

Penetrating Eye Injury: A Case Study

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Abstract

Eye injuries resulting from ocular trauma pose a frequent threat to vision the world over. The setting and causes of eye injury are diverse, but previous studies have demonstrated that the risk and type of injury is often correlated with age, gender, and race. While a focused history and prompt ocular examination are essential to immediate management, patient education regarding safety precautions and risk reduction help to prevent future recurrences.

This article describes a case of BB gun-related penetrating eye injury with a retained intraocular foreign body in a 10-year-old male. The case discussion will review the initial examination, resultant management decisions, and final visual outcome. A suggested approach to the management of patients with ocular trauma with emphasis on the differential diagnosis, clinical signs, management, and referral of common injuries to the eyes will be discussed.

Introduction

Vision is one of the most valued and powerful senses. Intact binocular vision plays an important role in development, independence, quality of life, and personal safety. Ocular injury is a frequent and preventable cause of visual impairment. The lifetime prevalence of sustaining any type of ocular trauma approaches 19.8%.¹ Eye injury covers a broad range of severity, from a small corneal epithelial abrasion to the more severe penetrating and globe rupture injuries.

The pediatric age group accounts for 8-14% of all eye injuries. Pediatric ocular injury is usually accidental and uniocular.^{2,3} In contrast, adult ocular injury is usually the result of intentional assault. Males are more often affected than females, at a rate approximating 4:1, and suffer injury at a younger age.^{1,4,5} Patients with a prior history of ocular trauma have a threefold increase in recurrence risk in a five-year period compared to those without prior injury.¹ Prompt evaluation and appropriate management of ocular injuries are paramount in the preserva-

tion of vision. Visual acuity, presence of an afferent pupillary defect, the type of injury, the location, and extent of penetrating injury, type of lens damage, presence and severity of vitreous hemorrhage, presence of and composition of intraocular foreign bodies mostly contribute to the final visual outcome in patients suffering penetrating ocular injuries.⁶ In this article, we describe the evaluation and management of penetrating injury and intraocular BB foreign body in a 10-year-old male.

Case Report

M.R. is a 10-year-old male patient who presented to a local emergency department complaining of sudden severe left eye pain while shooting a BB gun with a friend without adult supervision. He reported the sudden onset of intense pain in the left eye after being struck by a BB that had ricocheted off a nearby tree. There were no complaints related to the right eye. He denied wearing any protective or prescription glasses at the time. He had no past history of ocular trauma, ocular surgery, glasses, or contact lens wear. Past medical history was unremarkable, and he was not on any medications. Current immunization for tetanus was confirmed by the parents. Family history was non-contributory. He lives at home with his parents and younger sister and attends elementary school.

On examination, M.R. was a well-developed 10-year-old male in acute ocular distress. On examination, his vision, using the Snellen visual acuity card at two feet, was 20/40 in the right eye and no light perception in the left with good illumination. The flashlight examination revealed no facial abnormalities. The right eye pupil was round, about 3.5 mm in diameter constricting to about 2.5 mm on direct light exam. There was no reversed afferent pupillary defect. The pupil also reacted normally to accommodation. The left pupil was very difficult to evaluate due to the presence of blood in the anterior chamber. The left eye had normal eyelids without bruising, mild subconjunctival hemorrhage, mild conjunctival chemosis, and an irregular linear corneal laceration extending from seven to one o'clock. Examination of the left eye anterior chamber revealed

significant iris prolapse through the corneal laceration and hyphema. Visualization of the lens was obscured by the hyphema and necrotic iris tissue. Examination of the anterior and posterior segments of the right eye was normal without signs of trauma. Given the extent of the penetrating eye injury, the ocular examination was terminated, the eyes protected with a fox shield, and the patient was prepared for surgery. A pre-surgical computerized tomography (CT) of the orbits revealed a round, metallic foreign body at the level of the iris plane. Otherwise, all the other orbital structures were normal.

The diagnosis of penetrating eye injury with corneal laceration and intraocular metallic foreign body was made. The patient was given fentanyl for pain control, and informed consent was obtained from the parents. The patient was prepared for exam under general endotracheal anesthesia, repair of corneal laceration, and removal of intraocular foreign body.

