Chapter 13

PRIMARY REPAIR OF THE POSTERIOR SEGMENT: PENETRATING, PERFORATING, AND BLUNT RUPTURE INJURIES

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INTRODUCTION

Successful repair of a scleral laceration resulting from operational casualties requires an understanding of the mechanisms of combat eye injury and a hierarchy of surgical repair goals. Once globe penetration is suspected, timely surgical exploration and repair are required to prevent infection, tissue necrosis, sympathetic ophthalmia, and tissue downgrowth. Proper wound exposure greatly facilitates globe closure. The initial repair should succeed in creating a watertight closure, free of entrapped tissues and foreign bodies (FBs). Reconstructive efforts should be minimized during the initial repair. Following primary repair, the patient should be evacuated for further evaluation, removal of FBs from the eye, and reconstructive surgery.

OPERATIONAL EYE INJURY

Ocular injuries sustained in the battlefield have become increasingly common throughout the 1900s as weaponry has favored blast fragmentation munitions. Most of these injuries occur in the setting of multiple trauma, reflecting the effectiveness of modern weapons,[1] and in recent conflicts, 13% of all those wounded have had injuries to the eyes.[2] Small, high-velocity fragments easily penetrate exposed soft tissues, including the eyes and adnexal structures. The depth of particle penetration depends on the shape, mass, and velocity of the FB. Most FBs that penetrate and remain within the eye are 5 mm or less in size[3,4]; larger particles tend to perforate the eye and travel deeper into the orbit or adjacent tissues (Figure 13-1).

Penetrating and perforating injuries account for 20% to 50% of all wartime ocular injuries,[5] and approximately 15% to 25% of injuries are bilateral.[1,6–8] The most common weapons responsible for fragmentation ocular injuries are shells, rockets, grenades, and mines. Roughly 55% of combat FBs are nonmagnetic, reflecting the nonferrous composition of mines and secondary missiles.[5] The mortality of close-proximity shell injuries is very high; most ocular injuries occur at a distance of 150 feet or more from highly explosive blasts.[9] Rifle bullets and large projectiles are less often responsible for isolated ocular injuries because of such injuries' high mortality when they occur in the head region. Antipersonnel mines commonly produce severe extremity and ocular injuries,[10] and from the perspective of maintaining the fighting strength, the data are even grimmer: 75% of soldiers who suffered ocular injuries during the Vietnam War were unable to return to duty.[11]

Regardless of the setting, ocular trauma that results in globe rupture tends to derive from mechanisms that include projectile penetration, sharp laceration, and blunt contusion.[12] Combat blast injuries threaten the eye through release of high-velocity missiles, direct concussion effects, or architectural collapse leading to sharp laceration or blunt injury of the globe.

Ocular injuries that occur during peacetime operational settings more closely reflect those commonly encountered in the industrial workplace. The National Eye Trauma System Registry reports that 65% of these injuries result from projectiles, 24% from sharp injury, 9% from blunt objects, and 3% from blasts.[13] The majority of both civilian and peacetime military ocular injuries are preventable and occur in individuals who fail to wear adequate eye protection.[14]

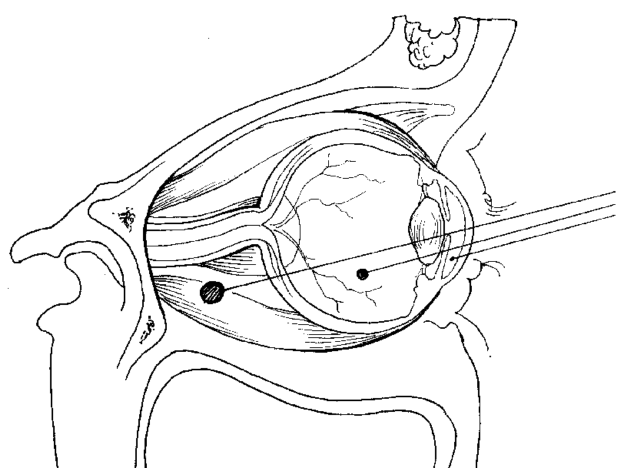

Fig. 13-1. *Penetrating* globe injuries result from a foreign body's (FB's) entering and remaining within the globe, commonly within the posterior segment. In general, the larger the FB, the more likely it will travel deep into the eye. Most FBs that penetrate and lodge within the eye are 5 mm or less in size. A *perforating* eye injury results from an FB's passing entirely through the eye and lodging within the orbital tissues. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

