An Evidence-Based Approach To Traumatic Ocular Emergencies

A 21-year-old male presents to the ED complaining that his vision seems “waxy,” as if something is jiggling inside his eye. One hour earlier he was standing on the street when he heard what sounded like a gun firing. He felt “something funny” in his eye, but there was no blood and no real pain. On exam there is no periorbital swelling and no obvious trauma to the eye itself. His visual acuity is 20/40 in the right eye and 20/30 in the left. Further examination of the right eye reveals a small gray mark in the sclera just lateral to the iris. You wonder if this could be an entry wound and, if so, what would be the best way to detect an intraocular foreign body (IOFB). You also wonder whether you should administer an antibiotic.

While you are thinking about the young man’s problem, another patient with an eye complaint arrives in the ED. A 55-year-old woman presents with pain in her eye after walking along a wooded trail. She thinks that she felt something fly into her left eye, and the pain started after she rubbed her eye. Back at home, she rinsed her eye out with some water and felt “something funny” in his eye, but there was no blood and no real pain. “Wavy,” as if something is jiggling inside his eye. One hour earlier he was feeling "something funny" in his eye, but there was no blood and no real pain. You also wonder whether you should administer an antibiotic.

Eye emergencies account for almost 3% of all ED visits in the United States\(^1\) and 1.4% of all ED visits involving an injury.\(^2\) It is exceedingly likely that the ED clinician will encounter ocular trauma on at least a weekly basis. Patients are often understandably anxious about their vision and the threat of vision loss. A systematic approach to evaluating the injured eye is essential to identify the cause of the problem.

Upon completion of this article, you should be able to:
1. Identify common traumatic eye injuries and disorders.
2. Develop a systematic history and physical examination for traumatic eye injuries.
3. Initiate emergency evaluation for blunt and penetrating eye trauma.
4. Initiate emergency treatment for blunt and penetrating eye trauma.

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Prior to beginning this activity, see “Physician CME Information” on back page.
1988 the United States Eye Injury Registry (USEIR) was established to collect information from EDs as well as from physicians’ offices; the forms can be found online (www.useironline.org) in single-page format, with a 6-month follow-up report. The USEIR also introduced a standard classification called the Birmingham Eye Trauma Terminology (BETT) to improve data collection and facilitate the sharing of information. (See Figure 1.)

**Critical Appraisal Of The Literature**

A literature search was conducted using PubMed (www.pubmed.gov), Ovid MEDLINE® (www.ovid.com), University of Medicine and Dentistry of New Jersey (UMDNJ) electronic books and journals, the Cochrane Database of Systematic Reviews, and specialty practice guidelines. The search was limited to English language literature published between 1999 and 2009. Search terms included eyelid and canalicular lacerations, intraocular foreign bodies, corneal abrasions and lacerations, traumatic uveitis, cataract and glaucoma, hyphema, orbital wall fractures, globe rupture, and endophthalmitis.

From this initial search, more than 120 articles were chosen for review, and additional articles were identified through a manual search of the bibliographies. High-quality research related to ocular trauma is scarce, and most of the literature consists of case series and retrospective analyses. In addition, data on eye injuries in the US have been limited by the lack of consistency in terminology and ambiguity in the descriptions of these injuries. In 1988 the United States Eye Injury Registry (USEIR) was established to collect information from EDs as well as from physicians’ offices; the forms can be found online (www.useironline.org) in single-page format, with a 6-month follow-up report. The USEIR also introduced a standard classification called the Birmingham Eye Trauma Terminology (BETT) to improve data collection and facilitate the sharing of information. (See Figure 1.)

**Anatomy Of The Eye**

The frontal, maxillary, zygomatic, and lacrimal bones come together to form the bony orbit. The walls of the orbit are referred to according to their anatomic location: superior, inferior, medial, and lateral. The eyelids, lacrimal gland, and canalicular system make up the adnexal structures of the eye. (See Figure 2.) The globe is divided into 2 segments: anterior and posterior. (See Figure 3.)

The anterior segment includes the cornea, limbal conjunctiva, iris, anterior chamber, and lens. The conjunctiva is a thin, transparent mucous membrane that covers the sclera (bulbar conjunctiva) and the inner surface of the eyelids (palpebral conjunctiva). The sclera is a tough layer of collagen and elastic fiber that surrounds the entire globe, except for the cornea, and gives the eye its white appearance. The cornea is the anterior-most aspect of the eye. It is transparent, allowing light to be transmitted and focused through the pupil. The iris is a diaphragm

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**Figure 1. BETT Eye Injury Classification**

![Figure 1](image-url)

**Note:** Some injuries are difficult to define, such as a BB pellet within the vitreous; technically, this is an intraocular foreign body (IOFB) caused by a blunt object. As a result, it can also be described as a “mixed” rupture with IOFB. This figure was published in *Ophthalmology Clinics of North America*, Volume 15, Kuhn F, Morris R, Witherspoon CD. Birmingham eye trauma terminology (BETT): terminology and classification of mechanical eye injuries, pages 139-143, copyright Elsevier, 2002. Used with permission.
Chemical exposures are the second most common events. In industrialized countries, eye injuries due to traffic “accidents” are increasing in incidence; just walking along a highway is associated with risk for corneal injury and an IOFB. In the US, injuries related to firearms and BB guns represent 12% of injuries. States that allow the private use of fireworks report a much higher incidence of eye injuries than do states where it is prohibited. Sports injuries, especially among baseball and basketball players, represent 12% of eye injuries. Sixty percent of paintball pellet injuries involve the eye. When injuries related to eyeglasses are considered as a separate category, 89% occur in wearers over 65 years of age.

**Injury Prevention**

ED clinicians have been leaders in advocating for mandatory seatbelts, child restraints, and motorcycle and bicycle helmets. Public health and professional organization websites provide information for educating people about appropriate eye protection at work and at play.

**Worksite Safety**

In the US, the Occupational Safety and Health Administration (OSHA) provides oversight to regulate and enforce protective eyewear on the job. The National Institute for Occupational Safety and Health (NIOSH) offers an Eye Safety Checklist that is available at no charge at their website (www.cdc.gov/niosh).

**Highway Safety**

Public safety initiatives requiring seat belts and airbags have been shown to save lives and reduce injuries. Laminated windshields – which shat-
ter into many smaller pieces rather than into large, sharp shards – have also helped reduce eye injuries.3

Protective Eyewear In Sports
Over the past 20 years, the use of protective eyewear by athletes who participate in ice hockey (especially in youth leagues), racquetball, and squash has had a positive impact on the incidence of serious eye trauma.3 In 1995–1996, the American Academy of Ophthalmology, together with the American Academy of Pediatrics, published a joint policy statement on the use of protective eyewear during sports. The guidelines include specific recommendations for a variety of sports and the minimum eyewear requirements for each type of sport based on research carried out by the American Society for Testing and Materials (ASTM). Updated and reapproved in 2003, these guidelines were designed specifically for the protection of young athletes, but they can be extrapolated for anyone engaging in a sport that puts the unprotected eye at increased risk for a traumatic injury.11 (See Table 1.)

Prehospital Care
There are no evidence-based guidelines for the prehospital management of eye injuries. Local protocols may vary depending on the emergency medical services (EMS) command, trauma triage guidelines, the number and proximity of receiving hospitals, and the length of transport time. In all cases, however, the ABCs of resuscitation and trauma evaluation take precedence over the management of ocular injuries.

Textbooks for emergency medical technicians (EMTs) and paramedics provide a general approach to eye injuries that covers 3 discrete areas: (1) decontamination of chemical exposure; (2) stabilization of a protruding object; and (3) protection of the eye from further damage. Any object protruding from the eye should not be removed but should instead be stabilized during transport.13 If there is nothing obviously sticking out of the eye and the patient cannot open the eye, the EMS provider should refrain from forcibly opening the lids and should apply either a metal or a rigid plastic shield over the eye. If such a shield is not available, a disposable cup can be taped over the injured eye.14

ED Evaluation
The goal of the “ophthalmologic” evaluation is a systematic and logical delineation of any and all injuries. Life- and limb-threatening conditions take priority. For example, in the setting of multiple traumatic injuries, the evaluation of the ruptured globe may need to be deferred until other major systemic or brain injuries are addressed.

History
The EMT or the ED clinician should attempt to determine how, when, and where the eye injury occurred and what the injury entails, making sure that the following information is requested.

• Mechanism of injury: How did the injury occur? The answer elicited should be as detailed as possible. Ask the patient or witness to describe the event and ask whether the injury was blunt or penetrating, whether an airbag deployed, and whether protective eyewear was in place. If the injury is an IFOB, remember that 20% of all such patients have no associated pain.

• Time of injury: When did the injury occur? Is this a recent (“fresh”) penetrating injury that might need emergency surgery, or did the injury occur a few days ago? A delayed presentation that appears “quiet” (ie, with no evidence of infection) might continue to be managed expectantly and nonoperatively.

• Place of injury: Where did the injury occur? Was it in a rural environment?

