The Slate Turkey: A Model For Secondary Angle Closure Glaucoma

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An inherited eye disease leading to a secondary angle closure glaucoma has been observed in turkeys (Meleagris gallopavo) of the Slate variety. The initial indications of the disease involve a low grade aqueous cell and flare reaction, associated with progressive posterior synechiae formation resulting in pupillary block and iris bombe. A midperipheral iridocorneal adhesion follows, accompanied by corneal edema, breaks in Descemet's membrane, and buphthalmos. IOP is not elevated substantially until a complete iris bombe occurs. Expression of the defect is sex-influenced, with females exhibiting the most severe pathological changes. Invest Ophthalmol Vis Sci 27:1751-1754, 1986

Animal models of human diseases permit extensive investigations into their etiology and pathogenesis, which are not possible in human patients. However, of necessity, most investigations of glaucoma involve induced types, due to the scarcity of spontaneous animal models.

A spontaneous glaucoma has been described in several breeds of dogs and in a strain of New Zealand rabbits.1 A primary angle closure glaucoma has been studied in the Cocker Spaniel.2 The glaucoma reported in the Basset Hound appears to be a congenital form of glaucoma.3 In addition, a laboratory strain of Beagles exhibits a glaucoma that can be reproduced consistently through controlled breeding. This glaucoma appears initially to involve an open angle mechanism, which is followed, in later stages, by an angle closure process.4 A buphthalmos in rabbits is inherited as a semilethal autosomal trait,5 but its value as an animal model is limited, since it affects general viability as well.

An inherited eye disease, leading to a secondary angle closure glaucoma, has been observed in a Slate line of domestic turkeys (Meleagris gallopavo) maintained at the University of Massachusetts Poultry Research Center. Preliminary studies suggest the inheritance to be autosomal, and due to a dominant mutation.6 The glaucoma found in the Slate turkey represents an inherited form of glaucoma, with the potential to be a model for certain types of human secondary angle closure glaucoma. This report describes the clinical signs of the eye disease and its progression.

Materials and Methods. Four consecutive generations of Slate turkeys were subjected to biweekly slitlamp examinations with a Kowa SL5 portable slit lamp (Kowa Co. Ltd., Tokyo, Japan), beginning on the day of hatching in order to determine the presence and progression of pathological changes associated with the development of the eye disease. Examinations were also made of normal controls from an unrelated white plumaged strain. Intraocular pressure (IOP) was determined with a Digilab Model 30D pneumotonometer (Digilab, Cambridge, MA). Gonioscopy was performed on selected turkeys with an OLI 2 Layden infant 10.5 mm goniolens.

The anterior segments of Slate turkey eyes were studied using conventional light microscopy. Eyes were processed using routine laboratory procedures. Animal experiments were performed in conformity with the recommendations of the ARVO Resolution on the Use of Animals in Research.

Results. Clinical examination: Slitlamp biomicroscopy and gonioscopy were utilized to study the control and Slate birds in a serial fashion. The 64 control recessive white turkeys that were observed showed a clear cornea, a relatively deep and clear anterior chamber, an iris with only minimal convexity, and a round pupil, which dilated and constricted readily in response to light changes (Figs. 1A, 2A). The first observed pathological change in the 423 Slate turkeys examined was the presence of a small number of posterior synechiae, associated with a subtle flare response in the anterior chamber (Fig. 1B). The iris was only minimally convex. As the disease progressed, the area of posterior synechiae formation increased, associated with an increasing convexity of the iris (Figs. 1C, 2B). At this stage of the disease, the cornea was still clear at this time, and no other abnormalities were noted on slitlamp examination. The iris was only minimally convex. As the disease progressed, the area of posterior synechiae formation increased, associated with an increasing convexity of the iris (Figs. 1C, 2B). At this stage of the disease, the corneal diameter was observed to be increased. Many of the eyes showed a large eccentric pupil, as well as a low grade flare reaction.

In later stages of the disease, the increasingly convex iris was noted to be in apposition to the midperipheral
cornea in a complete iris bombé configuration (Fig. 2C). After the establishment of anterior synechiae, tears in Descemet's membrane were observed, and the cornea became opaque. In a group of 35 severely affected adult birds, the corneal diameter increased markedly, ranging from 10.2-12.0 mm, as compared to diameters of 8.5-9.8 mm for 15 age-matched controls.

Gonioscopic observations correlated well with the results from the slit-lamp examinations. In the control birds, an open iridocorneal angle was observed, with unobstructed view of the drainage area and its pectinate ligaments. In the Slate turkey, the angle remained open and unobstructed until the establishment of the midperipheral iridocorneal adhesion. Gonioscopic and slit-lamp examinations indicated that the progression of the disease was similar in all cases, although there was variation in the degree of severity in affected eyes. A total of 201 Slate turkeys were examined in 1983, and, in 29.9%, the disease did not progress beyond a minimal number of posterior synechiae (involving an area of less than 90° of the pupil), with minimal iris convexity. Another 35.8% exhibited posterior synechiae, greater than 90° but less than 360°. These eyes showed a moderately convex iris, but less than a complete iris bombé. The remaining 34.3% of the birds demonstrated the total progression of the disease to iris bombé, eventually exhibiting an opaque buphthalmic eye. Eighty-five percent of the turkeys exhibiting a complete iris bombé did so by 8 weeks of age.

