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Journal

American Journal of Veterinary Research, 55(4)

ISSN

0002-9645

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Publication Date

1994-04-01

Peer reviewed

Reprinted from the AMERICAN JOURNAL OF VETERINARY RESEARCH, Vol. 55, No. 4, Pages 477-479.

A-1110

Tonometry of normal eyes in raptors

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Summary

An applanation tonometer was used to estimate intraocular pressure in normal eyes of several species of raptors. No bird had active injury or illness, though some were nonreleasable to the wild because of previous injury. Mean (± SD) intraocular pressure was 20.6 (± 3.4) mm of Hg in red-tailed hawks (*Buteo jamaicensis*, n = 10), 20.8 (± 2.3) mm of Hg in Swainson's hawks (*Buteo swainsoni*, n = 6), 21.5 (± 3.0) mm of Hg in golden eagles (*Aquila chrysaetos*, n = 7), 20.6 (± 2.0) mm of Hg in bald eagles (*Haliaeetus leucocephalus*, n = 3), and 10.8 (± 3.6) mm of Hg in great horned owls (*Bubo virginianus*, n = 6). There was no significant difference in intraocular pressure between hawks and eagles. Mean pressure in great horned owls was significantly ($P < 0.01$) lower than pressure in hawks or eagles. Reliable intraocular pressure readings could not be obtained in barn owls (*Tyto alba*).

Using the MacKay-Marg and Tono-Pen applanation tonometers, values for intraocular pressure in normal eyes of dogs, cats, horses, ferrets, rats, and cows have been reported.[1-8] To the authors knowledge, studies of tonometry in raptors have not been reported, although ocular disease in raptors is common.[9-13] Although there are no reports of glaucoma in raptors, ocular disease or trauma may alter intraocular fluid dynamics and increase or decrease intraocular pressure. The objective of the study reported here was to estimate intraocular pressure as measured by use of the Tono-Pen applanation tonometer in normal eyes of several species of raptors.

Materials and Methods

Birds—Birds studied were housed at the University of California, Davis Raptor Center. They had been previously free-living and had been brought to the center because of injury or illness. All birds studied had recovered from injury or illness. Most were long-term residents because of injuries that had left them nonreleasable to the wild. A few were being conditioned for release at the time of the study. Criteria for inclusion in the study were that: at least 3 birds representative of the species be available for examination, none of these birds have active injury or illness, and ophthalmic examination results be considered normal for at least 1 eye (preferably 2 eyes) of each bird. All birds examined were adults, with the exception of 1 bald eagle that was a juvenile (between 3 and 5 years old). Sex of the birds was not known.

Several species were evaluated, including red-tailed hawks (*Buteo jamaicensis*), Swainson's hawks (*Buteo swainsoni*), golden eagles (*Aquila chrysaetos*), bald eagles (*Haliaeetus luecocephalus*), great horned owls (*Bubo virginianus*), and barn owls (*Tyto alba*).

Ophthalmic examination—Birds were manually restrained, and slit lamp biomicroscopy and direct ophthalmoscopy examinations were performed. If there was evidence of ocular disease or previous trauma, the affected eye was eliminated from the study. After examination, proparacaine,[a] a topical anesthetic, was applied to the cornea, followed by tonometry.[b] Three readings from each eye were obtained, each reading being an averaged value of several corneal touches having a variance of ≤5%. The tonometer was applied to the lateral aspect of the cornea approximately 5 mm from the lateral limbus in all birds, except great horned owls, to minimize the bird's visualization of the instrument which frequently results in excursions of the third eyelid. In great horned owls, which have a larger corneal diameter than do the other raptors studied, the tonometer was applied approximately 10 mm from the limbus. All readings were obtained between 9 AM and 12 PM to minimize diurnal fluctuations in intraocular pressure as a variable. All examinations and tonometry readings were obtained by one investigator (JS). The tonometer was <1 year old and, thus, was considered to still be under valid calibration specifications of the manufacturer.

Analysis of data—Data were available for 20 eyes of 10 red-tailed hawks, 12 eyes of 6 Swainson's hawks,

Received for publication May 24, 1993.
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The authors thank Drs. Theresa Morishita and Dale Brooks and the University of California-Davis Raptor Center for assistance.

[a] Alcaine, Alcon, Humacao, Puerto Rico.
[b] Tono-Pen XL, Bio-Rad Laboratories, Santa Ana, Calif.

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14 eyes of 7 golden eagles, 5 eyes of 3 bald eagles, and 10 eyes of 6 great horned owls. Measurements of intraocular pressure were attempted on 17 eyes of 9 barn owls as well, but reliable readings could not be obtained in this species.

The data were statistically evaluated by the use of ANOVA for a repeated-measures design. The within-subject factors were eye (right vs left) and replication (first, second or third tonometry reading). Multiple pairwise comparisons of the mean pressure values from each eye and from each bird (2 eyes combined) of each species, using Tukey's procedure, were evaluated to determine the nature of observed species effects. Data were considered statistically significant at $P \leq 0.05$.