In the operative suite the left eye was carefully prepped with 5% Betadine and a sterile eye drape was placed. Exam under anesthesia revealed a full thickness angled corneal laceration extending from corneal apex to seven o'clock approximately 5 mm and to 1 o'clock another 5 mm. Marked hyphema and an inferior displacement of the crystalline lens was observed on anterior chamber exam. Ten interrupted 10-0 nylon sutures were placed to reapproximate the corneal wound. The hemorrhage was aspirated from the anterior chamber using an irrigation-aspiration hand piece, and necrotic iris tissue was excised. A lensectomy was performed on the inferiorly displaced lens. Multiple attempts at extraction of the BB with BB forceps were unsuccessful. The BB was noted to move slightly posteriorly before attempts were abandoned, with the fear of further posterior migration and subsequent retinal damage. All superficial surgical wounds were closed with interrupted nylon sutures, and the wound was checked with a Fluorescein strip (Fluor-1-Strip, fluorescein sodium 1mg, Bausch & Lomb), and found to be watertight (Seidel negative). Subconjunctival injections, including 100 mg of cefazolin and dexamethasone 2 mg, were given inferiorly. At the end of the procedure topical 1% atropine prednisolone acetate 1% and Vigamox® (Moxifloxacin hydrochloride 0.5%, Alcon) were administered. Tobradex ophthalmic ointment (tobramycin and dexamethasone, Alcon) a double eye pad, and metal shield were applied to the left eye. He was then taken to the recovery area and later admitted in stable condition.

On hospital day two, the patient was taken back to the operative suite by a vitreoretinal specialist for removal of the BB, using a large intraocular magnet, open-sky anterior vitrectomy, revision of the corneal wound, and intravitreal antibiotic injection. The BB was successfully extracted using an external approach. The corneal wound was closed, and the anterior chamber was reformed. Intravitreal vancomycin (1 mg) and ceftazidime (2mg) were administered. Tobramycin/dexamethasone ophthalmic ointment, pressure patch, and a metal eye shield were placed over the left eye.

The patient was discharged from the hospital on day three with a clinic visit scheduled for the following day. His parents were advised to keep the metal eye shield in place at all times. Discharge eye medications included frequent administration of topical prednisolone acetate to control inflammation and prophylactic antibiotic coverage with Vigamox®. Tylenol with codeine was to be given as needed up to every six hours for pain and discomfort. The following day vision in the left eye remained at no light perception. The patient was followed closely over the next few days without improvement of visual acuity. After discussing the possibility of sympathetic ophthalmia, risks, benefits, and alternatives to surgical enucleation, in a blind eye, the family decided on enucleation and placement of prosthesis in the left socket. Polycarbonate eyeglasses were prescribed to protect the right eye from future injury.

Discussion

Ocular injury is classified into blunt or penetrating, depending on the causative factor. Blunt ocular trauma can be defined using the basic physics concept of energy exchange. Energy is transferred between the injurious object and periocular or globe structures without intrusion of the injured tissue by the offending object.⁷ Penetrating injury involves intrusion into the injured tissue by the offending agent. Blunt trauma can produce a very different clinical scenario and pattern of tissue injury when compared to that of penetrating injury. Classifying the injury as blunt or penetrating early in the patient interaction will facilitate a more focused and effective exam, reducing the time required to provide definitive management. Initial evaluation and identification of penetrating ocular injuries is important in minimizing further ocular complications. Once the diagnosis of open globe is made, immediate referral for surgical exploration and repair should be made to the eye specialist. The eye should be protected with a fox metal eye shield while awaiting definitive treatment. Baseline exam findings and visual acuity are important in advising patients and family members on the prognosis and final visual outcomes. Findings supporting a favorable outcome (20/50 or better) include a normal lens at presentation and an anterior segment location of intraocular foreign body. However, more discouraging findings for final visual outcome, many present in the case being discussed, are afferent pupillary defect, visual acuity of light perception or worse, prolapse of uveal tissue, BB injury, and foreign bodies posterior to the lens.⁸ If there is a poor view of the fundus, one should consider B-scan ultrasonography to examine integrity of posterior tissues. Orbital radiographs or computed tomography (CT) scanning should be done if a foreign body may be present. Magnetic Resonance Imaging (MRI) is contraindicated in cases involving a suspected metallic foreign body. If a metallic intraocular foreign body is present, its prompt removal has been shown to be important in attaining the best visual outcome possible.⁹ In the case that we presented, the decision to use an external approach to remove the BB was based on the greater strength of attraction observed between a BB of the same composition (copper lining with a steel core) and the large external magnet compared to that of the smaller internal magnet. A