MECHANISMS OF OCULAR INJURY

High-velocity projectiles are responsible for most battlefield globe ruptures. Aside from the fragmentation produced directly by munitions, particles of glass, metal, stone, or vegetable matter may become secondary missiles in a blast (Figure 13-2). In the Iran–Iraq War (1982–1988), roughly 22% of intraocular foreign bodies (IOFBs) were composed of organic materials.[15] Metal striking metal also commonly leads to high-velocity metallic fragments with enough energy to penetrate the eye. Small projectiles may become lodged within the globe or perforate the globe and travel into the orbit. Between 80% and 90% of wartime IOFBs are located in the posterior segment.[8,15–17] By location and frequency, 15% of IOFBs are found in the anterior chamber (look in the inferior angle), 8% in the lens, 70% in the posterior chamber, and 7% in the orbit.[18]

Large, high-velocity projectiles (eg, bullets) can generate an associated shock wave within the surrounding tissue at impact and may rupture the globe despite an adjacent but noncontiguous penetration site. Bullet injuries directly impacting an eye produce devastating and often irreparable damage.

Although high-velocity, metallic FBs are usually sterile, secondary missiles produced by a blast injury are likely to increase the risk of endophthalmitis. The wartime incidence of endophthalmitis (6.9%–7.9%) is slightly higher than that documented in civilian industrial reports.[1,3,4] Vegetable matter carries the largest risk for introducing infectious contamination into the wound. Debris associated

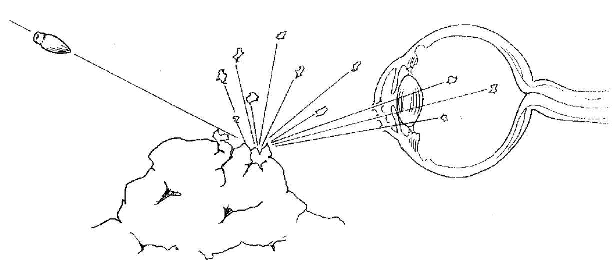

Fig. 13-2. Secondary missiles are produced when a high-velocity projectile strikes a stationary object, causing it to shatter into many high-velocity particles. In combat, secondary missiles are often responsible for tissue injury and typically are composed of such materials as rock, soil, glass, vegetable matter, clothing, or metal. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

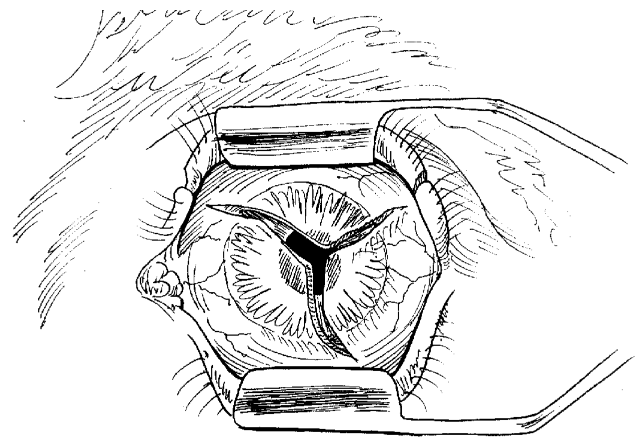

Fig. 13-3. Ocular injuries resulting from a sharp laceration commonly involve multiple tissue layers, including the eyelids and anterior segment. In evaluating an eyelid laceration, a careful inspection of the globe must be completed to exclude an associated ocular injury. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