Results

Mean (± SD) pressures and ranges of pressures for all birds studied were obtained (Table 1). There was no significant difference between the right and left eyes or between the first, second, or third tonometry reading in any species. There was no significant difference in intraocular pressures between hawks and eagles. There was a highly significant ($P < 0.01$) difference between the mean pressures for the great horned owls and those for the hawks and eagles.

Data from tonometry readings in barn owls were so inconsistent and erratic that no meaningful information could be obtained. It was the subjective impression of the investigator performing tonometry that the eyes of barn owls had pressure similar to that of great horned owls and lower than that of hawks or eagles.

Discussion

The Tono-Pen applanation tonometer has become a popular instrument for estimating intraocular pressure because of its ease of use and acquisition of clinically reliable readings in many species.[1-7] The small corneal diameter of many raptor species precludes use of a large instrument, such as the Schiøtz indentation tonometer or, possibly, even the medium-size head of the Mackay-Marg applanation tonometer. Excursion of the third eyelid in raptors occurs several times a minute, and becomes a prominent reflex action when the birds visualize an object approaching the eye. The Tono-Pen has a smaller surface area and requires only light corneal touches, making it a suitable instrument for use in birds with small corneal diameter and rapid third eyelid responses. The Tono-Pen is designed to take several readings and average them into a final value that is displayed on the instrument along with the range of coefficient of variance (5, 10, 20, or > 20%). The manufacturer recommends accepting as valid only readings with ≤ 10% variance.

Table 1—Intraocular pressure (IOP) for various raptor species

Species	No. of birds	No. of eyes	IOP for all birds (mm of Hg)*	Range
Red-tailed hawk	10	20	20.6±3.4	17 to 30
Swainson's hawk	6	12	20.8±2.3	18 to 24
Golden eagle	7	14	21.5±3.0	14 to 26
Bald eagle	3	5	20.6±2.0	16 to 21
Great horned owl	6	10	10.8±3.6†	5 to 16

* Data are expressed as mean ± SD. † Significant difference from hawks and eagles at $P \leq 0.01$.

The inability to gather meaningful data in barn owls was unexpected. Seventeen eyes from 9 birds were evaluated on 2 occasions. In general, the tonometer would not average readings because they varied too greatly. When a reading with ≤ 5% variance was obtained, it often differed markedly from the next reading in the same eye, thus preventing reliable assessment of intraocular pressure in this species. Even use of the Tono-Pen manufacturer's recommendation to accept values with ≤ 10% variance did not result in consistent and reliable readings in the barn owl. We tried to pinpoint the problem by using a different handler and reevaluating all birds on a different occasion, but the erratic readings persisted. The behavioral and conformational characteristics of barn owls made them more difficult to handle in a consistent manner, compared with the other raptors examined, and this may have had a role in the widely variable intraocular pressures recorded. Although rapid pupillary excursions were not observed in this species, it may be that a physiologic process resulting in rapid change of aqueous humor dynamics could exist in this species, resulting in changing intraocular pressures. Wide variations in intraocular pressure measurements, using the Tono-Pen, have been reported in the eyes of living horses.[5]

Hyphema has been reported to be the most common abnormal finding on ocular examination of raptors.[9] Our experience also suggests hyphema to be a common finding, particularly in owls. Hyphema has the potential to compromise the iridocorneal angle and alter the flow of aqueous humor, thus changing intraocular pressure. Our data provide a basis for evaluating the effects on intraocular pressure in these instances, as well as for assessment of the eyes of raptors in general.

Lower intraocular pressure in great horned owls, compared with other raptors studied, may be related to several factors. Anatomically, the eye of owls is different in size and shape than is the eye of hawks or eagles. The corneal curvature and rigidity differ in owls, compared with hawks and eagles, and may contribute to altered readings with the Tono-Pen, which is an instrument designed for the human eye. The lower readings seen in owls also could be related to the fact that they were the only nocturnal bird providing data in this study. If diurnal fluctuations in pressure exist in this species, a lower value might be expected during the morning hours when they would not be active. This type of diurnal fluctuation in intraocular pressure has been observed in cats, another nocturnal species.[14] Further studies, including evaluations at night, would be needed to determine whether diurnal fluctuations exist.

Estimates of intraocular pressure in raptors by use of the Tono-Pen may not reflect actual intraocular pressures in the species reported. The instrument is designed for use in human beings and, therefore, cannot be directly extended to other species. In ad-

dition, intraocular pressure measurements can vary depending on the tonometer and the tonometrist and even the same model of tonometer may yield significantly different results.[1] This study was intended to estimate pressures in various raptor species, using the Tono-Pen, because it is an instrument highly suitable for use in birds. Given the small number of birds available for inclusion in this study, the values stated are not intended to be representative of intraocular pressures in the species in general, but to give a starting point and frame of reference for future studies of intraocular pressures in birds of prey.

With the finding of a lower intraocular pressure in great horned owls, compared with other species in this study, it is clear that interspecies extrapolations of normal pressures might not be reliable. It is hoped that other investigators will report tonometry values for normal eyes of raptor species. Once tonometry values for normal eyes of raptors are known, comparisons with those obtained for birds with ocular disease may be of prognostic or therapeutic value.

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