Chapter 3

OCULAR TRAUMA: HISTORY AND EXAMINATION

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INTRODUCTION

Both the soldier fighting on a modern-day battlefield and the civilian residing in a 21st-century city are at risk of ocular trauma. The prevalence of such injury is not trivial. For example, recently gathered data indicate that the rate of ophthalmic injury during military-supported demining missions is 23%.[1] The military and nonmilitary patients who were unlucky enough to be near exploding ordinance, or actually caused the device to explode by tripping the device, or setting the device off as they attempted to remove the explosive ordinance also had a significant rate of nonophthalmic injury and death. It is clear that today's soldiers who survive their time on the battlefield will continue to suffer eye injuries. Additionally, the many other hazards of the modern battlefield—many of which are high- and low-speed particles from fragmentation weapons—cause many injuries to unprotected and partially protected soldiers.[2]

Individuals who sustain eye injuries caused by blunt forces, sharp (ie, penetrating) forces, fragmented projectiles, or a combination thereof can present with a spectrum of ocular problems. There are further indications that if these injuries are not recognized and treated effectively, the outcome for the patient is poor. This fact is exemplified by the spectrum of injuries that were seen during the ophthalmology support trip to Yemen, during which patients injured by land mines were examined.[3] Within 5 years after the civil war between North and South Yemen in 1994, a dichotomy in patient outcomes had become evident. Patients who had sustained minimal or no injury to the ocular structures from land mines had excellent vision. Those who had sustained moderate-to-severe or devastating injuries were uniformly blind.

The ophthalmologist who begins care and the ophthalmologist who finishes the treatment can encounter severe challenges throughout a trauma patient's clinical course. The initial treatment is vitally important, however, because it sets the patient's clinical course and offers a chance for useful vision after injury. This care, of course, begins with the injury itself. This chapter focuses on the steps needed to understand fully the mechanism of injury, discover all the aspects of the eye that have been injured, and set the stage so that the initial repair and follow-on specialty work can yield a successful outcome for the patient. The care of specific problems will be addressed in chapters throughout the book. A concentrated effort to achieve a complete and appropriate history and examination of the traumatized eye follows (Figure 3-1).

Because ocular trauma represents a spectrum of ophthalmic diagnoses, understanding the variety of patients and possible injuries is a requirement for successful treatment of the patient with an ocular injury. In the battlefield or on the city streets, the eye is susceptible to blunt forces, sharp or penetrating forces, and injury by foreign bodies (FBs). The specter of chemical insult looms large over the modern battlefield but is perceived as a smaller threat in the civilian "battlefield." The ophthalmologist and trauma specialist must be prepared to diagnose and treat any of these types of injuries or combinations thereof. The Israeli medical system documented that 11% of their troops' injuries were ocular and adnexal. A significant minority of injuries was multiple,[4–6] notwithstanding protective measures that had been issued but were not in use at the time of the injury.

Before physicians can begin correcting the ocular and adnexal injuries sustained, the patient must be stabilized from an Advanced Trauma Life Support (ATLS) standpoint. In the military during combat, the initial care provided to an injured soldier is unlikely to be rendered by an ophthalmolo-

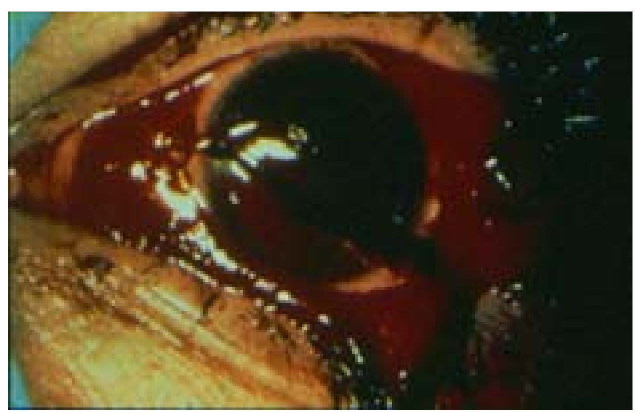


Fig. 3-1. This eye has suffered a typical sharp laceration of the anterior segment structures. The laceration involves limbal structures, the cornea, the trabecular region, lens, and perhaps more posterior structures. The efforts of the initial treating physician and the ophthalmic surgeon in acquiring an appropriate history and physical examination, discovering any occult injuries to the eye, and applying correct and effective diagnostic and surgical techniques can lead to a successful repair of severe eye trauma.

EXHIBIT 3-1

THE FOUR PHASES OF ADVANCED TRAUMA LIFE SUPPORT EVALUATION AND CARE

1. Primary survey: assessment of ABCs (airway, breathing, and circulation)
   A. Airway and cervical spine control
   B. Breathing
   C. Circulation with hemorrhage control
   D. Disability: brief neurologic evaluation
   E. Exposure/environment: completely undress the patient but prevent hypothermia
2. Resuscitation
   A. Oxygenation and ventilation
   B. Shock management-intravenous lines, Ringer's lactate
   C. Management of life-threatening problems identified in primary survey is continued
   D. Monitoring
3. Secondary survey
   A. Head and skull
   B. Maxillofacial
   C. Neck
   D. Chest
   E. Abdomen
   F. Perineum, rectum, vagina
   G. Musculoskeletal
   H. Complete neurological examination
   I. Appropriate roentgenograms, laboratory tests, and special studies
   J. "Tubes and fingers" in every orifice
4. Definitive care

Adapted with permission from Committee on Trauma, American College of Surgeons. *Advanced Trauma Life Support Program for Physicians: Instructor Manual.* 5th ed. Chicago, Ill: American College of Surgeons; 1993: 36–37.

gist; however, stabilization of the patient's airway, and initiation of respiratory and circulatory resuscitation (and their continued support), are in the ophthalmologist's purview. The military surgeon is trained in these abilities, is prepared to carry them out, and should not hesitate to review ATLS treatment algorithms (Exhibit 3-1).[7] Conversely, the civilian emergency room physician must be ready to render aid to trauma patients in accordance with Advanced Cardiac Life Support (ACLS) and ATLS algorithms, but he or she must also be prepared to provide the ATLS care required for the traumatized eye itself. The first physician at the side of a trauma patient should be familiar with the initial steps needed to care for the eye-injured patient as described in these chapters and elsewhere.[8]

We should strive to obtain as complete a history and ocular examination of the patient in the battlefield as we would with any patient seen in a clinical setting. Wartime injuries that include the globe, orbit, and adnexal regions are incapacitating to the soldier,[9] but commanders on the modern battlefield want all soldiers to have minimal time as "walking wounded." The treating ophthalmologist should expect a moderate amount of pressure to treat with success and return the "recovered" soldier to the field commanders in a very short time. Further taxing battlefield medical capabilities, mass casualty scenarios that sometimes occur in

EXHIBIT 3-2

HISTORY AND EXAMINATION SEQUENCE

History
1. Chief complaint
2. Age of patient
3. Details of the traumatic event
4. Review of ocular systems
5. Additional review of systems
6. Past surgical history
7. Past medical history
8. Medication history
9. Allergies

Physical Examination
1. Visual acuity examination
2. Pupil examination
3. Visual field examination
4. Motility examination
5. Intraocular pressure
6. Adnexal examination
7. Anterior segment examination
8. Posterior pole examination

Imaging Studies
1. Ultrasound
2. Plain film radiographs
3. Computed tomography (CT) scan
4. Magnetic resonance imaging (MRI)

combat may preclude doing a complete history and ocular examination, thus forcing the treatment of the injured to move forward with incomplete data.

During conflicts that involve troops and mass casualties, it is important to remember to conduct triage and perform medical maneuvers that allow the most care for the most injured. In the best of all situations, given plenty of time and the appropriate instruments, a detailed ocular history and examination aid in the diagnosis and treatment of military personnel with eye injuries. Exhibit 3-2 can be used to ensure that all significant facets of the patient's history and physical examination are covered in the initial and subsequent interactions with the ocular trauma patient.

