricetus auratus*).

Variable	Mean \pm SD			Range		
	All (n = 40)	Male (n = 21)	Female (n = 19)	All (n = 40)	Male (n = 21)	Female (n = 19)
IOP (mm Hg)	4.55 \pm 1.33	4.90 \pm 1.41	4.20 \pm 1.22	2–8	2–8	2–7
mSTT (mm/min)	2.07 \pm 0.97	2.09 \pm 1.15	2.05 \pm 0.76	0–5	0–5	0–4
PRTT (mm/15 s)	5.57 \pm 1.51	5.15 \pm 1.56	6.00 \pm 1.41	3.0–10.0	3.0–7.5	4.5–8.5
EAPPTT (mm/min)	4.52 \pm 1.55	4.40 \pm 1.48	4.65 \pm 1.68	2–7	3–7	2–7
HPFL (mm)	5.84 \pm 0.10	5.87 \pm 0.49	5.81 \pm 0.50	5.16–6.72	5.32–6.70	5.16–6.72
EBF (blinks/min)	1.68 \pm 0.43	1.66 \pm 0.53	1.70 \pm 0.35	1.2–2.4	1.2–2.4	1.4–2.4
Body weight (g)	83.40 \pm 18.20	83.81 \pm 20.76	83.13 \pm 15.61	42.2–122.0	42.2–122.0	51.0–105.0

EBF = Eye blink frequency.

than assessing de novo tear production by the lacrimal glands.

The HPFL for Wistar rats and Swiss Webster mice is 6.45 ± 0.09 mm and 3.59 ± 0.27 mm, respectively.¹⁰ Adult Syrian hamsters of the present study had a larger HPFL than did mice of similar body weight. It is worth mentioning that the ease with which globes prolapse with handling of hamsters is related to the longer lid aperture.

Measurement of IOP is important for evaluation of ocular health. Reference IOP values for mice and rats have been obtained with a rebound tonometer.^j Mean \pm SD IOP of conscious rats is 18.4 ± 0.1 mm Hg.²⁰ Mean IOP differs among strains of mice (10.6 ± 0.6 mm Hg for Balb/c mice, 13.3 ± 0.3 mm Hg for C57-BL/6 mice, and 16.4 ± 0.3 mm Hg for CBA mice).²⁰ Mean IOP determined by use of a rebound tonometer^g in New Zealand White rabbits is 9.51 ± 2.62 mm Hg.²¹ The mean IOP of 4.55 ± 1.33 mm Hg for Syrian hamsters of the present study was significantly lower than values measured in mice, rats, and rabbits. Differences in handling and restraint of animals, time of day, and position of the body or head could have been responsible for the difference between IOP of Syrian hamsters and IOP of other rodents; however, in the authors' opinion, such factors are unlikely to result in such a marked difference. The low IOP in Syrian hamsters requires further evaluation.

A comparison of 2 types of rebound tonometers^{g,j} has been performed for chinchillas²² and red-ear sliders.²³ The rebound tonometer^j for laboratory animals may be more accurate than the veterinary rebound tonometer^b used for red-ear sliders.²³ However, no significant differences were observed in IOP of chinchillas for the various models of rebound tonometer.²² In the present study, IOP was obtained by use of a veterinary rebound tonometer^g with the device calibrated by use of the p setting. Use of a veterinary rebound tonometer^g would appear to be most appropriate owing to its widespread availability as a diagnostic device in veterinary clinics.

Contact between the cornea and probe rarely causes a corneal reflex in dogs.²⁴ Similar to results for Hermann's tortoises (*Testudo hermanni*),²⁵ impact of the probe invariably induced a blink reflex in the Syrian hamsters during the study reported here. Although this discrepancy may be attributed to the size of the ocular globe of Syrian hamsters, interspecies differences in corneal innervation cannot be excluded.²⁵

Eye blink frequency of Syrian hamsters in the present study ranged from 1.2 to 2.4 blinks/min. Eye blink frequency of guinea pigs is 2 to 5 blinks/20 minutes.¹¹ Eye blink frequency of dogs, cats, horses, cattle, black-tufted marmosets, and pigs is 3 to 5 blinks/min,²⁶ 1 to 5 blinks/5 minutes,²⁶ 5 to 25 blinks/min,²⁶ 5 blinks/min,²⁶ 3 to 5 blinks/min,⁵ and approximately 10 blinks/min,²⁶ respectively. Blinking maintains the physiologic thickness of the precorneal surface by spreading tears over the corneal surface.²⁷

The study reported here provided reference values for ophthalmic examinations of adult Syrian ham-

sters. The IOP was measured by means of rebound tonometry, and tear production was assessed by use of a number of tests.

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Footnotes

- a. Binocular indirect ophthalmoscope, Welch Allyn Inc, Skaneateles Falls, NY.
- b. Fluorescein Glostrips, Nomax Inc, St Louis, Mo.
- c. PSL portable slit lamp, Reichert Inc, Depew, NY.
- d. Zone-Quick, Menicon America Inc, San Mateo, Calif.
- e. Roeko color, number 30, Coltene/Whaledent GmbH & Co KG, Langenau, Germany.
- f. Opstrip, Ophtechnics Inc, Haryana, India.
- g. TonoVet, Icare, Tiolat, Helsinki, Finland.
- h. IP54, 0-150 mm, resolution, 0.01 mm, Guanglu, Guilin, China.
- i. IBM, SPSS version 17.0 for Windows, SPSS Inc, IBM Co, Chicago, Ill.
- j. TonoLab, Icare, Tiolat, Helsinki, Finland.

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