• Composition of IOFB: What might the foreign body contain? Is it organic material (vegetal) or metallic? If the latter, what was the specific type of metal? If the object is composed of chemicals, is it basic or acidic? Is it a biologic or chemical weapon? Answers to these questions are critical both for determining the method of evaluation and for optimal management.

• Past medical history: Are there any general medical conditions or medications that could affect the visual outcome? For instance, diabetes and chronic steroid use are well-known risk factors for poor healing.

• Previous ocular surgery: Had the patient undergone any eye surgery in the past? The site of a previous surgical incision is likely to be a weak point, predisposing to an open-globe injury.

• Current ocular medications: The use of intraocular steroids prior to the injury may predispose to infection.

• Baseline vision: What was the patient’s vision like before the accident? It is important to establish visual acuity both before and after the injury in each eye and in both eyes. Injury to the good eye carries great significance for a patient who is functionally or physically blind in the other eye.14

Physical Examination
The key to examining the injured eye is to use a systematic approach while remaining vigilant for possible penetration or rupture of the globe. First, do an external inspection, followed by an assessment of visual acuity, central and peripheral vision, and ocular motility. Next, if possible, evaluate the specific areas of the eye from “outside in” using a slit
lamp; if the patient is unable to sit still or cooperate, a handheld light and magnifying glass may be used instead. Finally, perform direct ophthalmoscopy, but remember that dilation is contraindicated in patients with an open-globe injury.

**External Examination**

Under a bright light, inspect the scalp, face, periorbital tissues, and eyelids for lacerations, ecchymoses, foreign bodies, and edema. Inspect the globe for protruding foreign bodies, prolapse of ocular contents, hemorrhage, irregular pupils, and pronounced exophthalmos. Stabilize, but do not remove, any protruding foreign body until controlled removal can be accomplished in the operating room (OR). If you suspect globe rupture, stop the examination, avoid placing any pressure on the orbit, and lightly tape a protective shield over the eye. Contact the ophthalmologist on call, who will need to do a full examination in the operating room under controlled circumstances. Only after you are certain that there is no globe rupture or penetration, apply gentle traction to the eyelids or gently use a lid retractor or speculum to gain access to the visual axis.

**Visual Acuity**

Ideally, determine visual acuity using a Snellen chart. Each eye should be evaluated separately, with the injured eye evaluated first to prevent memorization of letters on the chart (assuming poorer vision in the injured eye). Have the patient sit or stand 20 feet from the chart; the exact procedure for reading the eye chart has been well described elsewhere. Record the results as a fraction, with the numerator as the distance to the chart and the denominator being the line at which 50% of the letters are correctly identified (eg, 20/100).

For many moderately or severely injured patients, standing up and reading a chart is not feasible or practical. The next best option is a near card, held 14 inches from the eye(s). With this method, 14 becomes the numerator, and the line at which 50% of the letters can be identified is the denominator. If the patient’s eyeglasses are lost or missing, a pinhole card may act as a substitute for them. Several small pinholes are made in a piece of cardboard and held in front of the patient’s eyes, 1 at a time, as vision is again checked with the Snellen chart or near card. The pinhole card allows parallel rays of light to pass through the holes and land directly on the retina without the need for refraction (ie, glasses). When a patient who usually wears glasses is unable to see with this method, this is suggestive of a pathologic lesion interfering with visual acuity.

For patients who are unable to see the letters, the ED clinician can employ other means of assessment. In decreasing order of their abilities, patients should be asked to count fingers, to detect gross hand movements, and finally to respond to light by estimating perception as bright, barely, or none. Changes in color vision may also reflect optic nerve defects; when the optic nerve is damaged, red objects will appear grayish or washed out.

**Afferent Pupillary Defect**

An important indicator of visual function is the presence or absence of an afferent pupillary defect (APD), also referred to as a relative afferent pupil defect (RAPD). In the normal eye, the pupil constricts to direct light (the direct light reflex) but

<table>
<thead>
<tr>
<th>High Risk</th>
<th>Moderate Risk</th>
<th>Low Risk</th>
<th>Safe</th>
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<tbody>
<tr>
<td>Gun sports:</td>
<td>Tennis</td>
<td>Swimming</td>
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<tr>
<td>Air gun</td>
<td>Badminton</td>
<td>Diving</td>
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<td>BB gun</td>
<td>Soccer</td>
<td>Skiing (snow or water)</td>
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<td>Paintball (ASTM 1776)</td>
<td>Volleyball</td>
<td>(ASTM F659)</td>
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<tr>
<td>Balls and “sticks”:</td>
<td>Water polo</td>
<td>Wrestling</td>
<td></td>
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<tr>
<td>Baseball (youth) (ASTM F910)</td>
<td>Football</td>
<td>Bicycling</td>
<td></td>
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<tr>
<td>Softball</td>
<td>Fishing</td>
<td>Martial arts — no contact</td>
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<tr>
<td>Cricket</td>
<td>Golf</td>
<td>Track and field</td>
<td></td>
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<tr>
<td>Ice hockey (ASTM F513)</td>
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<td>(Javelin and discus require good field supervision)</td>
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<tr>
<td>Field hockey</td>
<td></td>
<td>Gymnastics</td>
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<td>Racquet sports with close contact:</td>
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<td>Squash</td>
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<td>Racquetball</td>
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<td>Fencing</td>
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<td>Boxing</td>
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<tr>
<td>Martial arts — full contact</td>
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</tbody>
</table>

American Society for Testing and Materials (ASTM) recommendations should be used when purchasing or using protective eyewear. Unless otherwise noted, the eyewear recommended by the ASTM for all sports is ASTM F803.
also when light is shone into the other eye (the consensual reflex). This requires intact iris muscles, retina, and optic nerve. The swinging flashlight test to detect an APD is performed as in Figure 4.\textsuperscript{15,16,17} A penlight or other light source is shone first in one eye and then in the other, swinging back and forth. Both pupils should constrict when light is shone in either eye and dilate when the light source is removed (as in the left column). If, as in the center column, the left eye has an afferent defect due to damage to the retina or optic nerve, the left eye will constrict to light shone in the right eye but dilate to direct light (preserved consensual reflex). The term “relative” is used when the pupil constricts a little but less than the normal eye. The right-hand column indicates what happens if the left pupil has both an afferent as well as an efferent deficit.

**Visual Fields And Ocular Motility**

At the bedside, conduct gross, confrontational visual-field examinations of each eye separately. To assess ocular motility, have the patient look in all 4 directions while keeping the head pointed straight ahead. Entrapment of ocular muscles (eg, with an orbital wall fracture) can be demonstrated by asking the patient to look upward. However, do not perform this test if globe rupture is suspected.\textsuperscript{14}

**Slit-Lamp Examination**

The slit lamp is used to examine the conjunctiva, cornea, sclera, anterior chamber, iris, and lens. If the patient has (or is suspected of having) an open-globe injury, this test should not be performed! The patient must be able to sit up and cooperate. Before examining the conjunctiva and sclera, administer a few drops of topical anesthetic (such as 0.5% proparacaine or 0.5% tetracaine), but be sure to use an opened bottle to prevent the introduction of possibly contaminated material into the injured eye.\textsuperscript{14}

To evert the eyelid, ask the patient to look down, and applying a clean, cotton-tipped swab to the superior palpebral sulcus, grasp the eyelashes with your free hand and gently lift the lid back over the swab. Do a thorough exploration and eversion of both lids to look for foreign bodies that might be sequestered under the lids. Again, do not perform eversion if there is an obvious open-globe injury. In gathering data, remember that conjunctival lacerations may indicate underlying injury to the sclera and that hemorrhagic chemosis may indicate orbital fracture or open-globe injury.\textsuperscript{14}

The Seidel test is used to detect full-thickness corneal laceration or rupture. This test is performed using fluorescein dye and a cobalt-blue light. A few drops of 2% fluorescein dye are placed on the cornea, and the result is positive when aqueous fluid leaking from a corneal laceration appears as a green stream in the middle of a pool of bright yellow.\textsuperscript{14,15}

Next, the anterior chamber should be examined for the presence of abnormal cells. Any inflammatory cells will appear similar to dust specks floating in a brightly sunlit room; red blood cells appear as brown dust.\textsuperscript{15} Blood in the anterior chamber will appear as a brown or red meniscus in front of the iris, called a hyphema. This type of hemorrhage can often be seen with the naked eye or a magnifying lens. (See section on Hyphema on page 10.) Ideally, the ED clinician should also try to assess the depth of the anterior chamber. A “deep” chamber may indicate posterior dislocation of the lens, iridodialysis, or scleral rupture, whereas a “shallow” chamber can occur with anterior lens dislocation, vitreous prolapse, leaking corneal or scleral wounds, choroidal injury, or closed-angle glaucoma.\textsuperscript{14}

Last, examine the crystalline lens for dislocation or cataract formation. In the absence of a slit lamp, a handheld light and ophthalmoscope set at +6 to focus on the cornea and anterior chamber should facilitate identification of a hyphema, a cataract, or pupillary irregularities.