series of 70 patients receiving treatment at McGill University Health Center in Quebec demonstrated that there was no significant difference in visual outcomes between external approaches to retrieval versus internal approaches (consisting of pars plana vitrectomy with removal using forceps or internal magnet).¹⁰

Antibiotics are generally started postoperatively in traumatic cases with open globes. Subconjunctival injections of vancomycin, ceftazidime or gentamicin, and dexamethasone postoperatively are recommended. Recommended topical antimicrobial therapy includes fourth generation fluoroquinolones, such as Vigamox® (moxifloxacin HCL 0.5) and Zymar (gatifloxacin 0.3%, Allergan) or, alternatively, fortified vancomycin and ceftazidime. Inflammation is managed with 1% prednisolone acetate ophthalmic solution. Cycloplegic agents, such as 1% atropine, twice daily will help in maintaining the depth of the anterior chamber and may enhance patients' comfort while facilitating the examination of the fundus. Broad spectrum intravenous antibiotics, like vancomycin, ceftazidime or fluoroquinolone, are commonly given preoperatively and discontinued after four to seven days.¹¹ The intravitreal injection of antibiotics has been shown to be an effective method of reducing the risk of post-traumatic endophthalmitis, a devastating intraocular infection.¹² The risk of endophthalmitis is increased in cases of ruptured globe injuries with or without retained intraocular foreign body. The most common organisms in post-traumatic endophthalmitis include *Staphylococcus epidermidis* and *Bacillus* species.

The Seidel test confirms or rules out cases of full thickness injuries to the anterior segment. In the Seidel test a moistened fluorescein strip (Fluor-1-Strip, fluorescein sodium 1mg, Bausch & Lomb) is painted over the suspected injury site. The orange fluorescein changes to apple green if there is a wound leak, and a stream of aqueous can be observed with cobalt blue light.

Partial thickness corneal lacerations require topical broad-spectrum antibiotic coverage and a cycloplegic agent for relief of photophobia and pain associated with ciliary spasm. A bandage contact lens may also be helpful for structural or tectonic support. Full thickness corneal lacerations, as in the case presented, require surgical exploration and repair with postoperative administration of antibiotic and steroids. Thus, in all cases of penetrating ocular injury, close daily follow-up is required to monitor progress and identify any sign of complications. The patient with severe penetrating injuries should be followed closely for potential complications like endophthalmitis, recurrence of hyphema, ocular siderosis, and sympathetic ophthalmia.¹³ When considering pediatric enucleation, the prosthesis takes on special importance. Proper sizing and adjustments play a role in the growth and development of the orbit and facial symmetry, improving chances for an acceptable cosmetic appearance and avoiding potential future complications.

Epidemiology of Ocular Trauma

BB-related trauma is one of the most common causes of severe eye injury among adolescent males.¹³ It is often the re-

sult of a ricocheted trajectory off a hard object near or behind the intended target. The muzzle velocity of projectiles fired from nonpowder guns ranges from 150 to 1200 feet per second and can maintain near maximum velocity after ricocheting off solid objects.¹⁴

In a review of National Injury Surveillance System data from 1993 to 2002, the rate of firearm-related eye injury was observed to decline while the rate of nonpowder (BB and pellet gun) injury remained relatively constant with a prevalence of approximately six per 1,000,000. Caucasian and Latino males were more likely to suffer nonpowder gun injuries, but African-American males more often sustained firearm-related eye injury.¹⁵