HISTORY

Chief Complaint

The chief complaint portion of the history has proven to be a valuable means of eliciting information during any eye examination. This observation is no different for the ocular trauma patient. The amount of time spent on this aspect of the examination depends on the physician and the patient. Most patients, when given the opportunity, can give tremendously useful information toward diagnosing their ocular problems. Obtaining this set of details can be well worth the time spent. Nevertheless, in some instances the acquisition of data toward the chief complaint or for the history in general is not necessary or should not be pursued, at least not immediately.

One scenario in which it is necessary to defer the chief complaint portion of the examination is that of a patient who presents with a chemical injury (for further information, please see Chapter 7, Chemical Injuries of the Eye, in this volume, and *Medical Aspects of Chemical and Biological Warfare*,[10] another volume in the Textbooks of Military Medicine series). The eye must be protected from what could be devastating and vision-affecting damage from an alkali or acid burn. Copious irrigation and removal of any particles are the mainstays of treatment of chemical injuries (Figure 3-2). The issue of an open (ie, perforated or penetrated) globe at this point creates a difficult situation, but the presence of the chemical takes priority over the other injuries and should remain a priority in the treatment plan.

It often happens, especially in warfare, that neither the patient nor witnesses can provide any information that will help elicit the patient's major complaint. A perception or evidence of injury—typically, decreased vision or pain—may be offered, but how the eye was injured may not be known. In this scenario, there is little reason to spend any more

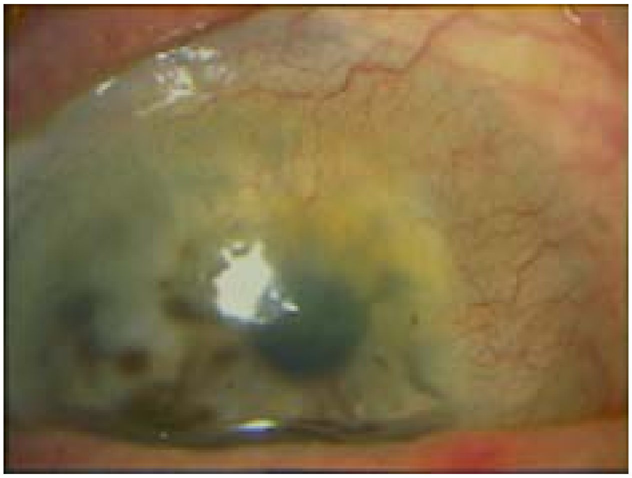


Fig. 3-2. The patient's eye sustained a chemical injury, but early, copious irrigation prevented more serious damage. Note, however, that the anterior segment is damaged. The alkali chemical penetrated the ocular coats and damaged the corneal endothelium. Corneal edema and anterior segment vascularization are the challenges presented to the ophthalmic surgeon by this type of injury.

than the minimum time interviewing the patient, because the likelihood of discovering useful details is quite low. As ophthalmologists we are fortunate, especially when ocular trauma is involved, because we can see the structures and, thereby, gather a wealth of details.

With certain clinical conditions, we can bypass much of the patient's history without jeopardizing the eventual outcome. When the eye is obviously injured, the history may be curtailed to conduct a clinical examination and determine the extent of the injury. Eliminating unnecessary steps and thereby getting the patient treated as soon as possible should be the goal for everyone. Trauma injuries that cross the boundaries separating different classes of injuries challenge the ophthalmologist and decrease the number of successful outcomes. An awareness of this concept and the military ophthalmologist's ability to use the information in the chapters that follow place the ocular trauma patients in the best hands to restore full vision potential.

Age of the Patient

Ocular trauma spans all age categories but does tend to occur more in the younger, more active population[11,12] because these people are participating in activities that put their eyes at risk.[13] Age determination, however, plays only a minor role in the decision to repair ocular trauma. The sequence of events to surgically repair the injured globe does not vary much, whether the patient is 2 or 62 years of age.

Details of the Traumatic Event

During a lull in the action or while waiting for the operating room to be freed up, the examiner can gather details of the event that led to the injury. Additional information about the mechanism of injury may lead to discovery of all the traumatic damage—overt and occult—done to the eye. Minimizing occult damage allows for a more complete primary repair, which, if done early in the course of treatment, can speed the patient's recovery process.

To prompt a full account of the injury, open-ended questions that refer to metal-on-metal events and explosive events are important. This line of questioning allows investigation of possible projectile injury and FB damage that should be included in the initial work-up of the patient. Other mechanisms of injury can also be investigated. The examiner must determine if the patient sustained a true blunt injury or if a sharp injury may have been involved. The examiner knows that the required information has been recovered when it is determined whether a sharp injury occurred and what the weapon of injury was. Was the injury caused by one sharp entry point, or by an explosive or missile injury that caused multiple sharp entries to the globe and the adnexa? To complete the data collection with regard to an FB injury, it is beneficial to determine the type of material, size of the projectiles, shape, metal type and content, and the possibility of contamination (Figure 3-3).

For thermal burns, it is important to gather data about the type of burn, the location of the burn, and the percentage of the total body surface area involved. For electrical injuries, it is beneficial to identify entrance and exit wounds in order to provide lifesaving medical care to the injured fighter.

On the modern battlefield, the physical examination and history need to include an active search for chemical involvement and injury. Identifying the chemical as an acid or base is always important; however, expect the description of the battlefield to be sparse. An additional benefit of identifying the type of chemical injury is that the information can be passed to the field commanders, thus giving them vital data to protect the soldiers who remain in the field. The ability to protect the troops more

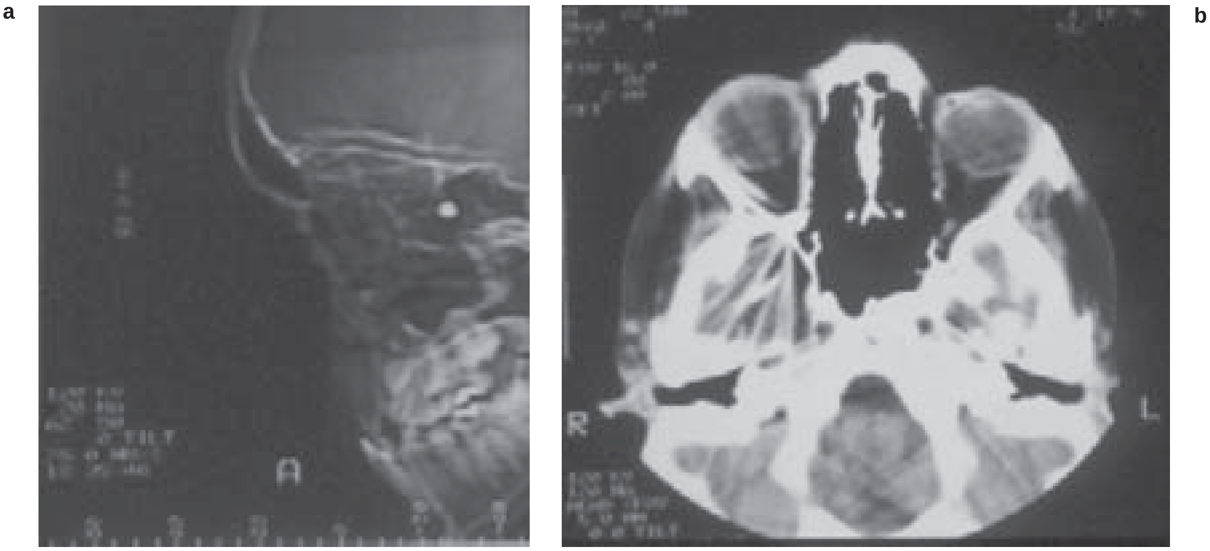


Fig. 3-3. These photographs demonstrate the utility of radiological examination in the ocular trauma patient. The patient history revealed that the injury occurred when a BB gun was discharged at close range during a neighborhood "game." The examination demonstrated a penetrating injury to the anterior segment, but (**a**) the plain scout film and (**b**) the computed tomography scan show the precise location of the foreign body—the critical information needed to plan the ophthalmic care for this patient. The need for radiological examination of the traumatized orbit and globe increases as the history and examination point toward a mechanism of injury that includes multiple, high-velocity foreign bodies—the exact type of environment that exists on the modern battlefield.

effectively is an asset that is well recognized by those in charge of the operational theater.