**Intraocular Pressure Measurement**

In open-globe injuries, measurement of the intraocular pressure (IOP) should be deferred until after surgical repair has been accomplished. Obtain pressures using a Schiotz tonometer, a hand-held tonometer, or a Goldmann applanation tonometer attached to the slit lamp.\textsuperscript{15} By consensus, normal IOP is considered to be between 10 and 20 mm Hg. Low pressures may be an indication of occult globe rupture or lacerations...
tion, injury to the ciliary body, or retinal detachment. A normal or even high IOP does not rule out open-globe injury or rupture. IOP may be elevated immediately after contusion to the globe, in the presence of cells in the anterior chamber, in mechanical angle closure, and with anterior dislocation of the lens.\textsuperscript{14}

**Direct Ophthalmoscopy**

Examination of the posterior segment (vitreous, retina, and optic nerve) performed early in the ED visit is probably the best opportunity to see the fundus before the “view” is obscured by hyphema, traumatic cataract, or vitreous hemorrhage.\textsuperscript{14} A 0.5% ophthalmic solution of tropicamide, a short-acting papillary dilator, may be useful for a better funduscopic view.

Again, ophthalmoscopy is contraindicated in patients with open-globe injuries. In cases of severe injury or open-globe rupture, the posterior segment may be evaluated by computed tomography (CT) or ultrasound (US). If neither of these modalities is available, ophthalmoscopy may need to be deferred until a ruptured globe or lacerations have been repaired.

**Imaging In Ocular Trauma**

Ultrasonography and CT scanning are the 2 most useful modalities in evaluating severe ocular trauma. With use of a high-frequency probe (7.5-10 MHz), US allows the ED clinician to rapidly evaluate many intraorbital structures. It can be used to delineate choroidal and scleral lacerations, vitreous hemorrhages, retinal detachment, radiolucent and radiopaque foreign bodies, and retrobulbar hematomas (See Figure 5.). Ultrasound can be performed at the bedside within a few minutes of the patient’s arrival in the ED. A small prospective observational trial of bedside US performed by ED physicians in traumatic and nontraumatic eye conditions demonstrated a sensitivity of 100% and a specificity of 97% compared to confirmatory CT or ophthalmologic examination.\textsuperscript{18}

Ultrasound is contraindicated when the risk of extrusion of intraocular contents is high, such as with large globe lacerations or the uncooperative patient.\textsuperscript{13} In addition, this modality may miss small, wooden, or organic foreign bodies, and the presence of small gas bubbles may yield false-positive results.\textsuperscript{7} In the cooperative patient, a large amount of ultrasonic gel can be applied to the closed lid, thus cushioning the linear transducer and avoiding its direct contact with the eyelid or globe. The eyelids remain closed and the patient will experience minimal additional discomfort.\textsuperscript{18,19}

CT scans are currently the most common modality used in hospitals to evaluate the injured eye. Both axial and coronal views should be ordered to detect any orbital fractures. Ultrathin (1 mm) tomographic slices may be needed to localize IOFBs. CT is also indicated when the posterior segment cannot be visualized and in cases of suspected occult globe rupture or laceration and with metallic foreign bodies.\textsuperscript{14,20}

For the past 20 years, magnetic resonance imaging (MRI) has been used in the diagnosis of orbital and periorbital tumors and to characterize optic nerve disorders.\textsuperscript{21} Unlike US, MRI can be used to delineate small, wooden, and organic matter foreign bodies; however, the operator must be sure that no metallic IOFBs are present, since application of the magnetic field risks further damage from shifting of the foreign object.\textsuperscript{7} Disadvantages of MRI include the relatively long scanning times and the need for patient cooperation to prevent motion artifact.\textsuperscript{21}

**Decision Models For Predicting Visual Outcome After Injury**

The ocular trauma score (OTS) was developed in 2002 by Kuhn et al using data from the USEIR and the Hungarian Eye Injury Registry and is used to predict visual outcome after injury.\textsuperscript{22} Points are assigned for several variables, including initial vision, presence of rupture, endophthalmitis, perforation, retinal detachment, and RAPD, and the totals fall into 5 prognostic categories, with higher scores reflecting better initial visual acuity and fewer structural defects. In general, the higher the initial score, the better the prognosis for a good visual outcome. These categories can be useful in preparing the

**Figure 5. Ultrasound Image Of Detached Retina**

Used with permission from Bret Nelson, MD.
The thin, transparent outermost covering of the eye is the cornea. It is made up of multiple layers and provides a physical barrier to the eye, protecting it from infection and trauma. In terms of history, the patient may or may not remember a traumatic event.

Presentations usually include acute pain, tearing, photophobia, sensation of a foreign body, blurry vision in the affected eye, and possibly headache. These symptoms usually worsen with exposure to light, repeated blinking, or rubbing of the eye. Direct visualization of the cornea, preferably using a slit lamp, is necessary to make the diagnosis. A topical anesthetic such as proparacaine or tetracaine should be instilled in the eye to facilitate the examination, followed by the application of fluorescein dye. The room is darkened and using a cobalt-blue filtered light, the entire cornea is examined. Abrasions will appear yellow-green.

Complications from simple corneal abrasions are rare; however, a syndrome of recurrent corneal erosion has been described that presents as repeated spontaneous corneal epithelial defects that may occur on awakening or after rubbing the eyes. Symptoms are similar to corneal abrasions but milder. The lesions appear at or near the original area of injury and are thought to be due to weakened corneal barrier function.

Minor corneal abrasions are treated with topical or oral nonsteroidal anti-inflammatory drugs (NSAIDs) and topical antibiotics. Common topical NSAIDs used include diclofenac and ketorolac. Studies have shown that topical NSAIDs are effective at reducing pain, allowing lower doses of oral analgesics and narcotics, and allowing the patient to return to work sooner. In clinical trials conducted more than 10 years ago outside the US, topical antibiotics not commonly used in this country (ie, chloramphenicol) produced conflicting results with regard to their benefit. To date, no new data have been reported. If a topical antibiotic is used, it should be affordable and safe and be associated with a low incidence of hypersensitivity reactions (eg, polymyxin B/trimethoprim ophthalmic drops). Neomycin preparations are associated with an unacceptably high incidence of sensitivity reactions. Most corneal abrasions heal within 24 to 72 hours, and outpatient follow-up with an ophthalmologist is usually necessary only for those patients with deep or large abrasions or those whose symptoms persist for longer than 48 hours.

A number of studies from the 1980s and early 1990s documented an association between soft contact lens use and susceptibility to Pseudomonas colonization and infection, since these lenses have been shown to enhance pseudomonal adherence to the cornea. No randomized, prospective trials have been conducted to confirm this. If a patient with a corneal abrasion wears contact lenses, or if the corneal abrasion was the result of contact with vegetal matter (eg, from a piece of wood), antibiotic coverage should include antipseudomonal activity (eg, ciprofloxacin or ofloxacin ophthalmic drops). Such patients should return for a follow-up visit with an ophthalmologist within 24 hours even if they are feeling well. Contact lenses should not be worn until the abrasion has healed and the course of antibiotic therapy has been completed.

A 2006 Cochrane review on eye patching after corneal abrasion identified 11 trials with a total of 1014 patients. These studies looked at pain reduction and rate of healing and concluded that minor corneal abrasions do not benefit from eye patching. Moreover, use of an eye patch causes monocular vision and may present a safety risk. Based on good-quality evidence, eye patches are no longer recommended for minor corneal abrasions less than 10 mm.

Complications from simple corneal abrasions are rare; however, a syndrome of recurrent corneal erosion has been described that presents as repeated spontaneous corneal epithelial defects that may occur on awakening or after rubbing the eyes. Symptoms are similar to corneal abrasions but milder. The lesions appear at or near the original area of injury and are thought to be due to weakened corneal barrier function.
tissue. Treatment is similar to that for the initial abra-
sion, with referral to an ophthalmologist in
cases of persistent symptoms or deep lesions. Pro-
phylactic measures such as topical lubricating gels
or topical antibiotics for a period of 2 months are
generally acceptable, although the evidence for these
measures is slim. According to a recent Cochrane
Review, evidence was not sufficient to support other
therapies for refractory cases, such as contact lenses
versus oral tetracyclines versus laser or surgical
treatments. (See Table 2.)

**Traumatic Uveitis (Iridocyclitis), Traumatic
Mydriasis, And Traumatic Iridodialysis**

The uvea is composed of the iris, ciliary body, and
choroid. These structures are usually flexible enough
to withstand moderate trauma without much dam-
age; however, with more severe blunt trauma, injury
either structural damage or a post-traumatic inflam-
atory response) can occur immediately or several
days later.

**Traumatic Uveitis**
The iris is the most anterior portion of the uveal
tract. Inflammation of this portion of the uvea has
been saddled with changing terminology over
the years. “Uveitis” or “anterior uveitis” are the
common terms and are often used interchange-
ably. “Iridocyclitis” describes the condition more
specifically, referring to the part of the uvea that
is actually inflamed, but it is not often used in the
emergency medicine literature. “Iritis” is an old
term that refuses to go away and may still be used
in day-to-day practice. In traumatic iridocyclitis,
the iris and its attachment to the anterior ciliary
body become irritated and inflamed, resulting in
miosis and spasm of accommodation. The annual
incidence of uveitis is 17 in 100,000 people. Ante-
orior uveitis is more common than posterior uveitis
and usually occurs between the ages of 20 and 50
but rarely before age 10 or after age 70.