There is significant variability in the estimated number of eye injuries from all causes in the United States. The wide range of estimates can be attributed to the setting reporting the data. Inpatient facility reports tend to underestimate figures because eye injuries are not often severe enough to warrant hospitalization, while inpatient and outpatient (emergency department) reports neglect cases of ocular injury treated in private physician offices. The prevalence of emergency-department-treated eye injuries in the US is 3.15 per 1000 population. The highest rates are among men in their 20s and 30s and among those of American Indian and African-American descent. Most injuries are reported to occur in the home and are secondary to contusions or abrasions.^{16,17} The prevalence increases to 6.98 per 1000 population when eye injuries that require treatment in inpatient, outpatient facilities, and private physician offices are considered. The more comprehensive approach used in this study also changed the demographics and most common modes of injury. Caucasian men in their 20s experienced the highest rates of ocular injury in this study population. The more common injury etiologies were superficial erosions, foreign bodies, contusions, and open wounds.^{17,18}

Classifying Ocular Injury

Eye injury can be anatomically classified into anterior segment, posterior segment, adnexal, and orbital trauma. Ocular trauma can be described as penetrating or perforating. In a penetrating injury only one surface of an ocular structure is damaged (i.e. an entrance wound without an exit wound). Perforating injuries are defined as "double penetrating" injuries, creating both entry and exit wounds.¹¹ Blunt trauma can result in hematoma and contusion of periocular structures and globe ruptures. A rupture is a full thickness injury of the tissue that makes up the external boundaries of the globe. Ocular structures that are vulnerable to rupture injury include the limbus, areas of scleral thinning just posterior to rectus muscle insertions, and previous surgical incision sites.

The Ocular Trauma Classification Group provides a classification scheme for mechanical ocular trauma based upon the type and mechanism of injury, grade of injury based on visual acuity at presentation, and absence or presence of an afferent papillary defect.^{17,19}

Management

A thorough history will help identify and detail the cause of injury. The history should include when, where, and how the injury occurred in the patient's own words. The reporting and documentation of the history and physical exam often have medicolegal consequences, as many are work-related or a result of assault. The physician should inquire into any previous treatments for the current injury and the events occurring from the time of injury until the time of presentation. Past medical history including eye injuries, ocular surgeries, or history of amblyopia, medications, allergies, family history, social history, and date of last tetanus vaccination complete the highlights of the eye injury history.