The final advantage to obtaining carefully documented information about the event is the ability to address any legal issues with solid data. This advantage may not always apply in the operational forces but does exist in nonmilitary health arenas. The armed forces are trending toward a more civilian application of healthcare, so additional well-documented information may be very helpful once the dust settles from the military or civilian event. Issues relevant to the initial level of injury, institution of timely and appropriately addressed surgical and medical care, and a complete treatment of all traumatic damage should have supporting data. This way, any legal scrutiny that may follow can be answered quickly, and care of the patient may be completed.

Review of Ocular Systems

A detailed review of systems for the eye is of next importance. The level of pretrauma vision is an extremely useful piece of data. Also, determination of previously diagnosed problems is key. The presence of glaucomatous optic neuropathy or any optic neuropathy puts the traumatized eye at risk for any pressure elevation experienced. Blunt trauma and postoperative courses are known to be associated with a high incidence of pressure elevations—either short term or chronic. Previous incisional surgery always leaves a weaker area in the ocular coat (Figure 3-4), which reminds us as ophthalmic surgeons to always inspect and be ready to repair these areas of prior surgical injury.

Previous conditions that can affect vision, especially negatively, are useful to uncover. Sometimes knowing the type of eye drops the patient has been using can give some insight into ocular conditions that involve the patient. Also, the need to aggressively repair all eyes with trauma is temporized if the physician knows ahead of time that the visual potential is poor.

Review of Additional Systems

The review of the patient's other systems (Exhibit 3-3) naturally follows the review of ocular systems. Items to be covered and understood are those that put the patient at risk for medical difficulties when surgery is performed, including a history of recent myocardial infarction or recent pulmonary disorders (eg, pneumonia, chronic obstructive pulmonary disease with recent exacerbations, reactive air-

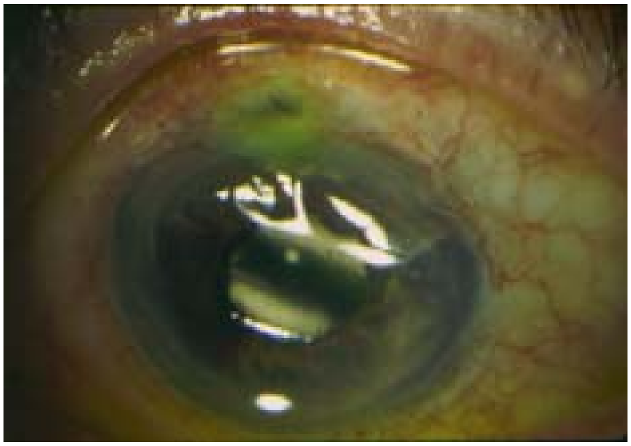


Fig. 3-4. The patient's episode of blunt trauma supports the premise that previous surgical sites never regain the tissue's original tensile strength. They remain areas of possible rupture during traumatic injury. Superiorly in the photograph, the previous cataract incision dehisced and required surgical repair to reinstate the structural integrity of the ocular coats. Other potential weak points in the ocular coats include the limbal region through Schlemm's canal and just posterior to the insertion of the extraocular muscles on the globe. These areas must be inspected before a ruptured globe is ruled out in the case of blunt trauma.

EXHIBIT 3-3

REVIEW OF SYSTEMS LIST

1. Head
2. Eyes
3. Ears
4. Nose
5. Throat
6. Neck
7. Chest
8. Heart
9. Lungs
10. Abdomen
11. Genitalia
12. Musculoskeletal system
13. Extremities
14. Neurological system
15. Skin

way issues). Cancer history with ongoing treatment or the presence of active disease, especially systemic infections, can complicate the care and recovery of the eye. These examples generally do not apply to the active duty military, but prisoners of war or the local civilian population who are offered equivalent treatment may carry some of these concerns to the ophthalmic surgeon. Ultimately, the goals of successful surgery and good vision may be difficult to achieve if these and other preoperative factors are missed or ignored in the time before surgery.

Surgical History

With the completion of the review of systems, information regarding past surgical history should have been discovered. As complete an accounting of previous eye surgeries as possible, in addition to systemic surgeries that the patient has undergone, is needed to allow safe and appropriate surgical care for the patient.

Medical History

A past medical history is developed at this time. The knowledge of the presence of hypertension, diabetes, or cardiovascular disease is important in understanding how the patient may respond to surgery. Time spent evaluating the past medical history, however short, can pay off in the end. For example, discovering a history of aspirin use or a full-blown bleeding diathesis can alter the surgeon's choice of surgical approaches or even the type of repair attempted for the specific injury discovered. The assessment of a patient's risk for having a contagious disease is not out of line today. In the trauma setting, this type of information may not only be unattainable but must be scrutinized for accuracy. The surgeon and other medical care personnel who care for trauma patients are well versed in the need to use universal precautions that protect them from communicable diseases. In a war, the soldiers involved usually have had a certain level of health screening that can detect human immunodeficiency virus, sickle cell trait, or other disorders. Of course, past medical histories for opposing forces or for civilian noncombatant casualties who receive care in the medical system will, to a large extent, be unknown.

Medication History

On the battlefield, most soldiers are fit and free from complex medical disorders. Nevertheless, obtaining a medication history on all trauma patients is wise. The value of this information increases as the patient enters into the category where medications are more commonly used. Medications that put surgical repairs at risk for failure, that put the patient at risk for difficulty with the surgical procedure or the general anesthesia, or that indicate the existence of complicating factors should be identified. Oral and topical steroids, anticoagulant therapy, antineoplastic agents, echothiophate products, and topical or systemic antibiotics tend to fit in those categories. Information about medication to treat systemic diseases—such as diabetes, hypertension, and pulmonary conditions ranging from asthma to pneumonia—are valuable in ensuring better care of trauma patients.

Allergies

If possible, the history portion of the examination needs to include a determination of the medication–allergy profile of the patient. Serious and fatal reactions can occur, and avoidance of known allergens is a wise and useful strategy as patients with ocular trauma are assessed and readied for treatment.

PHYSICAL EXAMINATION

With the history portion of the examination completed in appropriate detail and scope, attention is turned to the examination of the eye. The acquisition of accurate information, using all available examination techniques, allows the ocular surgeon to enter the treatment phase of the injury with knowledge to guide him or her toward appropriate surgery directed at the specific injury. This approach enables the highest success rate in the care of the ocular trauma patient because microsurgery to repair specific, known injuries with no occult injuries equals success for trauma repair.

Visual Acuity

The examination begins, as always, with an assessment of the level of visual acuity. The use of a Snellen visual acuity chart is an objective and familiar technique but is not required. Depending on the setting of initial care, a less formal assessment of visual acuity is acceptable. Assessing the visual acuity level with the "count finger" method is simple, and using the printed letters on an intravenous bag for the trauma patient to read is convenient. Both methods document valuable information for the clinical and surgical course the patient is about to undertake.

Light perception (LP) is an important threshold of vision. Without this level of acuity, initial repair and follow-on procedures may not result in any improvement. However, a patient with no light perception (NLP) should be managed aggressively, since a percentage of these patients will recover some vision.[14] If better vision is detected, repair of the worst injuries can be surprisingly successful.[15] The abilities to perceive light, to see hand movements, and to count fingers at a specific distance are the sequential levels of visual assessment. The ophthalmologist should test for vision in this standard fashion and always remember to test each eye separately. Using the 20/400 E and smaller letters, the Snellen's test type chart provides an accurate and reproducible measurement of the level of vision. The patient should be wearing glasses, if necessary, or the pinhole can be used to get an idea of the best corrected vision. Emphasis is placed on testing the vision early in the patient interaction. As is discussed in subsequent chapters, delay can cause additional clinical factors, such as bleeding and cataract, to depress visual acuity, and the amount of useful information acquired will be adversely affected.

The physician is challenged also to ferret out cases of malingering and secondary gain. These possibilities need to be addressed early in the treatment of the injured eye patient. These patients may take the opportunity to embellish the severity of their injuries or may attempt to fool the examiner into thinking there is "more than meets the eye." If this approach is successful, then the patient may end up with more, rather than appropriate, medical and surgical treatment than the actual condition requires. The accuracy of subjective visual acuity information should be questioned if the healthcare provider suspects a motive of secondary gain or the use of drugs and alcohol, or if the data are not making sense.