On presentation, the patient with uveitis may
complain of a painful, red eye with tearing, photopho-
bia, and blurry vision. The conjunctiva of the
affected eye may be injected, with a small, poorly
dilating pupil. Light directed at the unaffected eye
will result in pain and photophobia in the affected
eye. The presence of cells and flare in the anterior
chamber on slit-lamp examination, along with
miosis and pain, are diagnostic of anterior uveitis.

Itraocular pressure should be measured to identify
a more serious injury to the globe, such as secondary
glaucoma. The disease process is self-limited and
usually resolves within 7 to 14 days. Although there
are no outcomes data from randomized, controlled
trials to support the current treatment for traumatic
uveitis, recommendations include cycloplegic
agents, prednisolone acetate 1%, and discharge
home, with outpatient follow-up with an ophthal-
mologist within 2 to 3 days. Cycloplegic agents such
as homatropine 5% for 7 to 10 days will relieve the
pain associated with ciliary spasm and may pre-
vent adhesions from developing between the pupil
and lens. Prednisolone acetate 1% achieves a high
concentration in the anterior chamber and is thought

<p>| Table 2. Treatment Of Traumatic Ocular Emergencies |</p>
<table>
<thead>
<tr>
<th>Condition</th>
<th>Treatment</th>
<th>Clinical Pearl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corneal abrasion</td>
<td>• NSAIDs, either topical or oral</td>
<td>Think of Pseudomonas exposure with contact lens users and exposure to vegetal material</td>
</tr>
<tr>
<td></td>
<td>• Topical antibiotics</td>
<td></td>
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<td></td>
<td>• Oral narcotics</td>
<td></td>
</tr>
</tbody>
</table>
| Traumatic uveitis (irido-
  cyclitis)                | • Topical cycloplegics, eg, homatropine 5%    | Measure IOP to detect associated injuries such as secondary glaucoma |
|                            | • Topical steroids, eg, prednisolone acetate 1%|                |
|                            | • Ophthalmology consult with follow-up in 2-3 days|                |
| Traumatic glaucoma          | Treat with all:                               | Miotics may be contraindicated in patients who have undergone cataract surgery or lens extraction |
|                            | • Topical α-blocker                           |                |
|                            | • Topical β-blocker                           |                |
|                            | • Carbonic anhydrase inhibitor (acetazolamide 500 mg IV or PO) |                |
|                            | • Hyperosmolar agent (mannitol 1 to 2 g/kg IV) |                |
|                            | • Re-evaluate IOP hourly                      |                |
|                            | • When IOP < 40 mm Hg, start topical cholinergic agent (ie, pilocarpine) |                |
|                            | • Ophthalmology consult                       |                |
| Hyphema                    | • Rigid shield to protect eye                 | Check IOP: elevated IOP is an indication for admission; prolonged elevated IOP is an indication for surgery |
|                            | • Elevate head of bed 30°                     |                |
|                            | • Oral analgesics                             |                |
|                            | • Topical cycloplegics                        |                |
|                            | • Topical steroids                            |                |

Abbreviations: IOP, intraocular pressure; IV, Intravenous; PO, by mouth.
to reduce the inflammatory response. In severe cases, it may be administered hourly initially and then gradually reduced. Complications of uveitis include cataract formation and glaucoma; however, since steroid treatment itself has been associated with these 2 complications, prednisolone therapy should be initiated in consultation with an ophthalmologist, with the assurance of follow-up visits. (See Table 2, page 9.)

Traumatic Mydriasis And Miosis
Traumatic mydriasis (pupillary dilatation) occurs when there are small tears to the sphincter muscle of the iris. Traumatic miosis (pupillary constriction) occurs when the iris sphincter becomes damaged and irritated. With either entity, the patient often complains of eye pain or blurry vision. In a patient with significant head trauma or altered mental status, the possibility of cranial nerve palsy due to increased intracranial pressure must be ruled out first by means of appropriate neuroimaging. For isolated traumatic mydriasis or miosis, no specific ED treatment is indicated since the condition often resolves spontaneously.

Traumatic Iridodialysis
In traumatic iridodialysis, the ciliary body is torn from the iris root, leading to the formation of a “secondary pupil.” The patient may complain of pain as well as double vision in the affected eye, but visual acuity should be unaffected. Because of the force required to tear the ciliary body, a full eye examination must be done. If there is a hyphema or visual acuity is decreased, retinal or vitreous injury should be suspected and an urgent ophthalmologic consultation is warranted. If there is persistent monocular diplopia, surgical repair may be indicated.

Traumatic Glaucoma
Blunt or penetrating trauma may cause acute traumatic glaucoma. The increase in IOP may occur early or late after the injury. Although it can be due to various mechanisms, the increased pressure is usually due to impaired trabecular drainage. In a recent cohort study from the USEIR published in 2005, the risk of developing post-traumatic glaucoma was very low (2.67%). It is more likely to occur after a closed-globe injury (77%) than an open-globe injury (23%). The development of glaucoma was independently associated with advancing age, lens injury, poor baseline visual acuity, and inflammation. The presentation is similar to acute angle closure or “narrow angle” glaucoma, with patients complaining of cloudy vision and eye ache or pain. Nausea and vomiting are common. In healthy patients, the optic nerve can tolerate moderately elevated IOP for a short period of time; however, prolonged elevations in pressure can result in permanent vision loss.

Elevated IOP should be treated aggressively, and pressures exceeding 21 mm Hg should prompt a call to the ophthalmologist. The treatment of traumatic glaucoma is similar to that of acute narrow-angle glaucoma. In the ED, the patient should be given a topical β-blocker, a topical α-blocker, a carbonic anhydrase inhibitor (acetazolamide 500 mg intravenously [IV] or orally), and a hyperosmolar agent (mannitol 1 to 2 g/kg IV). Intraocular pressure should be reevaluated hourly. Once IOP drops below 40 mm Hg, a topical cholinergic agent such as pilocarpine should be started. Miotics may be contraindicated in patients who have previously undergone cataract surgery or lens extraction. (See Table 2, page 9.)

A 2007 Cochrane review that included 26 trials with 4979 participants clearly demonstrated medical management to lower IOP offers a protective effect on the visual field. Although these studies do not include traumatic glaucoma, ophthalmologists believe that this benefit applies to glaucoma of any etiology.

Hyphema
Hyphema is defined as blood in the anterior chamber. This may occur in one-third of cases of serious ocular trauma. The estimated annual incidence of hyphema is 17 to 20 per 100,000 population, with most patients being younger than 20 years of age. The sources of bleeding are the blood vessels in the iris or ciliary body. Hyphemas are classified from grade 0 to 4, based on the percentage of the anterior chamber filled with blood. Grade 0 represents microhyphemas in which circulating red blood cells can be detected only by slit-lamp examination. The grading system then progresses from grade 1 (less than one-third of the anterior chamber) to grade 4 (anterior chamber filled with blood). (See Figure 6.) The term “eight-ball hyphema” refers to an anterior chamber that is entirely filled with blood, making it appear like a black ball. Symptoms of hyphema include pain, photophobia, and blurry vision. With a grade 4 hyphema, there is sudden vision loss, high IOP, extreme pain, and nausea. Lethargy or somnolence can be associated with isolated traumatic hyphema but should raise concern for a concomitant head injury. Traumatic miosis or mydriasis may be present, but not an APD.

The goals of treatment in traumatic hyphema are to prevent repeated eye trauma and rebleeding, to promote the settling of blood away from the visual axis, and to control anterior uveitis and increases in IOP. As a result, treatment may run the spectrum from supportive care and medical management to surgical intervention.

Most patients with hyphema can be treated at home. Moderate activity (such as walking and reading) is allowed. When the patient is lying down, the...
head of the bed should be elevated to an angle of 30°. A metal shield should be applied over the entire orbit to protect the eye from further injury until the hyphema resolves. The shield must have holes or be made of clear plastic so patients can monitor their vision, since a decrease in vision is the earliest symptom of rebleeding.

Medical management may include oral analgesics as needed and topical cycloplegics for patient comfort. Topical steroids are believed to reduce intraocular inflammation and reduce the risk of secondary hemorrhage; however, the evidence is contradictory (see discussion below). Topical and systemic antifibrinolytics such as aminocaproic acid (ACA) and tranexamic acid delay clot dissolution, thereby acting to reduce secondary hemorrhage. Aspirin and NSAIDs should not be used because of an increased risk of rebleeding.

Results in the recent literature with regard to the use of steroids in hyphema are conflicting. In a retrospective cohort study published in 2008, pediatric patients with hyphema who were treated with tranexamic acid plus topical steroids did not have a significantly lower incidence of rebleeding than those treated with topical steroids alone. Corticosteroids have been used to treat hyphema and appear to be effective. Topical steroids have been shown to have fewer adverse side effects, but their effectiveness is unclear.

