
Jessica M. C. Czederpiltz, DVM; Noelle C. La Croix, DVM, DACVO; Alexandra van der Woerdt, DVM, DACVO; Ellison Bentley, DVM, DACVO; Richard R. Dubielzig, DVM, DACVP; Christopher J. Murphy, DVM, PhD, DACVO; Paul E. Miller, DVM, DACVO

Objective—To characterize the clinical and morphologic aspects of aqueous humor misdirection syndrome (AHMS) in cats and provide a hypothesis regarding its pathogenesis on the basis of detailed analysis of affected cats.

Design—Retrospective study.

Animals—32 cats (40 eyes).

Procedure—Medical records of cats in which AHMS was diagnosed from July 1997 to August 2003 were reviewed. In certain cats, results of additional diagnostic testing were also obtained, including A-scan, B-scan, and high-resolution ultrasonography; streak retinoscopy; video keratometry; and infrared neutralizing videoretinoscopy as well as results of analysis of flash-frozen sections and histologic examination of enucleated globes.

Results—Cats had a uniformly shallow anterior chamber, intact lens zonules, and a narrowed approach to an open iridocorneal angle. Mean age of affected cats was 11.7 years (range, 4 to 16 years), and female cats were significantly more often affected than male cats. Clinical signs included mydriasis, decreased pupillary light reflex, decreased menace response, and blindness. Glaucomatous changes to the optic nerve, incipient cataracts, and eventual blindness were seen. Intraocular pressure was ≥20 mm Hg (range, 12 to 58 mm Hg) in 32 of 40 eyes. Ultrasonography and histologic examination revealed a thickened anterior vitreal face interposed between the lens and ciliary body, partial ciliary cleft collapse, and cavitated vitreal regions. Various treatment modalities were used.

Conclusions and Clinical Relevance—AHMS affects older cats, especially females, and may result in glaucoma, vision loss, and signs of ocular pain. Topical administration of carbonic anhydrase inhibitors decreased intraocular pressure. (J Am Vet Med Assoc 2005;227:1434–1441)

Glaucoma is one of the most common causes of irreversible blindness in cats in the United States and affects as many as 1 in 108 cats > 6 years of age.1 Recognizing glaucoma in cats, however, can be difficult, as it is typically characterized by a slow, insidious increase in intraocular pressure (IOP) without the overt ocular vascular injection and corneal edema usually seen in dogs.1,2 In many cats, the only externally visible clinical signs are mydriasis, anisocoria, subtle corneal edema, or buphthalmia.1,2 Unfortunately, by the time clinical signs become apparent, irreparable damage to the optic nerve usually has occurred. In 1 study,7 73% of cats with overt clinical signs of glaucoma were blind at initial evaluation.7 These features have led to the suggestion to screen older cats for glaucoma in the hope that early recognition may improve the prognosis.1

Glaucoma is not a single entity, but rather a group of disorders that is unified only by the fact that IOP is too high for the optic nerve to function normally, and this leads to loss of part or all of the visual field.5 The various forms of glaucoma are usually differentiated by the anatomic location of the impediment to aqueous humor outflow and the mechanism by which this blockage occurs.5 In the healthy eye, aqueous humor is produced by the ciliary body, flows into the posterior chamber between the iris and lens, enters the anterior chamber via the pupil, and exits via the iridocorneal drainage angle.2 Obstruction to aqueous outflow at one or more of these locations may result in glaucoma.

In 1869, von Graefe6 described a form of postsurgical glaucoma in humans in which aqueous humor was diverted posteriorly into the vitreal cavity. This aqueous humor misdirection resulted in anterior displacement of the lens, a uniformly shallow anterior chamber, and increased IOP.1 The condition was called malignant glaucoma, not because the condition was neoplastic but because the prognosis for preserving vision in these patients was poor.1 Spontaneous forms of aqueous humor misdirection have also been infrequently described in humans.18 Results of a study1 in cats ≥7 years old indicate that 1 in 135 cats are affected by a form of glaucoma that appears to be similar to spontaneous aqueous humor misdirection in humans, indicating that this condition may be more common in cats than humans.1 Indeed, this may be the most common form of glaucoma in older cats examined in a private practice setting.2 Results of another study1 indicate...
an association between shallow anterior chambers and abnormal IOP in cats.