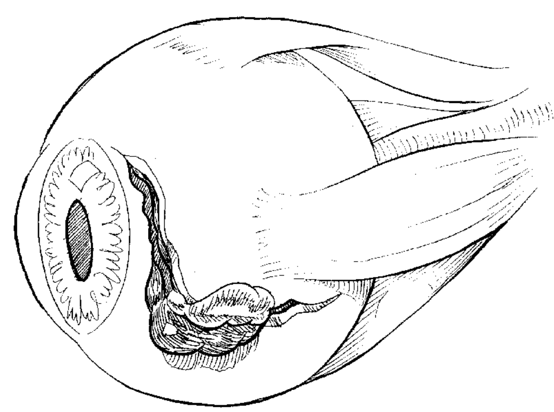

Fig. 13-4. Marked deformation of the eye occurs during blunt compression of the globe, generating tremendous intraocular pressure. A rupture occurs when the weakest portion of the globe gives way as the strength of the eye wall is exceeded by rising intraocular pressure. Common sites for globe rupture include the limbus, the area beneath the rectus muscles, and at the site of prior surgical scars. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

with mine blasts accounted for 40% of endophthalmitis cases in the Vietnam War.[19] Approximately 20% of these infections were attributed to *Bacillus* species, which causes severe infection with devastating visual effects.

Laceration to the globe from knives, glass, or sharp structural elements usually involves multiple tissue layers and frequently disrupts the eyelids and cornea (Figure 13-3). Despite severe tissue derangement, sharp lacerations often approximate precisely and carry a more favorable prognosis than some other forms of injury. Residue (eg, rust, glass fragments, paint) from the instrument of injury should be considered during wound debridement before globe repair.

With blunt compression, the globe undergoes marked deformation before rupture.[20,21] The weakest portions of the globe give way as the compressed intraocular structures generate tremendous intraocular pressure. Common sites for blunt rupture include the limbus, beneath the rectus muscles, or within the site of a prior surgical scar[12] (Figure 13-4). Many blunt ruptures extend parallel to the limbus and then turn sharply beneath a rectus muscle. The blunt mechanism of injury rarely induces more than one continuous rupture site.

INJURY HISTORY AND EVALUATION

If it is possible to obtain a history, the examining physician should seek to understand the mechanism and time course of the ocular injury. Details about the chronology of events will influence decisions on surgical management, and knowledge about the mechanism of injury will guide the preoperative investigation.

Intraocular tissues that prolapse through a rupture site often have limited viability. The decision whether to reposit or to amputate a prolapsed tissue is influenced by the duration of the extraocular exposure. When an FB is suspected, it is important to consider the possible materials involved (eg, glass, steel, copper, lead). Small, inert FBs may be carefully observed over time for infection and staining, whereas reactive materials such as copper require early removal from the eye.

Before assessing an ocular injury, the patient must be stabilized with regard to associated injuries. The physician should approach the patient with as complete an examination as is practical. The assessment will determine whether the globe should be explored and whether further studies should be performed to search for IOFBs. The physician should always maintain a high index of suspicion for a more serious injury than is readily apparent. Clinical signs of globe rupture by various mechanisms are listed in Table 13-1.

TABLE 13-1

CLINICAL SIGNS OF GLOBE RUPTURE

Mechanism and/or Location of Rupture	Clinical Signs
Corneal Laceration and Perforation	Shallow anterior chamber
	Seidel-positive wound
	Uveal incarceration
	Self-sealing tract
Posterior Scleral Rupture	Decreased motility
	Deep anterior chamber
	Hemorrhagic chemosis
	Vitreous hemorrhage
	Hypotony
Intraocular Foreign Body	Direct visualization (early in the examination, offers the best chance for locating and characterizing the foreign body)
	External penetration site
	Lens injury
	Tract within the vitreous
	Other sign of foreign body

Large projectiles often produce marked derangement of the globe with obvious perforation and extrusion of intraocular contents. The impact of a high-velocity missile can cause massive loss of ocular and adnexal tissue. The large mass of these missiles results in deeper penetration and greater damage to underlying and adjacent tissues.

Penetration of the globe by minute projectiles may cause minimal signs of overt injury at presentation (Figure 13-5). A high index of suspicion is often necessary to identify the FB and repair the injury. The examiner must search carefully for wound tracts, conjunctival lacerations, vitreous blood, and lens damage. If the view permits, indirect ophthalmoscopy affords the best opportunity to identify the composition, size, and shape of the projectile (Figure 13-6). Ancillary testing with computed tomography (CT) is helpful in detecting small, metallic FBs when visualization is not possible. Nonmetallic FBs are best visualized with magnetic resonance imaging (MRI) scanning. B-scan ultrasonography can help detect an FB but should not be used if an obvious rupture exists. Interpretation of the B-scan is often difficult owing to numerous tissue interfaces and artifacts in the blood-filled eye. Plain film radiographs are useful in determining the shape of radiodense FBs but lack the accuracy to precisely locate the object in three dimensions.