Hospitalization has been recommended for patients with hyphema who have rebleeding, elevated IOP, hyphemas involving more than 50% of the anterior chamber, or decreased visual acuity, as well as for noncompliant patients and in suspected cases of child abuse. Indications for surgical intervention after hyphema include IOP greater than 50 mm Hg for 5 days (since a prolonged elevation in IOP is associated with an increased chance of optic nerve damage and corneal blood staining), IOP greater than 35 mm Hg for 7 days, total hyphema still unresolved after 9 days, or microscopic corneal blood staining. Surgery has also been indicated for patients with sickle cell disease or sickle trait. Surgical techniques include paracentesis, anterior chamber washout, expression of the clot, automated removal of blood, and trabeculectomy. The most common complication of a traumatic hyphema is rebleeding, which occurs 2 to 5 days after the injury when the initial clot retracts and loosens. A hyphema that fills 75% of the anterior chamber typically results in a traumatic cataract and is associated with vitreous hemorrhage in about 50% of cases. (See Table 2, page 9.)

**Figure 6. Grade 3 Hyphema**

![Figure 6. Grade 3 Hyphema](image)

Used with permission from Rakesh Ahuja, MD.

**Lens Injuries: Post-Traumatic Cataract**

Cataract formation is the most common result of injury to the lens, with a 39% incidence in open-globe injuries and an 11% incidence in closed-globe injuries. The traumatic event may be blunt trauma (the major cause), exposure to a high-voltage electrical current, laser beams directed at the eye, or a lightning strike. Bilateral cataracts can develop after electrical injury and lightning strikes. Traumatic cataracts may occur acutely or develop over weeks to months and may therefore be difficult to diagnose when a patient presents long after the initial injury. A recent case report describes the development of an electrical cataract as the result of a Taser® gun attack. With a lens injury (as well as a unilateral corneal or retinal injury), monocular diplopia is present. (Binocular diplopia implies a problem with the extraocular muscles or nerves.) Definitive treatment usually involves cataract removal, thus requiring patient referral to an ophthalmologist. The visual prognosis for patients with traumatic cataract but without additional intraocular trauma is usually excellent.

**Trauma To Implanted Lenses**

After cataract surgery involving removal of the native lens and implantation of a standard polymethylmethacrylate intraocular lens, patients can sustain trauma to the implanted lens. Although implanted lenses are durable, are resistant to aging and climate, and can withstand the level of stress necessary for implantation, the lens to fracture and dislocate. This is a very rare event, and the patient presents with pain and blurry or double vision.

Other injuries involving the native lens are subluxation and dislocation injuries. Blunt trauma to the eye can cause damage to the zonule fibers, resulting in dislocation of the lens (posteriorly more commonly than anteriorly). The patient will complain of blurry vision or monocular diplopia. An anteriorly displaced lens can be visible on direct or slit-lamp
Injuries To The Posterior Segment (Vitreous, Retina, And Posterior Choroid)

Posterior Segment Injury Associated With Anterior Segment Injury
The ED clinician should consider the possibility of occult posterior injury for all patients with high-velocity or high-risk, seemingly “isolated” anterior segment injury. Inflating airbags can cause hypotonic maculopathy, retinal detachment, macular hole formation, and traumatic optic neuropathy. Vehicle occupants 66 years of age and older were found to be 2 to 3 times more likely to incur an eye injury after airbag deployment. In addition, patients who have undergone refractive surgeries such as radial keratotomy, photorefractive keratectomy, and LASIK are also at increased risk for posterior segment injury. Airgun, stun gun, or paintball injuries should be included in this group of patients at high risk and all should be followed up by an ophthalmologist.

Retinal Detachment Related To Trauma
According to the USEIR, the retina is involved in nearly one-third of all serious eye injuries, and the retina or vitreous is involved in almost 50% of all severe open- or closed-globe injuries. In adults, trauma accounts for only 10% of all retinal detachment, whereas in children trauma is the leading cause.

Retinal tears themselves do not cause pain. The patient may complain of seeing flashes of light or sparks, cloudy or smoky vision, or the more classic “cloudy curtain” descending over the field of vision. On fundoscopy, a hazy gray membrane of retina may be seen billowing forward; however, many tears are located in the periphery and are not seen with direct ophthalmoscopy. Visual acuity may be normal unless the macula is involved. Indirect ophthalmoscopy or US may be needed to demonstrate the tear. (See Figure 5, page 7.) Retinal detachment may also be seen on CT scan. (See Figure 7.) Sometimes after acute blunt trauma, a traumatic macular hole can develop in the posterior segment. The underlying mechanism is not well understood but may involve traction by overlying adherent vitreous.

Retinal tears, macular holes, and vitreal injury require emergent ophthalmologic consultation. Surgical intervention is needed to repair the detachment, perform a vitrectomy in the setting of vitreous hemorrhage, or repair the macular hole. In most cases today, such repair is successful.

Orbital Fractures
A direct blow to the eye can cause an orbital wall fracture, also known as an orbital “blowout fracture.” This term was coined in 1957, when Smith and Regan described the mechanism of injury. The medial and inferior walls of the orbit are fractured as a result of increased hydraulic pressure from the force of the blow to the globe. The fractures are usually confined to the orbital walls and do not reach the orbital rim. The patient may present with the classic triad of enophthalmos (recession of the eyeball in the socket), restrictive strabismus (diplopia on upward gaze), and infraorbital numbness (anesthesia below the eye along the infraorbital nerve distribution). Other clinical findings may include a step-off deformity on palpation of the infraorbital rim and intraorbital emphysema. In patients with blunt trauma who complain of diplopia, one must also consider a diagnosis of orbital hemorrhage or edema (without blowout), bruised extraocular muscle, and cranial nerve palsy. Plain radiographs are usually inadequate; CT scans, both axial and coronal, are the modality of choice. (See Figure 8.)

There are no well-designed prospective studies on the emergency management of orbital wall fractures. Based on historical practice, as well as expert opinions in the fields of emergency medicine and ophthalmology, the initial treatment consists of intermittent application of ice or cold to the site for 48 hours, the use of nasal decongestants, elevation of the head of the bed, avoidance of aspirin (unless required for other medical reasons), and an injunction against blowing the nose. In addition, antibiotics that cover sinus pathogens, such as high-dose amoxicillin (875 mg every 12 hours for 7 to 10 days) or amoxicillin-clavulanate are often recommended for patients with severe injury or subcutaneous air. Immediate surgery is recommended for patients with large fractures, hypoglobe (downward displacement of the eye), significant enophthalmos (posterior displacement of the eye), or signs of entrapment. Delayed surgery (ie, within the first 2 weeks after injury) is recommended for enophthalmos or persistent diplopia. Supportive medical management is for those who do not meet criteria for surgery. The choice of consultant — whether plastic surgery, ENT, oral, and/or maxillofacial surgery — together with ophthalmology is dependent on regional practice patterns.

Retrobulbar Hemorrhage
The bony orbit is a confined space, with little room for expansion. Retrobulbar hemorrhage is a rare complication of nondisplaced orbital fractures. In displaced orbital fractures, the blood escapes into the surrounding sinuses. In nondisplaced fractures, the blood accumulates behind the orbit, resulting in
a buildup of pressure behind the globe. This results in pressure on the globe and traction on the optic nerve, described by some as an ocular compartment syndrome. Patients with retrobulbar hemorrhage usually complain of severe eye pain, reduced eye movement, and/or a change in vision.

On examination, the patient may have proptosis, limited extraocular movements, decreased visual acuity or vision loss, a sluggish dilated pupil, an afferent pupillary defect, and/or increased intraocular pressure. Fundoscopy may show optic nerve pallor or venous dilatation of the disc. With this disease process, rising IOP compresses the ophthalmic and retinal vessels, resulting in retinal ischemia that can occur in as little as 3 to 4 hours. Early recognition of retrobulbar hemorrhage and decompression are the keys to preserving the patient’s vision. Bedside US may reveal a hypoechoic lucency deep to the retina. The definitive diagnosis is by CT scan. (See Figure 9, page 14.)

Of note, emergency decompression via lateral canthotomy may need to precede CT (or arrival of the ophthalmologist) if there is severe proptosis with diffuse subconjunctival hemorrhage, vision loss, and a RAPD. Lateral canthotomy is also indicated once a definitive diagnosis of retrobulbar hemorrhage has been made with evidence of increased IOP (> 40 mm Hg), acute vision loss, and proptosis. After a simple cleaning of the lids and lateral canthus, the lateral canthus is anesthetized with 1 to 2 mL of lidocaine (1% or 2%) with epinephrine. A small hemostat or Kelly clamp is used to crimp the skin at the lateral canthus for 1 to 2 minutes to minimize bleeding and to mark the site of the canthotomy. The canthus is incised, using small scissors to make a 1- to 2-cm lateral incision along the line made by the clamps, beginning at the lateral canthus and extending toward the orbital rim. The lower eyelid is then retracted to expose the lateral canthus tendon, which is cut and released from the orbital rim. Despite high IOP, often only a small amount of blood is expressed. The goal pressure should be < 40 mm Hg. Complications of a lateral canthotomy include bleeding, infection, and mechanical injury.