The purpose of the study reported here was to characterize the clinical and morphologic aspects of aqueous humor misdirection syndrome (AHMS) in cats and provide a hypothesis regarding its pathogenesis on the basis of detailed analysis of affected cats.

Criteria for Selection of Cases

Medical records of cats in which AHMS was diagnosed from July 1997 to August 2003 were reviewed. Contributing practices included the University of Wisconsin-Madison Veterinary Teaching Hospital; the Animal Medical Center, New York, NY; the Cat Care Clinic, (a large private practice in Madison, Wis); and Eye Care for Animals (2 private ophthalmology practices in Salt Lake City, Utah, and Tustin, Calif). Diagnosis of AHMS was confirmed by a Diplomate of the American College of Veterinary Ophthalmologists on the basis of the presence of a uniformly shallow anterior chamber secondary to anterior displacement of the lens-iris diaphragm, apparently intact lens zonules, and a narrowed approach to an otherwise open iridocorneal angle. Thirty-two cats met the criteria for case selection. Three additional cats were excluded because the diagnosis could not be confirmed by a Diplomate of the American College of Veterinary Ophthalmologists. All 3 excluded cats were spayed females, 1 domestic shorthair cat and 2 Persians (siblings), and all were 12 years old.

In many cats, but not all, the diagnostic features described led to overtly increased IOP and glaucomatous changes in the posterior segment of the eye. An eye was considered as an AHMS suspect if the other eye had overt AHMS and the eye in question had > 1 ocular abnormality, such as a subjectively slightly shallow anterior chamber as determined via slit-lamp biomicroscopy, a myopic refractive status suggesting anterior shifting of the lens, an IOP ≥ 20 mm Hg on 1 or more examinations (a value that represents 2 SD greater than the reference range for IOP in cats of this age1), altered peripapillary reflectivity, or an incipient axial cortical cataract.

Procedures

Information obtained from the medical records included signalment; clinical signs; concurrent disease; and results of aplation tonometry; slit-lamp biomicroscopy, indirect ophthalmoscopy; gonioscopy, pupillary light reflexes, and menace responses. In certain cats, results of additional diagnostic testing were also obtained, including A-scan, B-scan, and high-resolution ultrasonography; streak retinoscopy; video keratometry; and infrared neutralizing videoretinoscopy as well as results of analysis of flash-frozen sections and histologic examination of enucleated globes. Medical and surgical treatment and patient outcome were also recorded.

Evaluation of enucleated eyes—Two affected eyes from 2 cats were removed immediately after euthanasia for unrelated causes and fixed in Bouin’s solution. One additional eye enucleated for therapeutic reasons was also fixed in Bouin’s solution. These globes were embedded in paraffin, routinely sectioned for histologic examination, and stained with either H&E or Alcian blue–periodic acid–Schiff stains. Because precise anatomic relationships of ocular structures do not survive routine histologic processing, 2 additional globes from 2 cats with AHMS that were euthanized for health reasons were flash-frozen in liquid nitrogen and serially sectioned by use of a cryostat until the mid-sagittal section was obtained. Serial photographs were obtained to verify that the section was mid-sagittal, and the gross anatomic relationships among various ocular structures were determined by use of a dissecting microscope. After this was complete, the remaining block was immersed in Bouin’s solution and prepared for light microscopic examination as described.

Statistical analysis—A χ² test was performed on the distribution of males and females in the group. A value of P < 0.05 was considered significant.

Results

Thirty-two cats (24 spayed females and 8 neutered males) ranging in age from 4 to 16 years (mean, 11.7 years) met the inclusion criteria. In these 32 cats, 40 eyes were overtly affected by AHMS and 6 were suspected of having milder forms of AHMS (AHMS suspects). Breeds represented included domestic shorthair cat (n = 27), domestic longhair cat (2), domestic medium-hair cat (1), and Persian (2). Females were significantly (P = 0.005) more frequently affected than males.