Remember that the random Es and Allen figures are to be used if necessary. In the heat of battle or in the mass casualty scenario that war can often produce, a brief but reproducible method should be used and a short time expended to get the best vision estimate. The mass casualty situation also exists in the civilian emergency room and hospitals. We have only to look at the bombing of the Murrah building in Oklahoma City, Oklahoma, in

April 1995 to see a medical system stressed beyond capacity.[16] The 15 seconds it takes to assess monocular visual function is never wasted time.

Pupil

The pupil examination yields a tremendous amount of information in a very short time. The shape and location of the pupil is one of the first and easiest bits of data in the eye examination that yield information about

- the integrity of the globe,
- the presence of blunt and sharp destructive forces in and around the globe, and
- the health and status of the eye with regard to the presence of infection and FBs.

Direct visualization with a simple penlight for illumination is the simplest of techniques and provides a tremendous amount of useful data (Figure 3-5).

The appearance of the pupil (including ovality, irregular borders, missing portions of the pupil border, and blood adhering to the surface or margin of the iris) can indicate that damage has been done to the eye. For example, a peaked pupil usually indicates a globe rupture or laceration in the quadrant that the pupil points toward. On the modern battlefield, high-speed projectiles and explosion-generated particles can be the objects that induce the subtle pupil damage that must be noted if more serious anterior and posterior segment injuries are to be diagnosed at presentation.

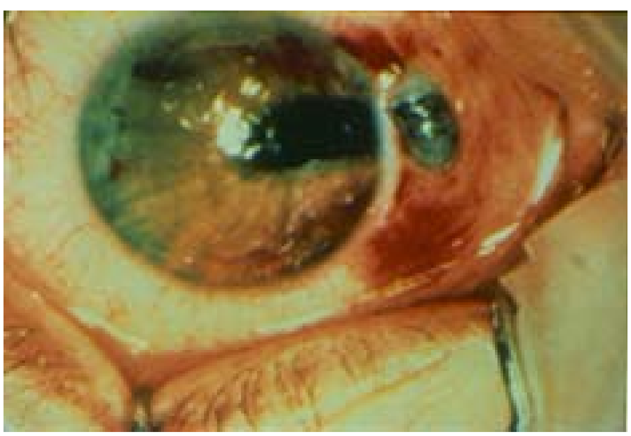


Fig. 3-5. This photograph demonstrates how a pupil examination can add useful information about the amount of damage sustained by the eye during a traumatic event. The shape of the pupil leads to several correct conclusions. The injury is penetrating and is located at the surgical limbus. Note the iris presentation anteriorly on the surface of the sclera, a finding that is also extremely important.

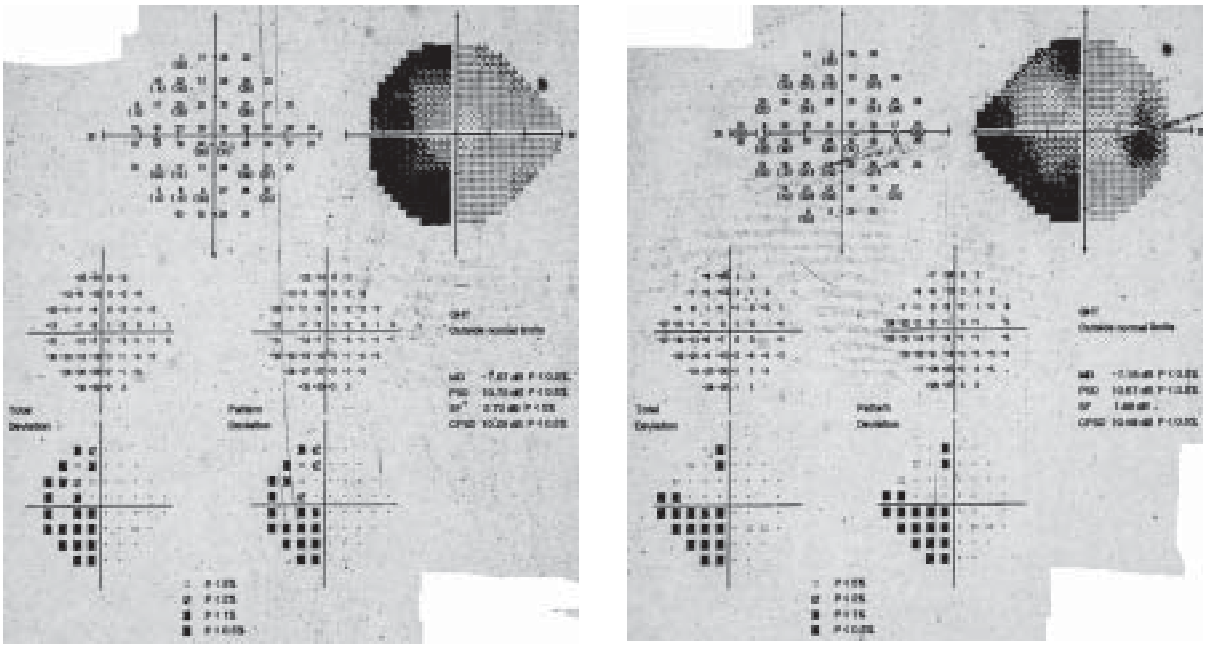
The pupil examination continues with a search for afferent pupillary defect (APD) or Marcus Gunn pupil. The technique of examining each pupil separately and then comparing the pupil's responses to light allows the health and function of the optic nerve to be compared and documented in an objective fashion. The absence of an APD is a powerful (and quick) indication that the intraocular optic nerve, the retroorbital portion of the optic nerve, and the optic canal portion of the optic nerve are relatively intact. That information can be ascertained in as short a time as it takes to check the pupillary reaction to light; this step should never be omitted when a trauma patient is examined.

If the pupil examination reveals a positive APD, we immediately know that there is a severe injury to the optic nerve or retina and posterior pole of the eye. Patients with the combination of NLP and APD tend to have a very poor prognosis. The presence of a relative APD causes concern about the well-being of the optic nerve, and the examiner then must study the eye for potential damage to the areas mentioned previously. Many ways exist to get information about damage or potential damage to the path of the nerve.[17] The detection of an APD on initial examination or subsequent examinations is a strong indication that there is severe damage to the eye or optic nerve.

Visual Field

The next portion of the examination is the determination of the patient's peripheral vision. The ocular trauma patient is at risk for myriad injuries to various portions of the eye. The specific injury determines whether visual field defects will be present. The difficulty in acquiring useful information from this aspect of the physical examination is that many or most of the findings will be nonspecific changes to the visual field. The time that would be spent conducting a more detailed examination to further identify the ocular or adnexal problem is probably best spent moving on to the remainder of the physical examination, ultimately preparing the patient and the eye for treatment and surgical repair of trauma-induced injuries.

Nevertheless, a carefully performed confrontation visual field test can be very useful for injuries that involve the retina, retroorbital spaces, the optic nerve, and the central nervous system. Inferior a b



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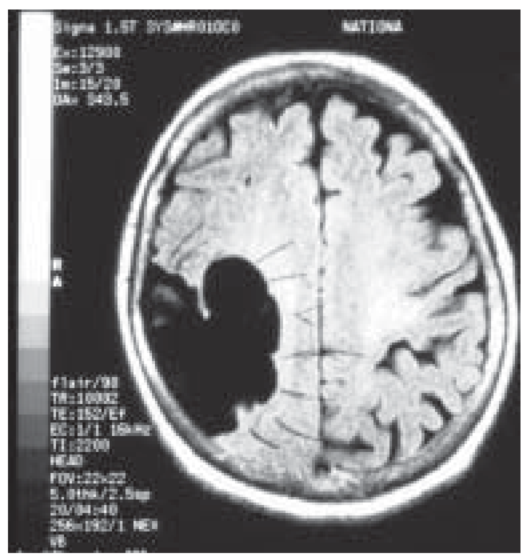


Fig. 3-6. This set of visual fields (**a**, left eye, and **b**, right eye) prompted further examination of this asymptomatic patient. After a magnetic resonance imaging (MRI) examination revealed (**c**) a large tumor of unknown duration in the right hemisphere, the patient underwent a neurosurgical excision of the tumor and the visual fields improved to near-normal.

altitudinal defects can indicate a contusion to the optic nerve in the optic canal or a retinal detachment when vision and the rest of the examination are deceptively "normal." Hemianopsia (Figure 3-6) always requires an evaluation of the posterior portions of the optic nerves and the visual pathways to assess for an injury to this portion of the visual system. However, the astute examiner may be able to gain some of this same information just by recording the quality of visual acuity and whether an APD exists.