Slit-lamp examination of 1-day-old Slate poults indicated all birds to show at least minimal ocular involvement; however, the severity of the disease appears to be influenced by the sex of the bird. Pooled data from three generations of pure Slate turkeys indicated a severe bilateral involvement (complete iris bombé with midperipheral anterior synechiae) in 64.4% of the females, compared to only 38.3% of the males ($P < 0.01$).

Mean intraocular pressure (IOP) in the turkey eye, as measured with a Digilab pneumotonometer, is illustrated in Table 1. IOP in the Slate turkey is not significantly higher than in normal controls until after the formation of an iris bombé. When damage to the ciliary body occurs, the IOP drops precipitously, even to levels which are too low to record with the pneumatonometer.

Pathology: Light microscopy of the normal control turkey eye confirmed slit-lamp and gonioscopic findings (Fig. 3A). One hundred and thirty-two affected Slate turkey eyes, representing a wide range in severity
Fig. 2. Narrow slit-lamp beam. A, Normal control turkey; normal depth anterior chamber; B, moderate involvement in a Slate turkey; convex iris secondary to posterior synechiae formation. Shallow anterior chamber; C, Complete iris bombe in Slate turkey with midperipheral iridocorneal contact.

of the disease, were examined, and, as in the controls, histology of the glaucomatous eyes confirmed slit-lamp and gonioscopic findings (Fig. 3B, C). In eyes where the disease had progressed beyond the stage of an iris bombe, an increase in convexity and diameter of the cornea was noted. This increase was accompanied by corneal edema and an increase in axial depth of the anterior chamber. In many cases, the buphthalmic eyes were as much as twice as large as a normal-sized globe.

Discussion. Slit-lamp and gonioscopic examinations were used to establish the sequence of events during the progression of the hereditary eye disease found in the Slate turkey. These data suggested the glaucoma to be a secondary angle closure glaucoma due to a pupillary block from posterior synechiae. In the Slate turkey, a slight flare reaction was observed in many of the glaucomatous eyes; however, only minimal histologic evidence of mononuclear infiltration was observed in the uveal tissue.

In humans, peripheral anterior synechiae are formed between the root of the iris and the ciliary body band, trabecular meshwork, or peripheral cornea. In turkey eyes with a complete iris bombe, a significantly increased IOP was observed, accompanied by an increase in corneal diameter, which was reminiscent of human congenital glaucoma, where a stretching of the ocular tissue, resulting in buphthalmos, occurs. The glaucoma observed in the Slate turkey does not appear to be a congenital glaucoma, since no angle abnormalities were noted in young pouls. In contrast, in adult humans the cornea and sclera are much thicker than in animals, where an increase in IOP may cause an enlarged eye until later stages of life.

Pneumatonometry established the mean IOP in normal unanesthetized turkeys at a level of 27 mm Hg.

Table 1. Intraocular pressure in normal and Slate turkeys as determined by pneumatonometry

<table>
<thead>
<tr>
<th>Phenotype</th>
<th>No. Birds</th>
<th>Mean IOP ± S.E. (mm Hg)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>21</td>
<td>27.0 ± 0.47</td>
<td>24-30</td>
</tr>
<tr>
<td>Minimally involved</td>
<td>57</td>
<td>25.7 ± 0.38</td>
<td>21-30</td>
</tr>
<tr>
<td>Moderately involved</td>
<td>38</td>
<td>27.3 ± 0.55</td>
<td>23-32</td>
</tr>
<tr>
<td>Angle closure</td>
<td>9</td>
<td>41.3 ± 2.06</td>
<td>35-54</td>
</tr>
<tr>
<td>Corneal decomposition</td>
<td>8</td>
<td>11.1 ± 0.64</td>
<td>9-14</td>
</tr>
</tbody>
</table>
In comparison, values of 12–23 mm Hg have been reported for chickens. Measurements obtained with a pneumatonometer are generally higher than those obtained with a Shiotz or other type of applanation tonometer. The results of IOP measurements in the Slate turkey agree well with a hypothesis of secondary angle closure glaucoma. IOP was not significantly higher than normal until after the formation of an iris bombe. Considerably elevated values were obtained in severely affected Slate turkeys. The low values of IOP that were observed in eyes with a long history of angle closure were presumably due to ciliary body damage with subnormal aqueous production. Light microscopy confirmed slit-lamp and gonioscopic data as well, and further supported the hypothesis of secondary angle closure glaucoma.

The glaucoma present in the Slate turkey appears to be a secondary angle closure glaucoma with an unknown etiology at the present. The Slate turkey appears to be a promising animal model for the human eye disease, and should allow insight into the pathogenesis of certain human secondary angle closure glaucomas.

Key words: glaucoma, animal model, Slate turkey, secondary angle closure glaucoma, pupillary block

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