Common clinical signs detected during initial evaluation included anisocoria (pupil mydriatic in affected eye; n = 21 cats), decreased pupillary light reflex (17), and decreased menace response (12). The condition was bilateral in 7 cats and unilateral in 24 cats, and in 1 cat, it progressed from unilateral to bilateral, which was detected during a follow-up examination. In 6 of the unilaterally affected cats, 1 eye had overt AHMS and the other eye was an AHMS suspect. Ophthalmic findings in overtly affected eyes included a uniformly shallow anterior chamber (n = 32 cats, 40 eyes), apparently intact lens zonules (32 cats, 40 eyes), a narrowed approach to an otherwise open iridocorneal angle (31 cats, 39 eyes), glaucomatous changes to the optic nerve head (31 cats, 39 eyes), incipient cortical cataracts (16 cats, 18 eyes), and blindness (12 cats, 13 eyes; Figure 1). Other fundic abnormalities included peripapillary hyperreflectivity (n = 12 eyes), retinal degeneration (3), tapetal mottling (2), attenuated vessels (2), a mottled coloration of the retina (2), and hyperreflectivity (1). In these eyes, IOP ranged from 12 to 58 mm Hg and was > 2 SD greater than the age-adjusted mean IOP (eg, ≥ 20 mm Hg) in 26 of 32 cats (32/40 eyes). In 6 cats, pools of clear fluid or liquefied vitreous could be seen on clinical examination of the vitreal space. A white membrane pressing between the ciliary body and lens equator also could often be identified via indirect ophthalmoscopy. The latter was interpreted as a thickened anterior hyaloid membrane. When refracted, severely affected eyes were also markedly myopic (range, –10 to –16.5 diopter), which was attributed to anterior shifting of the lens.

Abnormal findings in the 6 AHMS suspect eyes included subjectively mildly shallow anterior chambers
(n = 2 eyes), a myopic shift (−3.25 diopter in 1 cat that was refracted), a transient increase in IOP to ≥ 20 mm Hg on at least 1 examination (5), altered fundic reflectivity with clinically normal–appearing optic nerve heads (4), or an incipient axial cortical cataract (1).

Nineteen of the 32 cats were reported to have a systemic disease in addition to ocular disease, but no clear pattern was detected. These disorders included renal disease (n = 7), inflammatory bowel disease or lymphoma (6), systemic hypertension (5), heart disease (4), neoplasia (4), urinary tract infections (4), overt or suspect hyperthyroidism (4), severe dental disease (3), neurologic disease (3), diabetes mellitus (2), asthma (1), arthritis (1), and portosystemic shunt (1).

Other ocular findings detected in addition to AHMS included iris atrophy (n = 6), iris melanosis (5), nuclear sclerosis (3), central retinal degeneration (2), nonhealing corneal ulcer (1), corneal ulcer (1), vitreal hemorrhage (1), limbal cyst (1), subretinal mass in the unaffected eye (1), and post-traumatic synechia in the unaffected eye (1).

Seven cats received systemic oral glucocorticoid treatment for inflammatory bowel disease or another illness during the study. In 1 cat, initiation of corticosteroid treatment appeared to be associated with increased IOP, despite continued treatment for glaucoma, and when corticosteroid administration was stopped, the glaucoma became more manageable.

Nine cats also underwent A-scan, B-scan, or high-resolution ultrasonography with a 20-MHz probe. This analysis revealed uniformly shallow anterior chambers, hyperechoic tissues between the ciliary body and lens equator, mildly thickened lenses, and pools of hypoechoic fluid in the vitreous (Figure 2). In at least 1 cat, it appeared that the posterior vitreous was detached from the retinal surface.

Examination of flash-frozen sections of 2 eyes from cats with AHMS confirmed that the anterior chamber was uniformly shallow secondary to anterior displacement of the lens-iris diaphragm, that the lens zonules were intact, and that a narrowed approach to an otherwise open iridocorneal angle was present. Regional variations in the density of the vitreous consistent with pools of clear fluid were also detected in the frozen sections and on gross examination of Bouin's–fixed specimens (Figure 3). Histologically, the anterior vitreal face was thickened and interposed between the ciliary body and the lens (Figure 4). The anterior portion of the ciliary body often was edematous, and the posterior portion was displaced peripherally and anteriorly. The drainage angle and ciliary cleft appeared narrow but open. Glaucomatous optic neuropathy was observed in eyes in which IOP was chronically increased. The potential locations where misdirected aqueous humor may collect are illustrated (Figure 5).