In acute settings of trauma, formal or automated field testing is probably unnecessary. Formal visual field testing may be necessary, however, when documenting visual field loss due to traumatic optic neuropathy or a traumatic brain injury. These detailed examinations can usually occur in the weeks following the traumatic injury and need not occupy a priority in the care rendered in the battlefield.

Motility

The evaluation of ocular motility, a portion of the complete routine eye examination, has a purpose in the examination of the traumatized orbit and globe. Foremost, the examination should provide information as to the integrity of the ocular structures. An open globe tends to have decreased motility. However, any injury to the orbit and globe that involves the ocular muscles, motor nerves to those muscles, or origins and insertions of the muscles tends to present with some form of abnormal and decreased motility. Severe injury that leads to muscle and soft-tissue edema also has a certain amount of decreased movement as a presenting finding. Therefore, we can easily understand that although decreased motility can be present in the lacerated or traumatized globe, the clinical finding of abnormal motility does not confirm an open globe.

Several other conditions that decrease motility warrant mention. The examiner must include orbital hemorrhage, orbital wall fractures, and direct injury to the extraocular muscles in the differential diagnosis of a traumatized orbit and a disturbance in the motility of the eye.

Clinical experience helps guide the amount of detail needed to complete the appropriate level of examination. If the anterior segment is grossly unaffected by the individual injury, and if there is concern that periocular structures (muscles) are injured, then time can be spent assessing the motility and developing a differential diagnosis as to the type of injuries that support the clinical appearance of the patient.

The movement of the eye through the cardinal positions of gaze with penlight guidance is standard and easy to complete. If time permits and the patient's other difficulties allow, the assessment for strabismus can be completed at this time with the use of cover-uncover, cross-cover testing and, if available, neutralization of any misalignment with prisms. The quicker estimations of the Krimsky and modified Krimsky tests are also adequate at this level of initial trauma assessment.

As the level of injury and disorganization of the anterior segment increases, the need for detailed and time-consuming motility data decreases. If an open globe or an FB injury is present, then the globe and ancillary structures should be explored in an operating room setting. Direct inspection of the muscles will occur during this phase, and any needed treatment can be planned and completed without causing further delay in critical treatment.

An important observation must be kept in mind with regard to version and duction testing: if the architecture of the wound permits an opening of the ocular coats, then—as the attempt is made to understand the type of motility disturbance present—it is possible that the ocular contents may be extruded. The requirement to understand whether entrapment exists or if a paralytic component is present is not outweighed by the risk to the globe and the possible creation of a worse injury. Forced duction should be considered contraindicated until the eye wall has been confirmed to be intact and the eye can safely undergo more-extensive testing. Only then can the surgeon be confident that the examination itself will not lead to further damage of the eye. This thought process is logical because in a suspected blowout fracture, the repair of the open globe takes precedence over trapped orbital contents.

Adnexa

The time to complete the assessment of the surrounding structures begins as a "work in progress," with direct inspection occurring as the physical examination takes place. Viewing the surrounding soft tissues for signs of penetrating injury, lacerations, and infection while taking a history and completing the steps of the eye examination is a timesaving technique.

Specifically, the margins of the lids are to be examined for laceration. This type of injury may require repair in the operating room under magnification. The surface of the lid must be inspected for any signs of penetrating injury or laceration. If the laceration is superficial and does not involve the lid margin or canaliculi, then a simple closure with loupe magnification is acceptable. The presence of a deep or through-and-through laceration of the lid makes the examination of the globe very important, because the laceration may involve the ocular coats. Once such a laceration is identified, the appropriate steps to repair this injury should be instituted. Extreme caution must be used to ensure that an open globe is detected. Pressure on the globe during further examination or during an oculoplastics repair of a simple lid margin laceration can result in a poor outcome from the ocular trauma, secondary to the expression of ocular contents through the occult globe laceration.

When the injury completely transects the lid structures, a very obvious malfunction of the lid elevators may be present. The clinical examination can reveal specific information about an orbital structure, in this case the levator system. Once this information is known, the surgical plan can include steps to repair the levator damage during the surgical exploration. If the injury is above the tarsal plate in the upper lid, a helpful finding to look for during the examination is orbital fat prolapse. This finding of fat, not lacrimal gland, indicates that the orbital septum has been violated and that damage

Fig. 3-7. The medial location of the laceration and a high index of suspicion both led to the proper diagnosis of this canalicular laceration and lid margin laceration. Repair under the microscope or with loupes in an operating room setting allows a greater success rate with such lid injuries.

to structures deep in the orbit is possible. Additionally, the orbit has lost an important protective barrier to prevent the spread of infection within the injury site and the orbit. An injury to the canalicular system of the eyelids requires microsurgical repair (Figure 3-7).

Remember to palpate along the orbital rim and the bony structures that make up the orbit, because the detection of a step-off along the frontal, zygomatic, or maxillary portions of the orbital rims is diagnostic of fracture. An inferior floor fracture may entrap orbital soft tissues and require a surgical repair of a floor fracture (Figure 3-8). Testing for numbness of the infraorbital skin and upper teeth is a specific finding of infraorbital nerve damage and indicates a high likelihood that an inferior floor fracture is present. The appearance of more-extreme findings, such as orbital and subcutaneous emphysema, leads the examiner to rule out any traumatic connection that the sinuses may have with the orbit and subcutaneous spaces. These communications tend to arise from fractures of the bony support around the globe or to result from concomitant penetrations of the subcutaneous layers and the sinuses.

Direct inspection can also reveal conjunctival lacerations, which in and of themselves are benign. Once again, if the superficial injury appears deep to the conjunctiva, then surgical exploration of the peribulbar region using a surgical peritomy is required. Further information is best obtained as the examination shifts from inspection, to palpation of the ocular adnexa, to a magnified inspection with

Fig. 3-8. The result of trauma to the orbit and globe can be a fracture of the bony structure of the orbit. After an episode of blunt trauma, this patient suffered (**a**) a superficial upper lid laceration (repaired), upper and lower lid ecchymosis, subconjunctival hemorrhage, 2 mm of enophthalmos, and traumatic mydriasis. (**b**) An inferior floor fracture restricts the movement of the right eye in up-gaze. (**c**) Computed tomography scan evaluation reveals the prolapse of orbital contents through the orbital floor fracture into the maxillary sinus. Surgical intervention was required to restore eye motility. The posterior segment was clear of blunt rupture and commotio retinae.

the slitlamp during the anterior segment portions of the trauma examination.

Anterior Segment

The anterior segment examination is extremely important in patients with ocular trauma. During this portion of the examination, the ophthalmologist has the opportunity to inspect the ocular structures in the anterior portion of the eye with direct and indirect lighting, retroillumination, and magnification. The slitlamp biomicroscope is an important tool for the care of the patient with ocular trauma. If the examining ophthalmologist does not have access to this equipment, then an attempt to provide a light source and magnification is essential. A simple setup of a muscle light and a 20-diopter lens is a crude system that can aid the examiner. However, the use of a small, portable, handheld slitlamp may be the best compromise if the patient cannot get to an examination lane.

Trauma—especially blunt, FB, and penetrating types—leaves clinical signs. We have to become astute at detecting these signs, and that job has become easier with our modern equipment. An orderly sequence of evaluation for the anterior segment helps prevent oversight of any damaged vital structure that should be examined, including the lids and lashes, cornea, conjunctiva, anterior chamber (AC), angle, iris, lens, and anterior vitreous.

