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Change in intraocular pressure during maturation in Labrador Retriever dogs

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Abstract

Objective To measure intraocular pressure (IOP) in a group of dogs as puppies and young adults to determine if there is any change during maturation.

Animals studied Thirty-two healthy Labrador Retriever dogs.

Procedures Intraocular pressure was measured using a Tonopen XL initially at approximately 6 weeks of age (T1), then again approximately 1 year later (T2). Exact ages were known based on whelp date.

Results The dogs had marginally higher IOP OU at T2 (mean = 14.9 mmHg) compared to T1 (mean = 13.4 mmHg). However, the difference was not statistically significant. No differences were seen based on sex and litter. Intraocular pressure OD was statistically greater than OS at T1 but not at T2.

Conclusions Normal values for intraocular pressure are the same in puppies and adults. The results of this study do not support the previously suggested theory that younger dogs have sustained increased IOP as a requirement to drive growth of the globe. However, it does not rule out the possibility that a dynamic relationship between intraocular pressure and expansion of the globe may exist.

Key Words: dog, intraocular pressure, Labrador Retriever, maturation

INTRODUCTION

Intraocular pressure (IOP) is commonly measured during ophthalmic examination. Excessive elevation of IOP usually defines glaucoma, which is a serious vision-threatening ocular condition. The reported normal range in the dog is approximately 16.7 ± 4.0 mmHg.[1] Glaucoma in the dog is usually of acute onset with profound clinical signs such as vision loss, corneal edema, mydriasis, and episcleral injection. Mild elevations in IOP usually cause no observable clinical signs but could precede clinical disease. Because of these serious consequences, establishing normal values for intraocular pressure is critical.

Normal IOP values are known to vary among species,[2,3] but no difference among dog breeds has been documented.[4] Also, a diurnal effect has been detected in both normal and glaucomatous Beagles, with IOP being greater in the morning compared with early evening.[5]

Previous reports indicated that IOP varies with age. Many studies in humans have demonstrated higher IOP in immature vs. mature individuals; however, some showed the opposite.[6–11] Previous work in the Samoyed dog, Rhesus monkey, and American alligator demonstrated higher IOP in younger individuals.[12–14] It has been theorized that relatively increased IOP in young animals may serve to drive growth of the globe.[14] The purpose of this study was to evaluate IOP at different ages in Labrador Retriever dogs to determine if IOP changes during maturation.

MATERIALS AND METHODS

Thirty-two Labrador Retriever puppies from several litters received ophthalmic examinations for evaluation as prospective service dogs (Guide Dogs for the Blind, San Rafael, CA) (T1). There were 19 males and 13 females. There were 10 litters with a range of 1–8 members per litter, and the median was 5. All puppies were approximately 6 weeks of age; precise ages were known based on whelp date. The pupils were pharmacologically dilated with 1% tropicamide, then biomicroscopy and indirect ophthalmoscopy were performed. Next, 1% proparacaine was instilled and IOP was measured using a Tonopen XL. Examinations and measurements were performed between 9 and 11 a.m. The left eye was always measured first, and measurements were made by the same person. Measurements were repeated until the instrument per cent error was < 5%. Ophthalmic examination and IOP measurement were repeated approximately 1 year later (T2).

Mean and standard deviation of IOP measurements were calculated separately for each eye (OD, OS) and for both eyes (OU) at each evaluation. Differences in IOP between sex or litter groups were evaluated using the Student's *t*-test. Differences in IOP between T1 and T2, and between OD and OS at a given evaluation, were assessed by paired Student's *t*-test. Values of $P < 0.05$ were considered significant.

RESULTS

Ages are shown in Table 1; IOP data are shown in Tables 2 and 3. IOP at T2 was greater than T1 for OD, OS and OU. The mean difference between OU IOP measured at T2 and OU IOP measured at T1 for a given dog was 1.4 (± 2.7) mmHg. However, there was insufficient statistical evidence that the difference in IOP OU between T1 and T2 was significantly greater than 1 mmHg ($P = 0.18$). The mean difference between OD and OS at T1 was 1.16; OD was statistically greater than OS ($P < 0.01$). At T2, IOP OD was greater than OS (mean difference = 0.66 mmHg), but this difference was not statistically significant ($P = 0.13$). No differences were observed based on sex.

One litter ($n = 7$) which had a comparatively low IOP at T1 and an average IOP at T2, resulting in a relatively large positive change in IOP, was significantly greater ($P = 0.047$) than two other litters. As significant differences attributed to litter may have been confounded by differences in age, change in IOP was evaluated in a multiple linear regression model that included both litter and age as covariates; neither factor was significantly associated with change in IOP. However, nearly complete colinearity between litter and age precluded further delineation of the independent effects of these factors on IOP.