Five cats did not receive treatment for their eye disease. Two of those 5 cats were euthanatized for unrelated terminal illnesses shortly after evaluation, and 3 had mild disease for which treatment for glaucoma was not absolutely necessary. Twenty-seven cats were treated topically with various topical medications for glaucoma.
including 0.1% dipivefrin hydrochloride solution (n = 3), 0.5% timolol maleate solution (11), 2% dorzolamide solution (16), 1% brinzolamide solution (4), 0.5% pilocarpine solution (1), 1% pilocarpine solution (3), 4% pilocarpine solution (1), 0.005% latanoprost solution (2), and tropicamide (1) when IOP was > 2 SD greater than the age-adjusted mean IOP for cats. Three cats were also treated with the carbonic anhydrase inhibitor dichlorphenamide, and 1 cat was treated with methazolamide. Six cats underwent some form of surgical treatment for their ocular disease because medical treatment was not successful. Surgical procedures included enucleation (n = 4 cats), lens removal and anterior vitrectomy (1), and phacoemulsification (1).

Treatment for glaucoma was not instituted in 3 of 32 cats because in 2 of those cats, IOP was not consistently > 20 mm Hg at follow-up examinations performed 4 and 24 months after the initial evaluation. The third cat for which treatment for glaucoma was not instituted initially had conjunctivitis and was incidentally found to have overt AHMS in 1 eye (IOP, 18 mm Hg), and the other eye appeared clinically normal (IOP, < 19 mm Hg). During the next 5 years, IOP was frequently monitored and typically ranged from the high teens to low 20s in the overtly affected eye. In the 5-year period, peak IOP was 25 mm Hg in the overtly affected eye and 26 mm Hg in the other eye (which was later categorized as an AHMS suspect because of this IOP and an incipient cortical cataract). This cat was never treated with medications for glaucoma, and although it had AHMS and incipient cataracts, the cat retained useful vision (positive menace) in both eyes for the duration of its life. Unfortunately, assessment of glaucomatous changes was not possible before the cat died.

Of the remaining 27 cats (34 eyes) that received medical treatment for glaucoma, the IOP in 18 eyes was well controlled (IOP < 25 mm Hg) and vision was
Two cats (2 eyes) were evaluated for blindness and retained (positive menace) for the duration of the study (mean, 13.4 months; range, 2 to 36 months). Two cats (2 eyes) were evaluated for blindness and were treated medically only to maintain IOP in an apparently pain-free range (<25 mm Hg). Glaucocma in 3 cats (3 eyes) was not controlled with medical treatment (2 cats were lost to follow-up and 1 eye in 1 cat was subsequently enucleated), and 10 cats (11 eyes) ultimately had severely impaired or complete loss of vision in the affected eye during the study (in this latter group of 10 cats, vision was retained a mean of 14.7 months [range, 1 to 72 months]).

Undesirable adverse effects of medical treatment were detected in a few cats. One cat vomited after receiving 1% pilocarpine solution, and another cat had increased salivation after receiving 4% pilocarpine gel. In 1 cat, the prostaglandin F2α derivative latanoprost (0.005% solution, q 24 h for 11 days) resulted in extreme miosis, worsening the glaucoma such that IOP reached 63 mm Hg and vision was lost. In this cat, IOP decreased to 45 mm Hg after a single drop of 1% atropine solution. Latanoprost was discontinued, and the cat was treated with dipivefrin and dichlorphenamide. Three days later, IOP had decreased to 20 mm Hg and the anterior chamber grossly deepened, but the eye remained blind. Another cat, in which the angle was subsequently determined to be closed, had an increase in IOP from 32 to 50 mm Hg after topical application of topical tropicamide after lens extraction.

Dichlorphenamide was administered PO, and the cat received a single application of timolol, and IOP returned to within reference range.

When assessed separately, topically administered carbonic anhydrase inhibitors were used to treat 16 cats (22 eyes). Of these 22 eyes, 2 were blind initially but IOP was controlled (<25 mm Hg) with medical treatment. Thirteen eyes retained vision, and the IOP was maintained at <25 mm Hg. Of the remaining 20 eyes, 7 eventually became blind despite treatment. Of these 7 eyes, 4 were from 2 cats that had extremely advanced aggressive disease when AHMS was diagnosed. Although they went blind, IOP was again maintained within an apparently comfortable range (<25 mm Hg). In 1 cat, changes as a result of medical treatment were quantified. The topically administered carbonic anhydrase inhibitor, 2% dorzolamide solution (q 8 h), decreased IOP from 27 to 15 mm Hg, and serial high-resolution ultrasonography revealed a corresponding deepening of the anterior chamber from 2.5 to 2.89 mm. Adverse effects included 4 cats treated with 2% dorzolamide solution that had inappetance, increased salivation, vomiting, or vocalization after treatment. Clinical signs stopped when the medication was changed to another topically administered carbonic anhydrase inhibitor, 1% brinzolamide solution.