Globe Rupture And Enucleation

Globe rupture may be subtle or may be obvious if the intraocular contents can be seen protruding from a laceration. Globe rupture is a serious injury, a major cause of monocular blindness, and must be treated promptly. The patient will often – but not always – complain of pain and decreased visual acuity. Examination may reveal bloody chemosis (swelling or edema of the conjunctiva), severe subconjunctival hemorrhage overlying the scleral rupture site, a deep or shallow anterior chamber, limitation of extraocular motility, an irregularly shaped pupil, iridodialysis, or exposed uveal tissue that appears brownish-red to brownish-black.

When globe rupture is present or suspected, there should be no further manipulation of the eye. Specifically, any maneuver that may increase IOP,
including tonometry, should not be performed and a rigid shield should be placed over the eye for protection. Globe rupture can be easily visualized on CT. (See Figure 10.) Additional treatment includes antiemetics, avoidance of any Valsalva maneuvers that can increase IOP, analgesics, tetanus prophylaxis as needed, broad-spectrum systemic antibiotics to prevent endophthalmitis, and emergent consultation with an opthalmologist. If the patient requires rapid-sequence intubation for airway management, succinylcholine may be used after pretreatment with nondepoloizing and sedative agents. 34,60

**Post-Traumatic Endophthalmitis**

Endophthalmitis is an inflammation of the intraocular cavities. Post-traumatic endophthalmitis is a devastating complication of open-globe injury, with a poor visual prognosis. The incidence of endophthalmitis after an open-globe injury has been reported to be between 3.3% and 16.5%. Traditional risk factors include delayed primary repair and wound closure, a rural setting, the presence of a retained IOFB, and disruption of the lens. 61,62 In a recent, large, consecutive case series conducted over 7 years at 1 institution, the rate of endophthalmitis was 0.4% without IOFB and 3.2% with IOFB. 63 The most common complaints are pain, photophobia, and decreased vision. Pain that is out of proportion to physical findings is a particular red flag for endophthalmitis. Examination may show a variety of findings, including lid edema, conjunctival erythema and edema, hypopyon (pus or purulent fluid in the anterior chamber), vitritis, and retinal periphlebitis. It is common for these infections to be virulent and polymicrobial in nature. 64,65 Treatment options have consisted of early vitrectomy in addition to intravitreal, periocular, topical, and systemic antibiotics. In a multicenter, randomized, clinical trial of 346 eyes treated with either intravitreal gentamicin and clindamycin or balanced saline, the respective incidences of endophthalmitis were 0.3% and 2.3%. 66 Other specific antibiotic choices include intravitreal ceftazidime and vancomycin, systemic ceftazidime and vancomycin, periocular ceftazidime and vancomycin, and topical norfloxacin 0.3%. Intravitreal steroids have also been used, but their use is controversial and the supporting data are variable. 65 Suspicion of endophthalmitis necessitates urgent ophthalmologic consult.

**Penetrating Eye Trauma**

**Eyelid Lacerations**

There are no randomized, controlled, prospective studies on the treatment of eyelid lacerations. As a result, ED clinicians rely on the advice of specialty experts in review articles and textbooks for guidance in their treatment. Optimal repair of eyelid lacerations is important in maintaining proper function and health of the eyeball. Intraocular injuries take precedence over injuries to the adnexa (eyelids and canalicular system). A thorough examination of the entire eye must be done, as described earlier, before repair is undertaken. 55 Despite the absence of data, experts maintain that eyelid lacerations may be repaired up to 48 hours after injury. There seems to be a low risk of infection and a greater benefit when repair is achieved under optimal conditions — ie, the most experienced surgeon and the best operating conditions. 68,69 The goal of the ED clinician should be to prioritize lid laceration within the spectrum of any accompanying ocular or systemic injury.

**Figure 9. CT Scan Of Retrobulbar Hemorrhage**

![CT Scan Of Retrobulbar Hemorrhage](Used with permission from J. Brody, DO.)

**Figure 10. Globe Rupture With Lateral Wall Fracture And Intraocular Foreign Body**

![Globe Rupture With Lateral Wall Fracture And Intraocular Foreign Body](Used with permission from J. Brody, DO.)
Partial-thickness lacerations of the eyelids can be repaired in the same way as other facial lacerations. Careful removal of dirt and other particulate matter is necessary to reduce the chance of skin “tattooing.”

Lid margin lacerations are usually quite obvious. Spasm of the orbicularis muscle may suggest tissue loss, but this is extremely rare, and with careful closure, the lid will return to normal. An ophthalmologist should be consulted for lid margin lacerations because of the significant risk of complications. If, after consulting with an ophthalmologist, it is necessary for the ED clinician to repair a lid margin laceration, a technique for closure that involves 3 steps has been described by Long (as described below).

Contrary to most facial suturing (in which sutures in the skin are placed close together and shallowly) lid margin sutures may dehisce if they are not placed deeply enough, owing to extensive lid edema in the immediate post-repair period. Sutures placed at the lash line need to be fixed into sutures away from the edge to prevent their dropping onto the corneal or conjunctival surface and causing significant irritation or keratitis. General textbooks recommend applying topical antibiotic ointment to the laceration following repair, similar to the widespread practice for lacerations at other body sites. Long et al recommend occlusive patching both to support the repair and to reduce reactive edema.

Complications of inadequate repair include a notched eyelid, trichiasis (misdirected eyelashes), lagophthalmos (incomplete closure of the eye by the eyelid), and corneal exposure. A notched eyelid is largely a cosmetic issue and may occur because of wound dehiscence or poor repair. It may resolve over 6 months, but if not, elective repair using block excision and meticulous closure by an oculoplastic surgeon is usually curative. Trichiasis may occur because hair follicles were inadvertently incorporated into the wound during repair or because of microanatomic changes within the lid margin. Again, this can be repaired by block excision or cryotherapy and rotation of the eyelid margin. Scar contractures of the skin of the upper lid may lead to significant lagophthalmos, which in turn can lead to ocular pain, redness, and corneal exposure. Patching the eye at night, the use of artificial tears and ointments, and gentle massage may lead to improvement over a 6-month period; if not, scar revision may be necessary.

Figure 11 illustrates the process of the 3-step lid repair described by Long. The first step is to align the lid margin by placing a 6-0 silk suture at the “gray line” through both sides of the wound. No knot is tied, and an “assistant” pulls on both ends to bring the eyelid margin into good approximation. The next step is to repair the tarsus or tarsal plate. The tarsal plate of the entire lower lid is 4 mm wide, but the tarsus width of the upper lid varies from 2 mm to 10 mm. Tarsal closure may be accomplished with 5-0 Dexon™ using a D-1 needle and interrupted sutures. Care should be taken not to penetrate the full thickness of the eyelid to avoid keratitis due to protruding suture ends. The final step is closure of the anterior lamella (the orbicularis and skin) with deep and wide 6-0 silk or nylon sutures.

**Corneal And Scleral Lacerations**

The slit lamp is the preferred method for examining the cornea and anterior sclera, although a corneal laceration can sometime be seen with the naked eye. The Seidel test used to detect full-thickness laceration was described earlier under Physical Examination. The care of corneal and scleral lacerations requires the technical skill of an ophthalmologist.

**Canalicular Injuries**

In contrast to eyelid lacerations, which are usually obvious, canalicular injuries can easily be missed.

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**Figure 11. Long’s 3-Step Closure Of Eyelid Laceration**

<table>
<thead>
<tr>
<th>Direct Closure of a Marginal Eyelid Laceration</th>
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</thead>
<tbody>
<tr>
<td>Placement of initial margin suture</td>
</tr>
<tr>
<td>Partial-thickness lamellar sutures in the tarsus</td>
</tr>
<tr>
<td>Margin sutures tied through skin sutures</td>
</tr>
</tbody>
</table>

**Figure 12. Corneal Laceration**

Used with permission from The University of Iowa, EyeRounds.org.
Clinical Pathway For Blunt Eye Trauma

History (how, when, where, and what)

Obvious globe rupture?

NO

Proptosis?

YES → Bedside ultrasound / CT scan
NO → Retrobulbar hematoma

YES → Stop!

Entrapment of ocular muscles?

YES → CT scan
NO → Orbital fracture

YES → Primary or delayed repair (Class II)

Pupillary abnormality?

YES → Traumatic miosis
NO → Refer to ophthalmologist (See Table 2, page 9)

Traumatic mydriasis
Anterior uveitis
Iridodialysis

Rapid afferent pupillary defect?

YES → Optic nerve injury
NO → Urgent ophthalmologic consult

Large retinal tear
Large vitreous injury

Anterior chamber injury?

YES → Hyphema
NO → Provide supportive care (Class II)

Optic nerve injury
Administer topical steroids
Observe for rebleeding
Consult ophthalmology (See Table 2, page 9)

Abnormal vision?