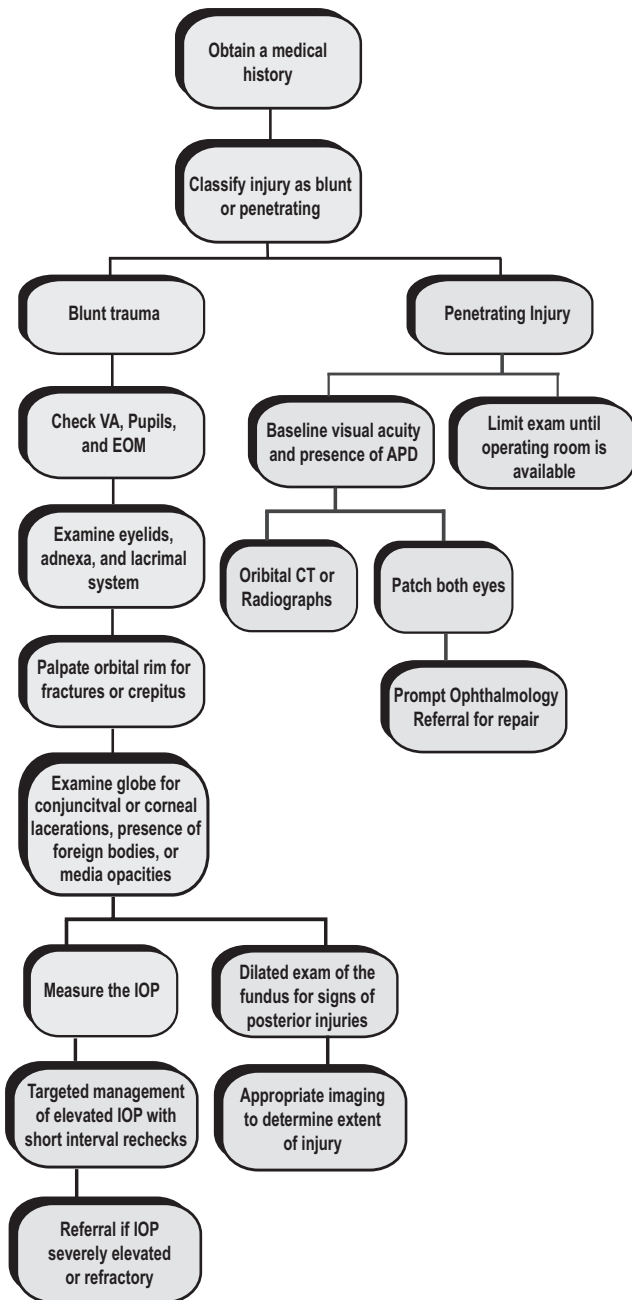


Figure 1: Management Guide for Ocular Trauma. Adapted with Permission from J Rowe and O Kosoko-Lasaki.

The examination should start with an assessment of visual acuity. Snellen Visual Acuity chart or near card testing are standard, but newspaper print is acceptable if neither is available. Counting fingers, hand movement, light perception, or no light perception should be documented, if the patient is unable to read the largest line (or 20/400 equivalent) on the visual acuity chart.

The examination of the eye should be comprehensive and must follow a logical sequence. A common practice among eye specialists is to examine the eye from the external and anterior structures to those more posterior. Examination of the traumatized eye thus begins with examination of the external structures and bony orbit. Palpation of the orbital rim detects fractures and or crepitus. The eyelids are evaluated for laceration, noting any involvement of the lid margins or lacrimal system. Examination of the pupils for their shape, size, symmetry, direct, and consensual responses to light should be noted. The pupillary exam is especially important in cases where intracranial injury is possible. The pupils should not be pharmacologically dilated until mental status has been assessed and neurologic status deemed stable. Evaluation of the extraocular muscle function in all directions of gaze may identify a restriction of gaze attributable to muscle entrapment within an orbital fracture or traumatic cranial nerve injury. Slit lamp examination of the globe allows classification of conjunctival hyperemia, subconjunctival hemorrhage, hyphema, corneal opacities and edema, foreign bodies, traumatic iris tears, and lens location and stability. Fluorescein strips can be used to delineate corneal abrasions and to detect any active aqueous leakage from the anterior chamber using the Seidel test. Intraocular pressure should be measured in all cases of ocular trauma, except those with an obvious open-globe injury, in which case manipulation of the globe should be minimized until evaluation and surgical repair is considered by an ophthalmologist.

Dilated fundus exam provides a view of the retina, macula, optic disc, and ocular vasculature. The red reflex is evaluated for brightness, shape, and symmetry between the two eyes. The ocular media is then checked for opacities, foreign body, or hemorrhage. Finally, the retina is evaluated for signs of choroidal rupture, commotio retinae, subretinal hemorrhage, and traumatic retinal tears and detachments. Depending on the type of injury, various forms of imaging modalities may be pursued. Radiographs, ultrasonography, CT, or MRI may be ordered. MRI is always contraindicated when a metallic foreign body is suspected. If perforating injury is suspected, imaging should be performed, both eyes patched, and immediate ophthalmology referral made for further evaluation and probable surgical repair. Figure 1 provides a general management model for blunt and penetrating ocular trauma.

Injuries to Anterior Structures

Orbital Injury: Trauma to the orbit, like all of ocular trauma, can be classified as blunt or penetrating. Orbital contusion is periocular bruising secondary to blunt trauma that can present with associated injury to the globe, sinuses, and bony orbit. The presence of an afferent pupillary defect, confrontation vi-

sual field defect, limited extraocular motility, and proptosis are ominous signs that should be further evaluated. Ice compresses can be used for 48 hours after injury to limit the swelling if the globe is found to be intact and vision is not affected. Orbital compartment syndrome is caused by the accumulation of blood from a retrobulbar hemorrhage. Clinical signs of orbital compartment syndrome include a tense orbit, proptosis, resistance to retropulsion of the globe, and limitation of eye movements. Emergency ophthalmology referral for possible lateral canthotomy is warranted.