The owner of 1 cat requested enucleation because, despite medical treatment, the cat had signs of pain attributable to a persistently uncontrolled IOP. The other eye of this cat continues to be treated 6 years after the onset of glaucoma, and although IOP remains between 26 and 34 mm Hg, the eye has retained a minimal degree of useful vision. In 3 other cats, an eye affected with AHMS that lost vision was also enucleated to relieve chronic ocular pain.

Two cats were treated by removing the lens in the affected eye. One cat underwent lens removal with anterior vitrectomy, but the IOP remained increased after surgery. One cat underwent phacoemulsification, and IOP decreased from 36 mm Hg preoperatively to 20 mm Hg as determined during follow-up examination performed 2 months later. The cat retained useful vision in this eye until it died of an unrelated systemic illness 3 years later.

Discussion

The essential diagnostic features of AHMS include misdirection of aqueous humor into the vitreous; a uniformly shallow anterior chamber caused by anterior lens-iris shift; intact lens zonules; juxtaposition of the ciliary body, consolidated anterior vitreal face, and lens to form a so-called ciliovitreolenticular block; and a narrowing of the approach to an otherwise initially open iridocorneal angle. Pools of clear fluid in the vitreous, although often quite challenging to identify in a clinical setting, may be appreciated in at least some eyes on detailed slit-lamp biomicroscopic examination of the vitreous or on B-scan ultrasonography. Alternatively, rather than being located in discrete pockets, aqueous humor may accumulate between the retina and the posterior vitreous as seen in at least 1 cat in our study or even be located diffusely throughout the vitreous.

We propose that the mechanism of this previously unrecognized form of glaucoma in cats involves an
abnormality in the anterior hyaloid that permits aqueous humor to be diverted posteriorly. The exact nature of this abnormality is not clear and may vary among cats. One possible cause is that, as has been described in humans, minute breaks in the hyaloid membrane near the vitreous base may act as a 1-way valve, permitting aqueous humor to flow posteriorly if anterior chamber pressure exceeds that of the vitreal cavity. Blinking or squeezing of the eyelids is just such a trigger and may intermittently force small aliquots of aqueous humor posteriorly into the vitreous, where it becomes trapped. Alternatively, aqueous humor may flow posteriorly between the retina and vitreous and form a discrete pocket in this location or ultimately gain access to the vitreous via a more posterior route. In at least 1 cat in our study, it appeared that the posterior vitreous was detached from the retina on B-scan ultrasonography, suggesting that this mechanism may be involved. Finally, as proposed by Epstein et al, aqueous humor may become trapped diffusely throughout the vitreous, rather than in isolated pockets.

Regardless of the mechanism by which aqueous humor is diverted posteriorly, the excess fluid within or behind the vitreous increases the pressure against the vitreal face. In experimental studies with eyes from humans and animals, this pressure initially results in increased flow of fluid through the vitreal face, but eventually, vitreal elements are displaced anteriorly and become compressed. This compression increases the resistance to flow of fluid through the vitreous, further entrapping aqueous humor within the vitreous cavity and potentially setting up a vicious cycle. Eventually, the thickened anterior face of the hyaloid (formed by displaced vitreal constituents) is forced anteriorly between the ciliary process and the equator of the lens, forming a ciliovitreolenticular block that provides even less surface area for trapped aqueous humor to escape the vitreal cavity. With time, the lens-iris diaphragm is also shifted anteriorly, leading to myopia (nearsightedness) and an anterior chamber that is shallow both axially and peripherally (uniformly shallow). Simultaneously, the posterior portion of the pars plicata of the ciliary body is rotated anteriorly and peripherally, and compression of this portion of the ciliary body with its attendant secretory pathways may explain the edema of the anterior portion of the ciliary body seen histologically. Eventually, this process may lead to a gradual increase in IOP if sufficient amounts of aqueous humor are unable to escape the vitreal space.