YES → Traumatic cataract
NO → Urgent ophthalmologic consult

Dislocated lens
Vitreous hemorrhage
Retinal detachment

Intraocular pressure?

HIGH → Acute glaucoma
LOW → Emergent ophthalmologic consult for medical treatment and/or possible surgery (Class I)

Hemorrhage within globe
Ruptured globe

Fundoscopy

See next page for Class of Evidence definitions.
Clinical Pathway For Penetrating Eye Trauma

History (how, when, where, and what)

Impaled object?

YES → Stabilize object
Call for ophthalmology consult
Remove object in OR (Class II)

STOP!

NO

Full eye examination

Lid laceration?

YES → Evaluate for canalicular injury

NO

Corneal laceration?

YES → Seidel test

NO

Intraocular foreign body?

Metallic?

YES → CT scan

NO → MRI

Vegetal?

NO

Indeterminate

Level of Evidence:

Class I
- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

Level of Evidence:
- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

Class II
- Safe, acceptable
- Probably useful
Level of Evidence:
- Generally higher levels of evidence
- Non-randomized or retrospective studies: historic, cohort, or case control studies
- Less robust RCTs
- Results consistently positive

Class III
- May be acceptable
- Possibly useful
- Considered optional or alternative treatments
Level of Evidence:
- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

Indeterminate
- Continuing area of research
- No recommendations until further research
Level of Evidence:
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

Injuries may be due to laceration, avulsion, or shear-ing. A small, retrospective case series from a single institution revealed that 66% of dog bite injuries to the face involved the canalicular system, as compared with 34% in the group not bitten by a dog. A high index of suspicion needs to be maintained for any laceration/avulsion in the area of the medial canthus. Evaluation of the canalicular structures is performed by the ophthalmologist and requires an awake, cooperative patient. Repair may be carried out 24 to 48 hours after the initial injury. The standard treatment is to use silicone bicanalicular intubation, with the tubing left in place for 2 months. Complications include dislodgment of the tubing, but the major complication is failure to diagnose canalicular system laceration at the time of the injury.

**Superficial Foreign Body**

Foreign bodies can become lodged under the lids or in the superficial layers of the cornea. Superficial corneal foreign bodies can often be washed away with saline irrigation, and those under the lids may be removed with cotton-tipped applicators. Foreign bodies embedded in the cornea should be removed with a spud device or a 25- or 27-gauge needle, preferably under magnification. Rust rings from iron-containing foreign bodies may be removed at the initial visit by the ED clinician or later at follow-up. Aftercare is similar to that for corneal abrasions.

**Intraocular Foreign Bodies**

Of the patients with an IOFB, 20% have no pain on presentation and may have normal or near-normal vision. If the history is suggestive, it is important to assume an IOFB until proven otherwise. Suspicious physical findings include hemorrhage over the sclera, localized corneal edema, and a nonsurgical hole in the iris. Other determinants of injury in IOFBs are as follows: the shorter the entry wound, the higher the risk of retinal injury; objects entering through the sclera are more likely to cause damage than those entering through the cornea; and the sharper the foreign body, the less destruction it causes. More than 50% of IOFBs end up in the retina or choroid. The composition of the IOFB is also important, not only because of the type of imaging required, but also because foreign bodies that contain iron or copper may cause severe chemical reactions that will lead to inflammation and further damage. Data from before 1990 cited in Mester and Kuhn lists missed IOFBs as representing 56% of all ocular trauma-related malpractice claims. Newer helical CT scanners are able to detect IOFBs as small as 0.048 mm. Ultrasound is an excellent modality in experienced hands but may miss small, wooden, or organic matter. MRI is very sensitive but cannot be used if the IOFB contains metal, since the magnet may cause shifting of the fragment and additional intraocular damage.

Management of an IOFB involves referral to a surgeon for what is likely to involve comprehensive globe reconstruction, including removal of the foreign body, wound closure, and treatment of each individual tissue lesion. Vision does not improve simply by removing the IOFB, and inappropriate or incomplete surgical intervention can cause iatrogenic injury. Endophthalmitis has been reported to be present in 90% to 100% of injuries with IOFB at

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## Risk Management Pearls For Traumatic Ocular Emergencies

1. **Do no harm:** do not cause iatrogenic injury by failing to protect an open-globe injury with an eyeshield. If you suspect an open-globe injury, stop the physical examination immediately and protect the eye with an eyeshield.

2. **Always check IOP unless you suspect an open-globe injury.**

3. **The management of IOFBs represented over 56% of ocular-related malpractice claims.**

4. **Get the most experienced person for the eyelid or canalicular lacerations, and remember that the repair can be delayed for 24 to 48 hours.**

5. **Dog bites to the eye result in a high incidence of canalicular injuries.**

6. **Do not contaminate a penetrating injury by administering nonsterile eyedrops.**

7. **Avoid use of eye patches in corneal abrasions less than 10 mm.**

8. **Always include an assessment of optic nerve function by using the swinging flashlight test (see Figure 4, page 6) when treating a patient with an opthalmologic complaint.**

9. **Use topical NSAIDs in order to minimize the need for systemic pain medications and their associated complications.**

10. **Consider admission for patients with a hyphema > 50%, since these patients are at significantly greater risk for complications.**
initial evaluation; however, in an early study, Mieler et al showed that positive vitreous cultures did not translate into clinical endophthalmitis in 7 out of 19 cases. High-risk lesions are IOFBs that consist of organic material or copper and wounds with soil contamination.

Early surgery has been considered the standard of care for IOFBs for a number of years, since it is believed to decrease infection and improve visual outcome. Historically, post-injury infection rates have been 4% to 8%. Andreoli et al reported that surgery within 24 hours, with removal of the IOFB plus systemic antibiotic therapy, resulted in an infection rate of 3.2%. A recent retrospective case series from the military showed that early closure of the globe was more important than removal of the IOFB in terms of visual outcome. These patients underwent early surgery for wound closure, but IOFB removal was delayed as long as 4 weeks, with prophylactic administration of topical and systemic antibiotics. Besides vision loss and infection, other complications following surgery include epimacular proliferation and retinal detachment, which can negatively affect vision. With IOFB, certain factors such as BB or shotgun pellets are associated with a poor prognosis; however, visual acuity of 20/40 or better can be expected in 71% of cases.

**Sympathetic Ophthalmia**

Sympathetic ophthalmia is a rare granulomatous uveitis that occurs in the uninvolved eye after injury or surgery to the other eye. The incidence has been estimated to be 0.03 per 100,000 patients. Onset is usually 3 months after the injury or surgery but has been reported to occur years after the original insult. It is thought to be an autoimmune process and may present acutely or insidiously. The diagnosis is made based on a history of previous injury or surgery plus findings of uveitis. Treatment consists of high-dose systemic steroids or other immunosuppressive therapy.

**Controversies/Cutting Edge**

Rebleeding is the dreaded complication of acute hyphema. Antifibrinolytic agents have been used in children with variable success, but their use in adults is controversial. Some studies have reported a decrease in the rebleeding rates when aminocaproic acid and tranexamic acid are used, but these same agents have serious potential side effects, including nausea, vomiting, muscle cramps, conjunctival suffocation, headache, rash, pruritus, dyspnea, toxic confusional states, arrhythmias, and systemic hypotension. These agents should be used only after consultation with an ophthalmologist.

Regarding the use of prophylactic antibiotics in globe rupture, there are no randomized, prospective studies of open-globe injuries treated with or without systemic antibiotics, nor are there likely to be any such studies in the future. For ED clinicians, the practice consensus is to begin prophylactic IV antibiotics, with choices including ceftazidime in combination with vancomycin or a fluoroquinolone.

**Summary**

The evaluation of blunt and penetrating injuries to the orbit represents a challenge to the practicing ED clinician. The history and physical examination need to be as complete as possible while remaining vigilant for open-globe injuries and IOFB. Some injuries are relatively common and self-limiting, such as simple corneal abrasions or traumatic uveitis. Other less-common injuries such as hyphema and traumatic cataracts also usually have a good outcome. However, other types of ocular trauma such as open-globe injuries, certain metallic IOFBs, and traumatic glaucoma can be devastating and threaten the patient’s vision. The ED clinician should know when to safely initiate appropriate treatment as well as when to stop the examination abruptly, stabilize the eye, and call in an ophthalmologist.

**Case Conclusions**

The small “gray dot” in the sclera and “jiggling” eyeball suggested globe rupture despite the young man’s near-normal visual acuity and the absence of pain. The physical examination was stopped immediately, and a plastic shield was placed over the eye to protect it from possible iatrogenic injury. The patient was sent for CT scan, which revealed a BB pellet located next to the right optic nerve on the medial side of the retrobulbar space. Ophthalmology was contacted, and the patient was taken to the OR, where the BB was successfully removed. At 6-month follow-up, his vision was normal.