Fractures of the orbit most commonly involve the orbital floor, and are termed blow-out fractures. The fracture of the maxillary bone allows prolapse of ocular contents into the maxillary sinus. Signs include diplopia in up or down gaze, enophthalmos, and orbital and eyelid emphysema if the patient has blown his or her nose since the injury. Urgent surgery is indicated in pediatric cases with signs of rectus muscle entrapment, but can be scheduled one week after injury in adults to allow reduction of swelling in the meantime.

Eyelid Injury: Eyelid trauma may often appear trivial but can have profound effects on injury associated morbidity. Recovery of full eyelid function and maintenance of the lacrimal apparatus are important considerations when approaching lid trauma. An eyelid contusion consists of edema and ecchymosis that often follows blunt trauma. The hematoma is embedded within the layers of the orbicularis oculi muscle and cannot be surgically evacuated. The hematoma of eyelid contusions does not typically result in ocular compartment syndrome, because they are located anterior to the orbital septum. Traumatic ptosis can result from direct injury to the levator muscles or mechanical effects of edema and hematoma and can take months to resolve. Cool compresses for 10-15 minutes a few times a day are generally sufficient in cases of isolated lid contusions.

When presented with eyelid avulsion (tearing or shearing injury) or laceration, the restoration of any lacrimal injury should be considered prior to repair. Injury to the canalicular system may require silicone tube stenting prior to careful suture placement. Unrecognized punctal, canalicular, or lacrimal sac injuries that are sutured without the use of a stent can lead to a lacrimal drainage obstruction and, subsequently, a chronic tearing state. Injuries to the inferior punctum, inferior canaliculus, or common canaliculus are more likely to cause significant tearing. Referral to an ophthalmologist is mandatory in cases of canalicular injury. The presence of orbital fat in the wound indicates a likely violation of the orbital septum and should be followed accordingly. Contaminated wounds should be debrided and treated with appropriate systemic and topical antibiotics. Tetanus vaccination status should be considered in all patients with these types of injuries.

Cornea and Conjunctival Injury: The anterior location of the cornea and conjunctiva make the structures vulnerable to both blunt and penetrating trauma. The conjunctiva may be torn or lacerated without damage to deeper or adjacent tissue. An area of hyperemia often surrounds the injury, which can be better

visualized using fluorescein. It is important to rule out damage to the underlying sclera and to rule out the presence of a foreign body. Smaller lacerations, generally those less than 5 mm in diameter, will heal without surgical intervention. Lacerations larger than 5 mm have the best outcomes when sutures are placed. Topical broad-spectrum antibiotic coverage is applied to prevent secondary infection of exposed tissues.

Corneal abrasions consist of epithelial cell erosions with an intact Bowman's membrane. The patient with a corneal abrasion often complains of a painful eye with reflex blepharospasm (involuntary lid squeezing) and increased tearing from the affected eye. The defect should be examined under the slit lamp to assess the size, location in relation to the visual axis, and rule out the presence of a foreign body. Application of fluorescein is used to visualize the defect, using a cobalt blue light. The benefit of patching the eye is controversial; however, it is a common practice by most health care providers. Close follow-up of the patient until the corneal epithelium has completely healed is standard practice.¹¹

Penetrating injuries of the cornea also require a complete eye examination to rule out damage to intraocular structures and the presence of a foreign body despite the obvious nature of the injury. Prolapsed iris tissue may be repositioned or removed during surgery, depending on the duration of exposure or the state (necrotic or not) of the tissue. Small puncture wounds and shelved lacerations often heal without suturing. Bandage contact lens and patching are options for treatment under the close care of an ophthalmologist. It is important to remove all foreign material and to reform the anterior chamber before placing corneal sutures.