Table 1. Ages (days) of Labrador Retriever dogs ($n = 32$) at initial (T1) and follow-up (T2) ophthalmic evaluations

	Mean	Median	Range
T1	46.2 ± 4.7	45	40–57
T2	409 ± 4.7	408	403–420

Table 2. Mean (± SD) intraocular pressure (IOP in mmHg) measured in Labrador Retriever dogs ($n = 32$) at approximately 6 weeks (T1) and 14 months (T2) of age

	T1	T2
OD IOP	14.0 ± 2.2	15.2 ± 2.3
OS IOP	12.8 ± 1.9	14.5 ± 2.4
OU IOP	13.4 ± 1.9	14.9 ± 2.0

Table 3. Mean difference (△) in intraocular pressure (IOP in mmHg) measured in Labrador Retriever dogs ($n = 32$) at approximately 6 weeks and 14 months of age.

	One-sided *P*-values			
	△ ± SD mmHg	△ > 0 mmHg	△ > 1 mmHg	△ > 2 mmHg
OD IOP	1.2 ± 3.1	0.020	0.37	0.92
OS IOP	1.7 ± 2.7	0.001	0.08	0.74
OU IOP	1.4 ± 2.7	0.002	0.18	0.88

DISCUSSION

This is the first published study controlled for sex, breed, litter and evaluator, in which IOP was measured in the same individuals both as puppies and later as young adults. In the group of dogs studied here, IOP at approximately 14 months of age was marginally (less than 2 mmHg) greater than at 6 weeks of age. Thus, the results of this study suggest that there are no significant changes in IOP (with a tendency to increase) in Labrador Retriever dogs within the first developmental year. An important clinical conclusion is that the range of normal IOP in puppies and adult dogs is the same. The range of pressures identified in this study was somewhat lower than in a previous study measuring IOP in normal dogs (19.2 ± 5.9 mmHg) also using the Tonopen instrument.[4]

IOP was higher OD compared with OS at T1. Also, IOP at T2 was higher than that at T1. In both cases the difference was less than 2 mmHg. Normal values for IOP are reported as a range rather than absolute values. Thus, it is likely that these differences have no clinical significance. Furthermore, we know of no logical reason for IOP to be greater in one eye than another in the same healthy individual.

Because IOP can be affected by many physical factors, vigorous attempts were made to ensure consistency of the measurements. The animals were all relatively calm, and this was assumed to negate any effect on IOP by rough handling or overactive behavior. All measurements were taken within 15–30 min after tropicamide was instilled, thus all eyes exhibited maximal pharmacologic mydriasis. All animals had OS measured first, were measured at approximately the same time of day (within 3 h), and were measured at approximately the same time of year. The latter two items should negate any effect of circadian rhythm. Furthermore, the Tonopen has been validated for repeatability in a study in children.[15]

In the embryo, early production of aqueous humor establishes pressure within the optic cup greater than that surrounding the embryo. Experimental studies offer evidence that this early intraocular pressure contributes to globe expansion and growth of the outer layers of the globe, particularly the choroid and sclera.[16–18] Persistence of the optic fissure may be associated with failure to establish and maintain intraocular pressure resulting in secondary, developmental (colobomatous) microphthalmia.[19]

This study did not demonstrate a sustained elevation of IOP during maturation. However, the magnitude of IOP necessary to stimulate growth of the eye may be labile; increased pressure may occur sporadically or at specific times and may be rapidly adjusted by compensatory expansion of the globe. Other factors known to influence globe growth include imposed optical errors,[20] TGF-beta from the retina,[21] and rate of scleral extracellular matrix production.[22]

Scleral rigidity is known to increase with advancing age. In human eyes of age 2 months to 94 years, the sclera was noted to undergo progressive degeneration of collagen and elastic fibers, dehydration, and accumulation of lipids and calcium salts, thereby causing increased scleral rigidity.[23] In adolescent marmosets (age > 100 days), the maximum rate of eye growth was seen when IOP was highest. However, juvenile marmosets (age ≤ 100 days) exhibited the most rapid growth during a period when IOP was lowest.[24] Likewise, in chick embryos, the IOP-dependent expansion of the globe occurs only prior to day 10 of gestation.[25] Sustained pharmacologic reduction in IOP by 4–5 mmHg for 4 months in juvenile rabbits did not affect globe growth.[26] The more elastic sclera of the immature animal may allow for rapid expansion in response to increased production of aqueous without any detectable increase in IOP. Thus, there may be a narrow developmental period during which globe expansion is able to occur in response to elevated IOP. Clinicians have observed the dramatic globe enlargement which can occur in puppies with only moderately elevated IOP. All of this supports a dynamic relationship between scleral elasticity and IOP in growth of the globe during maturation.

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