As for the second patient, examination of the left eye revealed a visual acuity of 20/30. The conjunctiva was injected, and the pupil was 2 mm in diameter and round. Anesthetic drops relieved the pain to some degree, but she still had pain when a light was shone into her other eye. Fluorescein staining revealed a 3-mm corneal abrasion at 4 o’clock. No foreign bodies were noted on lid eversion. Results of slit-lamp and IOP examinations were normal. The patient did not wear contact lenses. A cycloplegic agent was instilled in the eye, and the patient was discharged on topical antibiotic drops as well as NSAID drops, along with back-up oral analgesics. The following day the patient followed up with her ophthalmologist, at which time a healing superficial corneal abrasion with some mild anterior uveitis was found.
Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study, will be included in bold type following the reference, where available. In addition, the most informative references cited in this paper, as determined by the authors, are noted by an asterisk (*).


5. Forrest KY, Cali JM. Epidemiology of lifetime work-related eye injuries in the U.S. population associated with one or more lost days of work. Ophthalmic Epidemiol. 2009;16(3):156-162. (Epidemiologic prevalence study)


1. The ophthalmologic history should include:
   a. Location of injury
   b. Mechanism of injury
   c. Prior ocular surgery
   d. Time of injury
   e. All of the above

2. The swinging flashlight test:
   a. Detects blood in the anterior chamber
   b. Is a test of intraocular pressure
   c. Is a test of visual acuity
   d. May detect abnormalities of the optic nerve

3. A screwdriver is protruding from your patient’s eye. You should:
   a. Call ophthalmology and then remove it
   b. Give antibiotics and then remove it
   c. Remove it immediately
   d. Stabilize the screwdriver to prevent movement and call ophthalmology

4. Ultrasound is useful for detecting all EXCEPT:
   a. A dislocated lens
   b. Organic-matter IOFBs
   c. Retinal detachment
   d. Retrobulbar hemorrhage
   e. Vitreous hemorrhage

5. Risk factors for the development of endophthalmitis include all EXCEPT:
   a. Delayed repair of a penetrating injury
   b. A disrupted lens
   c. Injury in a rural setting
   d. A retained IOFB
   e. Retrobulbar hemorrhage

6. Factors that affect visual outcome after injury include all EXCEPT:
   a. An associated orbital fracture
   b. Vision at time of injury
   c. Presence of globe rupture
   d. Presence of RAPD
   e. Retinal detachment

7. Occlusive patching for corneal abrasion should be applied to:
   a. Abrasions greater than 10 mm
   b. All corneal abrasions
   c. Corneal abrasions associated with an IOFB
   d. Infected corneal abrasions

8. The Seidel test:
   a. Assesses visual fields
   b. Assesses visual acuity
   c. Tests for ocular motility
   d. Uses fluorescein dye to detect an aqueous fluid leak

9. All of the following may be part of the standard acceptable treatment for corneal abrasions EXCEPT:
   a. Eye patch
   b. Oral narcotics
   c. Topical antibiotics
   d. Topical NSAIDs

10. After trauma, the presence of cells and flare in the anterior chamber on slit-lamp examination together with pain is diagnostic of:
    a. Traumatic iridocyclitis
    b. Traumatic glaucoma
    c. Hyphema
    d. Traumatic retinal detachment

11. The earliest symptom of hyphema rebleeding is:
    a. Eye pain
    b. Decreased vision
    c. Nausea and vomiting
    d. Periorbital swelling

12. Emergent ophthalmology consultation is required for all of the following EXCEPT:
    a. Globe rupture
    b. Post-traumatic endophthalmitis
    c. Traumatic glaucoma
    d. Uveitis

13. In the setting of retrobulbar hematoma, increased IOP can cause permanent ischemic changes in as little as:
    a. Less than 5 minutes
    b. 10 to 15 minutes
    c. 15 to 30 minutes
    d. 3 to 4 hours

14. The first step in the treating globe rupture is:
    a. Assess IOP
    b. Examine the eye carefully
    c. Give tetanus prophylaxis
    d. Place eyeshield over the orbit
“Hospital Planning For Terrorist Disasters: A Community-Wide Program”

by Solisis Deynes, MD, MPH; Christopher Kahn, MD, MPH; and Kristi L. Koenig, MD, FACEP, FIFEM

Terrorism and healthcare are inescapably linked. A terrorist event would lead to casualties that hospitals would need to care for. Hospitals themselves may be seen as high-value and high-impact targets. Although the likelihood of any given hospital being impacted by a terrorist event is low, intelligence leaders have recently predicted an event as “inevitable.” Successful response to terrorism would ideally result from community-wide planning. “Hospital Planning for Terrorist Disasters: A Community-Wide Program” provides a foundation for planning based on accepted key principles and the experience of prior events.

As the report states, disasters are defined by whether the health and medical needs of the victims are able to be met. The phases of comprehensive emergency management, mitigation (prevention), preparedness (planning), response (immediate reaction to event), and recovery are reviewed. The principles of incident command and the Hospital Incident Command System (HICS) are introduced and the need for multi-agency coordination in terrorist events is emphasized.

Disaster triage is covered extensively with an emphasis on the use of the START triage. A key concept is that triage is a dynamic and not a static event. Anticipating and planning for the waves of casualties that occur in disasters, with the understanding that the most serious casualties often arrive after the least injured, is of critical importance. In addition, in the days beyond the initial event, planning for the volume of patients with exacerbation of chronic conditions in a disrupted healthcare system is important.

Education and ongoing training are emphasized as key areas for successfully implementing plans. Security, the development of alternative care site strategies, psychological support services, surveillance, media, volunteers, personal protective equipment, decontamination, communications, and surge capacity are discussed in this report as important components of the plan and response.

One of the major problems with disaster planning is that it is a lot like insurance – hard to pay attention to until you need it. Preparing for terrorist events is a galvanizing opportunity that can bring the concern, energy, and resources of a variety of community parties together. Planning for terrorist events provides a tremendous opportunity to strengthen overall disaster preparedness and use the resultant attention to develop improved community response. Learning from the more common non-terrorist events and the application to planning and response is the key. The special report, “Hospital Planning For Terrorist Disasters: A Community-Wide Program,” presents an excellent foundation for hospital planning for terrorism that can be readily adapted to a number of threats.

Reviewed by

Joseph Sabato, Jr., MD, FACEP
Assistant Professor
Department of Emergency Medicine
Director of Field Operations
University of Florida College of Medicine
Jacksonville, Florida

For more information on “Hospital Planning For Terrorist Disasters: A Community-Wide Program,” please visit www.ebmedicine.net/disasters
### Key Points

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<th>Key Points</th>
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<td>Always maintain a high index of suspicion for open-globe injury. The patient will often, but not always, complain of pain and decreased visual acuity.</td>
<td>Globe rupture is a serious injury and a major cause of monocular blindness and must be treated promptly. In gathering data, remember that conjunctival lacerations may indicate underlying injury to the sclera and that hemorrhagic chemosis may indicate orbital fracture or open-globe injury.</td>
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<td>Always measure the intraocular pressure (IOP) – except in the suspected or obvious open-globe injury.</td>
<td>Low IOP may be seen in occult globe rupture or laceration, injury to the ciliary body, or retinal detachment. Normal or even high IOP does not rule out open-globe injury or rupture. Elevated IOP may occur immediately after contusion to the globe, in the presence of cells in the anterior chamber, mechanical angle closure, and with anterior dislocation of the lens.</td>
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<td>Patients with previous surgery or injury have a higher incidence of open-globe injury.</td>
<td>In a retrospective analysis of 100 consecutive open-globe injuries at a single institution, Man and Steel compared CART and OTS predictions with actual visual outcomes and calculated the sensitivity and specificity of each model. The variables most closely predictive of poor visual outcome were RAPD, poor initial vision, lid laceration, posterior wound, and globe rupture.</td>
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<td>Think of posterior segment injuries when presented with anterior segment injuries that resulted from a high-velocity insult such as an airbag.</td>
<td>Motor vehicle occupants 66 years of age and older were found to be 2 to 3 times more likely to incur an eye injury after airbag deployment. In addition, patients who have undergone refractive surgeries such as RK, PRK, and LASIK are also at an increased risk of posterior segment injury.</td>
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<td>Penetrating injuries in the rural setting have a higher rate of endophthalmitis.</td>
<td>The incidence of endophthalmitis after an open-globe injury has been reported to be between 3.3% and 16.5%. Traditional risk factors included delayed primary repair/wound closure, rural setting, presence of retained intraocular foreign body (IOFB), and disruption of the lens. A recent large consecutive case series treated at 1 institution over 7 years showed a rate of endophthalmitis of 0.4% without IOFB and 3.2% with IOFB.</td>
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<td>Dog bites to the eye have a high incidence of canalicular injury.</td>
<td>A high index of suspicion needs to be maintained for any laceration/avulsion in the area of the medial canthus. Evaluation of the canalicular structures is performed by the ophthalmologist and requires an awake and cooperative patient. The repair may be carried out 24 to 48 hours after the initial injury.</td>
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REFERENCES

These references are excerpted from the original manuscript. For additional references and information on this topic, see the full text article at ebmedicine.net.


CLINICAL RECOMMENDATIONS

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