Rupture of the cornea and/or sclera can result from blunt trauma. Susceptible sites of rupture include the limbus, posterior to the rectus muscle insertions, and areas of previous surgical incision sites. Signs of rupture include subconjunctival hemorrhage, hyphema, a change in anterior chamber depth, limited extraocular movements in the direction of gaze towards the rupture, and low intraocular pressure (hypotony). Globe rupture is a surgical emergency. The patient should be referred to ophthalmology for surgical evaluation and treatment.

Hyphema is blood in the anterior chamber, one of the signs of severe blunt or penetrating trauma. Partial or microscopic hyphema will resolve spontaneously through macrophage phagocytosis and via the aqueous drainage system.¹¹ Hemorrhage in the anterior chamber can occur up to two weeks after the initial trauma event. If large, the hemorrhage may cause an increase in intraocular pressure and blood staining of the corneal endothelium. Corneal blood staining can occur rapidly but takes months to completely clear and may require anterior chamber washout. Most cases of hyphema are managed conservatively by advising the patient to wear dark sunglasses for comfort. In African-Americans, it is important to avoid the use of carbonic anhydrase inhibitors in the lowering of the intraocular pressure because of the risk of sickling of the red blood cells in those at risk.¹¹ Surgery is indicated if there is blood staining of the cor-

neal endothelium or in severe medically uncontrolled intraocular pressure elevation.¹¹

Uveal Injury: Injury and damage to the anterior iris and ciliary body can occur with trauma. Traumatic iritis is an inflammation of the iris tissue itself with associated hyperemia (perilimbal), pain, photophobia, and tearing. The traumatic event may cause tears in the pupillary sphincter muscles. These tears are seen as irregular areas in the pupillary ruff. Pupillary constriction may be limited by the defects in these muscle fibers resulting in traumatic mydriasis. Treatment of traumatic iritis consists of pharmacologic mydriasis for comfort and topical steroids to control the inflammation. Iridodialysis is the tearing of the iris root from the ciliary body. The tear is permanent, and surgical treatment is not needed but may be considered in severe cases. Traumatic iritis may result in the formation of anterior or posterior synechiae, iris adhesions to the cornea, and lens capsule respectively.

Lens Injury: Trauma to the lens may leave a ring of pigment, a Vossius ring, on the anterior lens capsule. This finding is benign and usually clears with time but, in some cases, can permanently stain the capsule. Ocular trauma may also result in lens subluxation or dislocation. Anterior displacement of the lens may result in pupillary block glaucoma. Trauma to the lens may also result in premature cataract formation years after the inciting injury.

Glaucoma Secondary to Trauma

Angle recession is a tear between the longitudinal and circular muscles of the ciliary body and is the most common complication of blunt ocular trauma, occurring in 80.5% of cases following blunt ocular trauma.^{17,20,21} Ten percent of patients with angle recession that involves more than 2/3 of the angle develop glaucoma secondary to scarring of angle structures. The damage from angle recession is seen as a widening of the ciliary band on gonioscopy. Treatment involves topical and, in some cases, oral medications to reduce a high intraocular pressure in the days following the trauma. Patients with significant angle recession injuries should be followed by an ophthalmologist for IOP elevations, visual field testing, and optic nerve changes.¹¹ Penetrating injury can also induce elevated intraocular pressures and subsequent glaucomatous changes of the optic nerve. A recent review of the United States Eye Injury Registry showed that 2.64% of patients suffering penetrating ocular trauma develop glaucoma.^{17,21} A dislocated lens may also block flow through the trabecular meshwork. Risk factors that have been shown to be associated with post-traumatic glaucoma include: advanced age, lens injury, inflammation of the anterior chamber, and a baseline visual acuity of 20/200.²⁰

Intraocular foreign bodies can cause mechanical and other tissue alterations that may result in secondary glaucoma. Intraocular metals cause characteristic late tissue alterations. For example, iron-containing materials can cause ocular siderosis, a staining of the trabecular meshwork, and toxicity to other angle structures. Copper can lead to chalcosis with similar toxicity to structures of the iridocorneal angle if left in place. These

changes make identification and removal of foreign bodies essential to minimizing late tissue alterations and the development of secondary glaucoma. The viable red blood cells, degenerated red blood cells, and macrophages containing ingested red blood cell remnants that accompany hyphema can also obstruct the trabecular meshwork.