Glaucoma may also be the result of a cascading series of blocks to aqueous humor flow. The initial impediment to aqueous outflow at the level of the ciliary body–lens–anterior vitreous can lead to obstruction at more anterior levels such as the pupil (as the lens is displaced anteriorly into the pupillary aperture), the ciliary cleft (as the ciliary body becomes more compressed), and, eventually, the iridocorneal drainage angle (as the peripheral iris is pushed anteriorly). In chronically affected cats, increased IOP leads to ocular pain and glaucomatous damage to the optic nerve. Unfortunately, once the retinal ganglion cells comprising the optic nerve begin to die, a cascade of apoptotic cell death may be initiated, which may continue even if IOP is returned to within the reference range. The latter argues that early diagnosis and treatment of cats with AHMS may be beneficial.

Early glaucomatous changes in the fundus of cats are difficult to assess clinically because of the anatomy of the fundus and individual differences. In cats, the optic nerve naturally appears somewhat dark and depressed from the retinal surface, relative to other species, because of a lack of myelin. Therefore, it is more difficult to detect glaucomatous cupping of the optic nerve in cats, and it is necessary to carefully assess the nerve and surrounding retina for degenerative changes that may represent glaucomatous damage. A mild degree of altered peripapillary reflectivity may also be normal in cats, or it can be the result of glaucomatous change. In addition, the tapetum may appear more reflective as a result of retinal thinning secondary to glaucomatous damage. Although 13 globes were reported to have evidence of glaucomatous changes to the fundus, an additional subset of cats also had suspicious lesions consisting of any of the following: peripapillary hyperreflectivity, retinal degeneration, and tapetal mottling. Therefore, because of the difficulty of assessing the fundus in cats, our understanding of how frequently AHMS results in glaucomatous changes and the exact nature of those changes is not complete.

Differentiation of cats with AHMS from those with subluxed lenses and shallow anterior chambers is important because in the latter, the treatment of choice is lens extraction. Differentiation can be made on the basis of a uniformly shallow anterior chamber in the case of AHMS and an irregularly shallow anterior chamber in the case of lens subluxation. In our study, in cats with AHMS, the iris or lens did not tremble when the eye moved (iridonesis and phacodenesis, respectively), unlike what is seen in cats with lens subluxation or luxation. Eyes of cats with lens subluxation or luxation often have other signs of anterior segment inflammation that are not seen in cats with AHMS.

Results of our retrospective study permit some basic trends to be defined regarding this disease. Females were more frequently affected than males. A female predisposition to certain forms of glaucoma has also been found in dogs and humans, perhaps because the anterior chamber is typically somewhat shallower and more crowded in females than males. It is also possible that this predisposition is because IOP in older female cats is typically somewhat higher than that in older male cats. Another observed trend was that several cats had incipient cataracts, perhaps secondary to the loss of nutrients as aqueous humor is directed posteriorly rather than over the lens surface. Two cats also had corneal ulcers, and a loss of nutritional support to the cornea could be suggested as a cause for this as well. Most of the cats reported here had concurrent diseases, but it was difficult to define a consistent causal relationship between these disorders and AHMS, in part because these cats tended to be geriatric and many of these concurrent disorders are also associated with advanced age. However, some treatments for concurrent disorders may exacerbate AHMS. Anecdotally, the ease with which increased IOP was
controlled in 1 cat varied with whether or not it was receiving corticosteroids for inflammatory bowel disease. Corticosteroids increase IOP in cats and other species; therefore, it seems reasonable to believe that corticosteroids may also worsen AHMS.22,23

One of the reasons that this condition affects older cats may be because some degree of age-associated vitreal degeneration is necessary for aqueous humor to find a posterior pathway for flow. As humans age, the vitreal gel tends to condense (especially peripherally) and there is a concomitant increase in the number and mobility of the fibrillar elements within the vitreal cavity.24-26 Eventually, optically empty spaces (lacunae) of pooled liquefied vitreous form.27,28 The pools of clear fluids seen on examination of frozen specimens and during ultrasonography may represent accumulations of liquefied vitreous rather than aqueous humor. The anterior shifting of the lens-iris diaphragm, however, strongly suggests that this shift is the result of additional fluid accumulating in the vitreal cavity because liquefaction of vitreal gel alone would not be expected to expand vitreal volume.24,25 Further morphologic studies with age-matched controls could help elucidate the role these findings play in the pathophysiology of this disease.