The equipment available to the surgeon for examining the anterior segment is vast. In addition to the illuminated magnification system provided by the slitlamp, the use of lid retractors—either a DeMarres or a bent paper clip—will aid in the discovery of damage to the anterior segment. Cotton-tipped applicators, fluorescein strips, local anesthetic to use in regional anesthesia of the lids, and a lid speculum all assist the patient and the ophthalmic surgeon in the completion of the most thorough and safe examination possible.

Direct Inspection

Direct inspection with illumination is the first step in examination of the anterior segment. The lids are examined for lacerations or any evidence of an FB injury. Special attention is given to any areas of swelling and ecchymosis. At this point in the examination, it is still necessary to consider the possibility of projectile injury. The direct examination of the surface of the eye is next. The use of direct, indirect, and retroillumination at the slitlamp are all valuable in assessing and finding damage to the cornea and conjunctiva. A defect in the surface of the conjunctiva or cornea, an area of chemosis or hemorrhage, or a glimpse of a foreign object—all of which can be seen at the slitlamp—lead the physician to the correct diagnosis of ocular injury. Specifically, in the examination of a corneoscleral laceration, the length of the laceration should be noted. The size of the laceration is important in predicting the final outcome for the patient (Figure 3-9).[18]

Fig. 3-9. This patient's shelved corneal laceration was first thought by the referring optometrist to be a nonhealing corneal abrasion. Careful slitlamp examination revealed the oblique nature of the laceration and the involvement of Descemet's membrane of the cornea. The use of the slitlamp biomicroscope is an extremely valuable part of the anterior segment examination. A wound leak was not present at the time of the consultant examination.

Penetrating corneal and scleral injuries that are not self-sealing yield additional clinical findings: these wounds will be Seidel-positive. The Seidel test involves the application of a fluorescein dye via a strip of paper, which, when viewed under a cobalt-blue light, reveals a rivulet of diluted dye—the egress of aqueous fluid—casting green fluorescence (Figure 3-10). Using strips of concentrated fluorescein is preferable to using a drop of dye, because the examiner can control the placement of the concentrated fluorescein.

The biomicroscope and the use of fluorescein dye offer another advantage: the differentiation of a corneal abrasion from a corneal ulcer. A break in the epithelium will allow the fluorescein dye to reach the corneal stroma, and the attached molecules will fluoresce. This finding supports the diagnosis of corneal abrasion. If a cellular infiltrate in the stroma (usually appearing white in color) is seen under biomicroscopy, then an infection is also present and the finding is most consistent with a

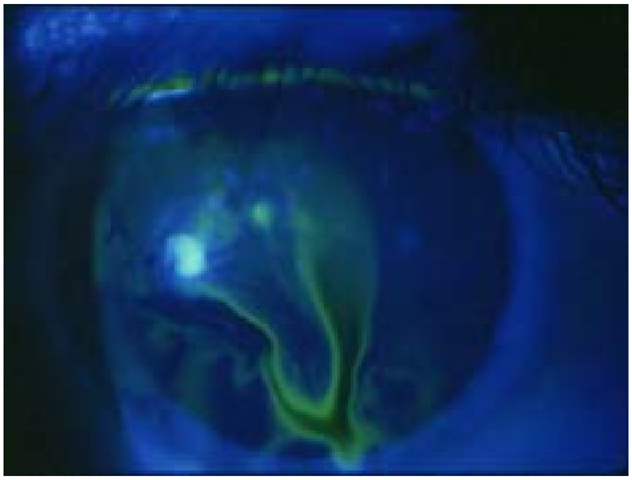


Fig. 3-10. This photograph of a sharp, penetrating corneal injury demonstrates positive findings of a Seidel test: a rivulet of aqueous is seen flowing from the penetration in the layer of concentrated fluorescein. This test is a valuable aid in the determination of anterior segment integrity.

corneal ulcer. The presence of an AC reaction, a history of soft contact lens use, and an absence of trauma to the eye also support the defect's infectious component.

Blunt injury to the eye can produce myriad findings. Globe rupture is the most serious injury and can be diagnosed with a complete examination of the anterior segment. Look for poor vision, a deep or shallow chamber, low intraocular pressure, and media opacities that obscure the view of the fundus.[19] An unusual but known finding of blunt trauma is the presence of concussive endotheliopathy (Figure 3-11). This finding is most common with a blunt FB injury such as a pellet (eg, a BB) that bounces off the cornea. A region of damaged endothelium in the posttrauma phase is present with a corresponding area of corneal edema.[20]

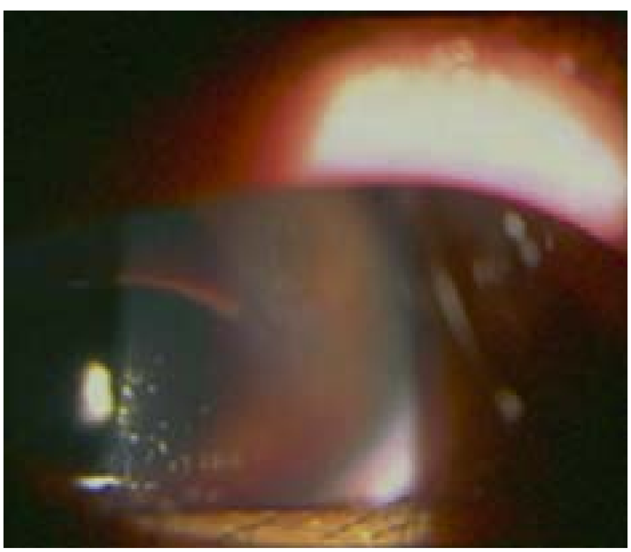


Fig. 3-11. The area of corneal edema seen in this photograph corresponds to the impact area of the BB that caused this blunt injury. Endothelial damage is present in the acute phase of these injuries.

The examination moves past the superficial structures of the eye, and slitlamp viewing of the internal structures allows the detection of further sequelae of ocular trauma. Within the AC—normally a clear, aqueous-filled chamber of the eye—hemorrhage; inflammatory cells; or FBs of metal, glass, or plastic can be seen easily with a careful slitlamp examination. The number, shape, and location of these objects should be noted to ensure removal of all FBs at the time of surgical repair.

Depth of the Anterior Chamber

The depth of the AC is also important. A rupture or laceration of the globe may release fluid from the AC and cause a partial or complete collapse. Some assessment of the chamber angle needs to take place once a blunt injury is suspected, because eyes that have sustained traumatic injury have a 14% incidence of this damage (Figure 3-12).[21] If there is a concern that rupture, laceration, or hyphema has occurred, a gonioscopic evaluation—in which the eye is instrumented with a gonioscopy lens—usually can be delayed. Van Herick's technique allows an initial evaluation of the AC depth for the acutely traumatized eye. A deep AC may indicate a posterior rupture, with increased AC depth due to the prolapse of vitreous from the scleral wound.

Intraocular Pressure

The determination of intraocular pressure (IOP) has questionable value in guiding the examiner toward a specific posttraumatic diagnosis. The differential diagnosis of low pressure after trauma includes rupture or laceration, iritis, retinal detachment, and cyclodialysis cleft. The possible diagnoses for an eye with high IOP after trauma include rupture or laceration, iritis, trabecular damage (contusion or recession), and retinal detachment. There is enough overlap among the clinical data that the examiner should consider IOP measurement only if the data are easily collected and can in no way cause further damage to the eye. There is some

Fig. 3-12. A broad area of angle recession is present in the photograph of this eye after an episode of blunt trauma. This area is asymmetrical with the appearance of the angle in the fellow eye. Because a wide variation exists in the level of insertion of the iris, it is important to examine the fellow eye. A symmetrical posterior insertion seen only unilaterally during an incomplete examination may lead the examiner to an incorrect diagnosis of angle recession.