Treatment of post-traumatic glaucoma is aimed at reducing IOP by decreasing aqueous formation by the ciliary body, preventing further obstruction to aqueous outflow, or creating an alternate aqueous drainage route. An aqueous washout procedure can be used in cases of uncontrolled IOP elevation related to hemorrhage.¹¹ Ophthalmic preparations of prostaglandin analogues, beta-adrenergic receptor antagonists, alpha-adrenergic receptor agonists, and carbonic anhydrase inhibitors are commonly used to help reduce IOP. In acute or refractory cases, oral carbonic anhydrase inhibitors or osmotic diuretics can be utilized. In addition, surgical options should be considered in cases of elevated IOP that is not controlled with medical management. Potential surgically therapeutic options include trabeculectomy with anti-metabolites or implantation of a glaucoma Seton valve.

Injury to Posterior Structures

Trauma may manifest in the posterior segment as commotio retinae, choroidal rupture, posterior scleral rupture, or retinal breaks and detachments. Commotio retinae generally presents as a gray-white discoloration of the retina secondary to disruption of the outer segment of the photoreceptors. It may be accompanied by choroidal rupture and subretinal hemorrhage and can be observed initially as asymmetry of the red reflex in the injured eye if sufficiently large and located on the central posterior pole. Choroidal rupture is a tear in the choroid, Bruch's membrane (the layer between the choroid and retinal pigment epithelium), and the retinal pigment epithelium following blunt trauma. These findings on dilated exam are supplemented by findings on ultrasound, CT scan, and MRI. Traumatic retinal detachments require emergent evaluation and possible repair by an ophthalmologist.¹¹

Sympathetic Ophthalmia: Sympathetic ophthalmia is the most feared complication of ocular trauma. It is characterized by a bilateral, granulomatous uveitis following penetrating eye injury. The pathophysiology is believed to involve an autoimmune reaction to uveal antigens encountered as a result of the initial trauma event. Inflammation first occurs in the injured eye. The uninjured eye is termed the "sympathizing" eye and becomes secondarily affected. Symptoms include blurred vision, photophobia, pain, and ultimately blindness. Once established, sympathetic ophthalmia requires steroids and immunosuppressant agents to slow the progression. Onset can occur anytime from one week to several years following the injury, but most cases do not occur before two weeks after injury. For this reason, injured eyes that have little or no potential for visual recovery are strongly considered for enucleation within two weeks after injury. In the case presented in this article the eye had no light perception and was recommended for enucleation.

Conclusion

Penetrating eye injuries can be challenging to assess, given the associated pain and difficulty with examination. A good history and minimal examination will prompt referral for management of these serious injuries.

While surgical treatment modalities continue to improve, the most effective approach to ocular trauma is a proactive approach to prevention. Primary prevention of ocular injury is firmly based in improving patient education, proper safety equipment and practices, risk reduction, and close supervision of all high-risk activities. Prevention of ocular trauma, like all types of trauma, remains an ongoing battle. Legislation efforts regarding nonpowder or air guns are in place or underway in 30 states. New York has the strictest regulations in the US. In New York City BB guns are entirely prohibited and licenses are not available. In the rest of the state, no one under the age of 16 can purchase or use a pellet gun unsupervised. Florida has also enacted legislation aimed at reducing injury rates. Florida state law holds a minor under 16 years of age to be guilty of a second-degree misdemeanor if found using a BB gun without adult supervision. The laws vary from state to state, with some states regarding nonpowder guns as firearms and other not addressing them at all. Many authors support wider restrictions on the sale and use of nonpowder guns.¹⁴ Others promote improving safety education and requiring proper apparel while using nonpowder guns. Standardization of warning labels and their strategic placement has been considered and modified. Perhaps a short safety course and test can be included in store packaging to be administered by a supervisory adult prior to use. Whatever means of prevention is pursued, the goal remains to minimize the risk of injury via responsible operation and safety precautions.

Finally, we recommend that all patients with previous ocular injury should be fitted with protective (polycarbonate) glasses, especially if they are involved in active sport activities.

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