Understanding the pathogenesis of AHMS is helpful when considering various treatment modalities. The most effective medical treatments in humans include cycloplegics, carbonic anhydrase inhibitors, hyperosmotic agents, and other medications for glaucoma that suppress production of aqueous humor.27-29 Cycloplegic drugs (eg, atropine) are believed to exert a beneficial effect by inactivating ciliary constriction and tightening the zonules, thereby effectively pulling the lens into a more posterior position and counteracting the posterior push of the vitreous.27 In advanced cases of AHMS, it may also help to decrease direct contact between the ciliary body and lens. The efficacy of cycloplegics in treating AHMS, however, is not clear, and the comparably small size of the ciliary body musculature in cats versus humans suggests that these compounds may be less effective in cats. In humans, cycloplegics are of little value in treating aphakic malignant glaucoma,29 and in cats, in our study a single application of tropicamide, which is a less potent cycloplegic than atropine,30 appeared to cause a spike in IOP prior to lens extraction, perhaps because the condition was chronic and the ciliary cleft was compromised.30

Carbonic anhydrase inhibitors decrease aqueous humor production,31 and in the study reported here, it was not uncommon for the anterior chamber to deepen when these drugs were used to decrease IOP. Presumably, this is attributable to a reduction in the amount of aqueous humor flowing posteriorly in the vitreal cavity, thus decreasing the buildup behind the ciliary lentiventricular barrier and reducing the force pushing the lens anteriorly. The clinician should be aware, however, that not all drugs that lower IOP are effective in treating this disease. Potent miotic drugs such as pilocarpine and, in cats specifically, latanoprost32 and timolol33 may exacerbate glaucoma by increasing contact between the iris and the lens, thereby worsening the block to outflow at the level of the pupil.34 Historically, miotics such as pilocarpine were used for many years to treat malignant glaucoma but were found to be almost uniformly unsuccessful, and it subsequently became evident that they may actually precipitate or aggravate malignant glaucoma.26,35 In 1 cat in our study, the potent miotic latanoprost exacerbated pupil block and appeared to be the proximate cause of the eye losing vision. For other drugs such as the β-adrenergic receptor blocking agent timolol, the miosis is less pronounced or dose dependent27-30 and may be mitigated to some extent by suppression of aqueous humor production. In general, however, it seems prudent to avoid use of potent miotics that do not alter aqueous humor production (eg, pilocarpine and latanoprost) and to carefully monitor cats that are treated with miotics that also suppress aqueous humor production (eg, timolol). Topically administered carbonic anhydrase inhibitors avoid the concerns over miosis and seemed to be effective in treating the cats in our study (decreasing IOP to < 25 mm Hg). Those cats in which treatment was not successful (ie, became blind) tended to be those individuals with either advanced disease at the time of diagnosis or those few with particularly aggressive disease. This illustrates the importance of early diagnosis and continued monitoring of IOP and vision. Unfortunately, vision loss is still possible despite adequate control of IOP because of the cascade of ganglion cell death that can occur after the initial hypertensive state.

If medical treatment is not successful in controlling IOP, surgical intervention is probably indicated.28 In theory, disruption of the abnormal hyaloid membrane through a pars plana vitrectomy prior to secondary closure of the drainage angle would effectively alleviate the block. Effective excision of this membrane, however, can be technically challenging because it is closely associated with the ciliary body, the lens zonules, and the posterior aspect of the lens. Although anecdotal reports35 have indicated successful IOP control with lens extraction and anterior vitrectomy, it was not therapeutic in 1 cat in our study. For reasons that are not entirely clear, IOP quickly returned to 40 mm Hg after surgery in this cat, perhaps because some residual block remained or the ciliary cleft was impaired. Lensectomy alone may not be effective if the posterior lens capsule remains intact and continues to act in accordance with the abnormal anterior hyaloid membrane to prevent the anterior passage of aqueous humor that has been diverted into the vitreal cavity. Despite this, however, 1 cat did appear to benefit from phacoemulsification and retained useful vision for the remainder of its life (3 years). Enucleation or evisceration with placement of an intrascleral prosthesis is also an option for chronically painful, glaucomatous eyes.23 Fortunately, with early diagnosis and treatment, many of the cats in our study were able to retain an apparently pain-free and visual eye for a substantial period, if not for the remainder of their lives.


b. Sules J, Purdue University, West Lafayette, Ind. Personal communication, 1999.
References