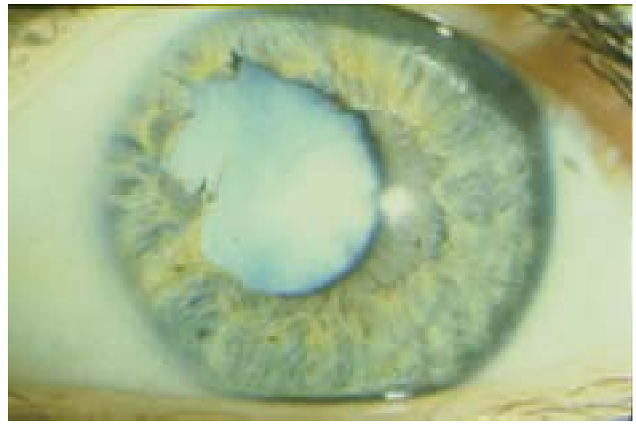


Fig. 3-13. Blunt trauma without rupture of the globe can generate fluid waves in the eye. The movement of the intraocular tissues by these waves can cause the type of iris and anterior segment injuries seen in this photograph. Note the irregular pupil margins secondary to sphincter tears and a developing cataract. This eye's drainage angle is seen in Figure 3-12.

value in knowing if the IOP is at one of the extremes. If there is any concern that the globe is unstable, then the measurement of the pressure of the eye can be postponed.

Iris

The iris may be the structure in the anterior segment that gives the most clinical information as to the damage the eye has sustained. It is a symmetrical, mobile structure. The appearance of the iris is important in all cases of trauma. A peaked pupil indicates that the iris has moved and is trapped or pulled into a defect in the ocular coat. Most likely, the opening is in the cornea or limbal region and is not self-sealing. By plugging the laceration or defect, the iris may have a sealing effect for the wound. Iris sphincter tears and irregularities indicate that the eye has experienced blunt and perhaps sharp trauma (Figure 3-13). The fluid wave generated in the injury is responsible for the traumatic enlargement of the pupil, stretching the pupillary sphincter and causing the tissue to tear.[22] Missing tissue or defects in the iris tissue generally indicate an episode of sharp trauma with possibility of an intraocular FB injury. Thus the iris, by its appearance, is able to lead the eye examination in appropriate directions. Each patient with ocular trauma should have a detailed examination of the iris; any asymmetry noted needs to be explained and understood.

Lens

A critical anterior segment structure to consider when examining a traumatized eye is the lens. This clear tissue lies posterior to the iris and can been seen through the pupil. Simple information about its location, clarity, stability, and the presence of capsular damage is collected in this stage of the eye examination. Lens position is determined primarily by zonular support. A traumatic event that damages zonular fibers (eg, blunt injury, sharp injury, or FB injury from penetration through the zonular fibers) influences the amount of support. Without uniform, 360° support from the fibers, the lens will likely be unstable, have some decentration, and exhibit tremulous movement known as phacodonesis.

The clarity of the lens can be influenced by the traumatic event (Figure 3-14). Focal lens opacities suggest a specific and local injury to the lens. A diffuse decrease in clarity is less specific. One important concept to apply in the examination of the

Fig. 3-14. This traumatic cataract developed after a penetrating corneal injury. Such cataracts can progress quickly, prompting the ophthalmic surgeon to examine the back of the eye before the cataract can obscure the view.

trauma patient is to examine the anterior vitreous and posterior pole through the clear media as soon as possible. The posttraumatic eye can undergo changes that inhibit a good examination. Traumatic cataract and intraocular hemorrhage are two excellent examples of traumatic changes that prevent the examiner from completing the routine eye examination.

Anterior Vitreous

The assessment of the anterior vitreous completes this portion of the examination. Taking the opportunity to view this region with the slitlamp allows the precise documentation of foreign objects (location and number); cellular debris, which may indicate early infection; and blood products, which indicate that posterior segment damage may be present. Having the vitreous examination occur at the end of the sequence while the patient is in the slitlamp position accomplishes two important examination goals:

1. The orderly sequence of the examination is maintained, which is important if overlooking any anterior segment structure is to be avoided. Attention must be directed to any disruption of tissues, foreign particles or objects, blood, and signs of infection. All may indicate traumatic injury to the eye, and all require action on the part of the ophthalmologist.
2. The examination can easily shift from the anterior segment to the slitlamp examination of the posterior segment.

Posterior Segment

The examination of the vitreous cavity, retina, choroid, and sclera is best done soon after the injury and with the pupils in a dilated state. A tropicamide (1%) and phenylephrine (2.5%) combination is an acceptable dilating regimen. In a battlefield situation, remember that it is important to document both *on* the patient's forehead and *in* the record that pupil dilation has been achieved pharmacologically. In the confusion of the battlefield, it is critical to maintain an orderly sequence of examination to ensure its completeness. The examination of the posterior segment must include the vitreous cavity; the optic nerve; the retina, including the ora serrata retinae and the pars plana corporis ciliaris; the choroid; and the sclera.

Indirect ophthalmoscopy is the premier examination technique for revealing the myriad findings that can be present in the posterior pole of an injured eye. Knowing this fact and knowing that the usefulness of the indirect examination depends on the clarity of the media, one should realize the importance of completing all the previous examination segments as quickly as possible to ensure accuracy and avoid delay in reaching the posterior pole examination. The development of a traumatic cataract, the accumulation of inflammatory products, the presence of blood, or the disruption of tissues in the visual axis can obscure the view of the back of the eye. Delay can relegate the remainder of the data collection to ancillary tests used to see into eyes with no view or a poor view into the posterior pole. These ancillary tests are extremely useful; nevertheless, they are not a substitute for the indirect ophthalmoscopic examination.

The examination of the posterior segment can begin at the slitlamp when the anterior segment examination is completed. The use of the 78-D or 90-D lens to examine the optic nerve and the surrounding fundus is an excellent examination technique. Close attention should be given to the characteristics of optic nerve health. Signs of pallor, hemorrhage, tissue disruption, and edema are all-important findings and generate concern that the visual system may be damaged at this anterior site.[23] Working methodically from the optic nerve, the presence of FBs and foreign materials will be noted. If found, they should be counted and characterized as to the type of material they are made of, if possible. The macular region is studied for damage that can provide information that helps determine the level of postinjury visual abilities (Figure 3-15). Retinal tears and breaks are searched for as the ex-

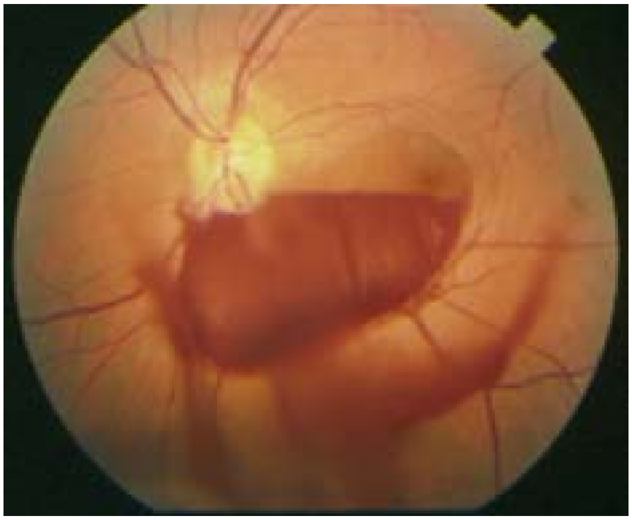


Fig. 3-15. Blunt injury can lead to preretinal hemorrhage with extension into the vitreous cavity, as is seen in this patient. The soldier had noticed decreased vision after carrying a field pack during an extended march. Valsalva's maneuver may have played a role in this particular injury to the posterior pole.

amination continues (Figure 3-16). Subretinal fluid (indicating retinal detachment) and subretinal blood (indicating trauma to the region) are pertinent findings. Inspection of the choroidal and scleral coats is also to be made (Figure 3-17). Retinal detachment and scleral and choroidal rupture, which may be hidden by hemorrhage, are common trauma-related injuries that must be addressed by the ophthalmologist in the hope of recovering the best visual function for the patient.[2,24,25]

Switching to the indirect ophthalmoscope at this point in the examination allows for a more panoramic view, although with less magnification, of the optic disc and the surrounding fundus. The indirect ophthalmoscope is also used to examine the

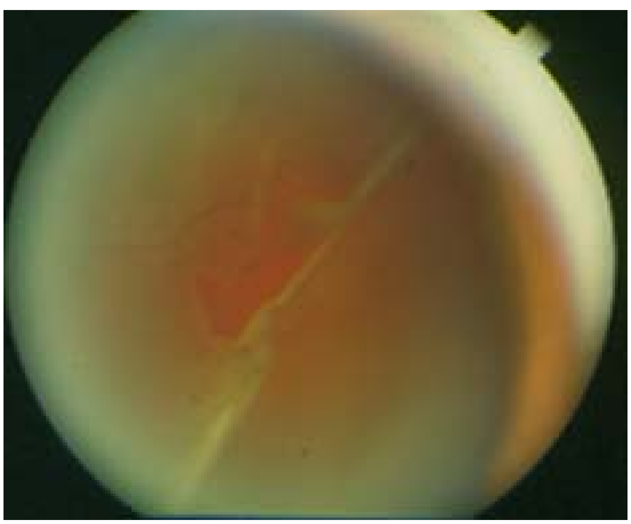
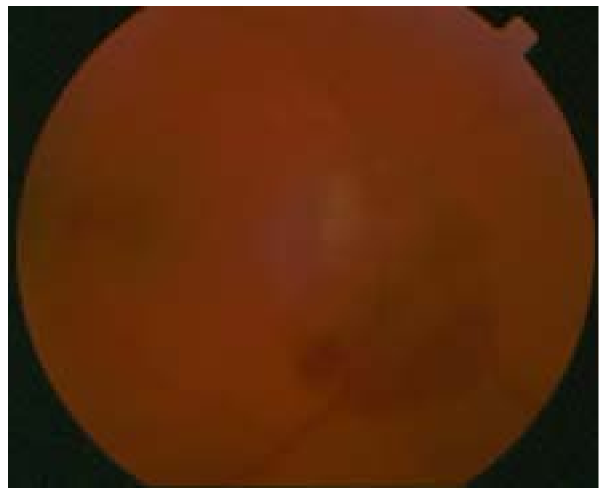


Fig. 3-16. This example of a rhegmatogenous retinal detachment is a reminder that both blunt and sharp injury may produce this type of injury to the retina. Keys to finding retinal injury are to look for injury when the view through the anterior segment allows inspection of the retina and to use available ancillary tests when the view of the posterior pole is poor.

a



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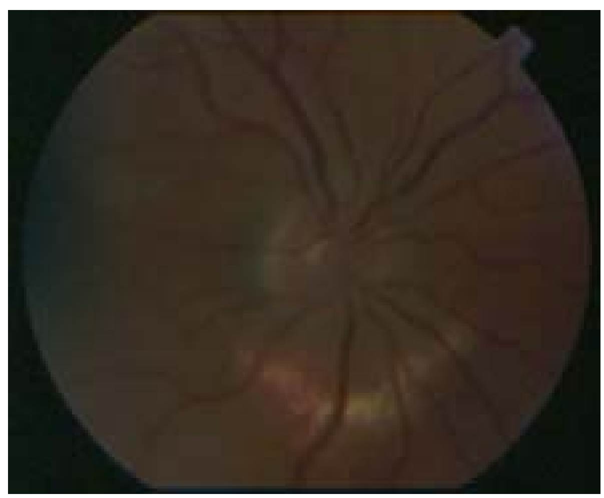

Fig. 3-17. Injury to the posterior pole can be extensive. The vitreous cavity can be involved with the collection of blood, the retina can sustain damage, and the choroidal layer can sustain injury. Early in the treatment phase (**a**) the extent of the injury may not be apparent. If the clinical course permits, serial examinations can reveal additional areas of concern (**b**) when the choroidal rupture becomes obvious after the vitreous hemorrhage clears.

vitreous, equatorial fundus, peripheral fundus, and vitreous base. Even though complete visualization of the posterior pole allows the most accurate assessment of the injuries to the back of the eye, caution must figure into the decision to use scleral depression. Any possibility of a ruptured ocular coat or an open globe should indicate to the examiner that the scleral depression portion of the examination should be delayed to prevent further damage to the traumatized eye. In the absence of rupture, an alternative technique for viewing the posterior structures is the three-mirror Goldman contact lens, which can provide additional data about the injury.

The evaluation of the injury should include an assessment for surgical repair. How much scar tissue is present? What track did the object take? Which method of removal should be entertained? Is there an associated retinal detachment present with the FB? Is infection present? These issues can be addressed if a view of the injuries is available. Without a good view to the posterior pole, the answers to all these questions become more difficult.

Without a view of the posterior pole structures, the ultrasound B-scan, plain film radiography, CT scan, and MRI technology are brought into use. Chapter 4, Imaging of Ocular and Adnexal Trauma, is devoted to the use of these techniques and a review of the advantages and disadvantages of these examination methods.

PREOPERATIVE PREPARATION

With the ocular and adnexal examinations completed and the ancillary procedures planned, the patient must be readied for the transition in care from data gathering to actual treatment and recovery. This phase's importance should not be underestimated. During the preoperative phase, several aspects of the patient's care are manipulated.

First, the safety of the patient is assessed. The patient should be stabilized and life-threatening surgical and medical conditions treated. The patient is moved expeditiously out of harm's way to an area of the battlefield that allows an initiation of the history and examination portion of the ocular and adnexal examination (and for any of the other body systems that have sustained injury). When attention turns to the ocular injuries, the preoperative phase is used to initiate therapy that can protect the eye from sequelae of the trauma.

Risk of infection is a large concern. The battlefield is a dirty environment where foreign objects achieve high velocities and contribute to ocular and adnexal injuries. The need for preoperative, posttraumatic antibiotic therapy is decided at this time. To best prepare the eye for a successful postoperative course, the use of intravenous antibiotics is recommended for open globe injuries.[8] No ointments or solutions toxic to the retina are recommended until the ocular coats are proven intact. This fact is usually confirmed in the operating room by an ophthalmologist. Medical officers in the field without access to the slitlamp and operating room microscope should not use topical therapy for trauma patients.

One goal worth striving for is to have definitive ophthalmic care occur within 36 hours.[18] An early repair gives the surgeon the opportunity to deal with viable, uninfected tissues. The primary repair then proceeds with greater ease, achieving closed ocular tissues and reapproximated adnexal tissues.

A second goal is the protection of the ocular and adnexal structures from further injury. Metal eye shields are an excellent method of protection. Substitutes are readily made from material at hand, such as the bottom of a paper cup. Preventing further damage to an open globe is the primary concern. The unstable eye is susceptible to injury exacerbation from any external pressure. The patient can cause additional injury by rubbing and squeezing the injured eye. Maneuvers to prevent these actions include chemical or physical restraints, sedation, and anesthetic blocks to decrease lid activity.

The use of pain relief is an important consideration in the ocular trauma patient. Effective analgesic therapy for trauma patients can help stabilize wounds and minimize additional injury during the preoperative phase. Of course, once these medications are administered, the ability to get informed consent from the patient is lost. Again, in the battlefield, the need for consent differs from the requirements of civilian practice. In the care of the injured soldier, the ophthalmologist is entrusted to make the appropriate surgical decisions for the patient.

Valsalva's maneuver can be a huge enemy to the open globe, so antiemetic therapy is important when preparing the patient for both transport and repair of the eye injury. Intramuscular and intravenous routes of administration are recommended. The slow and unpredictable effects of oral medications in trauma patients make this route of administration a less desirable alternative.

SUMMARY

Providing ophthalmic care to patients with ocular trauma in a wartime setting is challenging because of difficulties in accessing both the injured soldier and the equipment necessary for visualizing and diagnosing injuries to the ocular and adnexal structures. Compared with the peacetime civilian arena, these wartime factors make it difficult for military ophthalmologists to care for soldiers with eye trauma and consistently achieve excellent results. Nonetheless, if the sequence of history and examination techniques is followed as presented in this chapter, the chance of overlooking important clinical information is reduced. Adhering to a set sequence reaps even more benefits as the battle intensifies and confusion escalates. The goal to return the injured soldiers to their units and their families as healthy as possible is within reach.

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