Sharp lacerations leading to globe rupture frequently involve deep puncture or lacerations through the eyelids and adnexal structures. Hemorrhage and blood clots from the eyelid laceration often obscure the globe injury. Full assessment of ocular integrity may require surgical exploration at the time of lid repair.

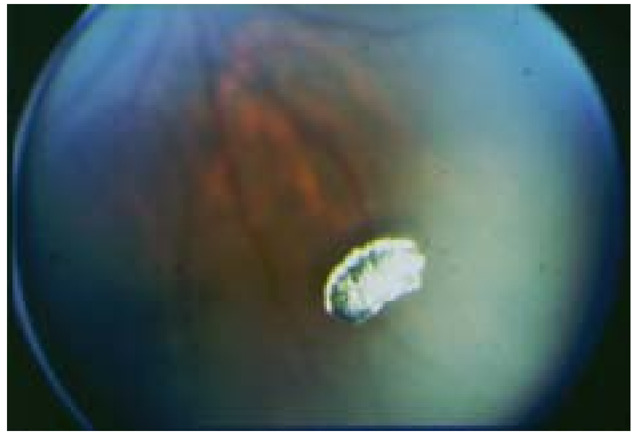

Fig. 13-6. An intraocular foreign body such as this metal fragment located in the vitreous (arrow) is often visible by ophthalmoscopy in the early postinjury period. Direct visualization of the foreign object offers the best opportunity to determine the size, shape, and composition of the projectile.

Blunt posterior globe rupture often produces hemorrhagic chemosis, deep anterior chamber, reduced ocular motility, vitreous hemorrhage, and increased tearing (Figure 13-7). Although intraocular pressure is usually low, ocular tension may be normal or elevated. Visualization of a clear vitreous cavity with an intact retina and choroid excludes the diagnosis of blunt posterior rupture. Any eye suspected to have a possible posterior globe rupture should be surgically explored to determine whether the integrity of the eye has been compromised.

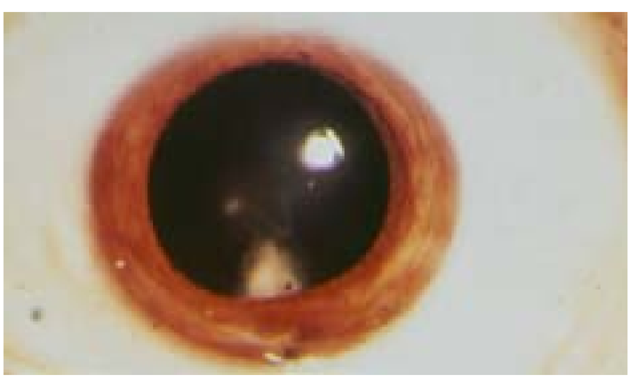

Fig. 13-5. Occult globe penetration by a foreign body may be revealed when the pupil is dilated. In this example, the small foreign body (FB) passed through the limbus and lens before lodging in the posterior segment. The white triangle at the 6 o'clock position is the lens opacity induced by the FB's passing through the eye.

Fig. 13-7. This eye with a blunt posterior globe rupture demonstrates hemorrhagic chemosis and a deep anterior chamber. A low intraocular tension and reduced ocular motility were associated with the injury.

SURGICAL MANAGEMENT

Surgical Goals

Delayed closure of a ruptured globe is *not* a viable option in ocular surgery; prompt repair reduces the risk of endophthalmitis, tissue downgrowth, and tissue necrosis. Because all subsequent ocular reconstructive surgeries depend on a strong, watertight closure, the goals of the 3rd-echelon ophthalmologist are to

- identify the extent of injury,
- rule out an IOFB if possible,
- close the open globe primarily,
- limit reconstruction as much as is practical, and
- guard against infection, sympathetic ophthalmia, and tissue downgrowth.

Although FB identification is important, removal is usually not practical in this arena. Steps to identify FBs (eg, CT scan, ultrasonography) may also be deferred to the 4th echelon if they are impractical to perform at the 3rd echelon of care.

The ophthalmologist should surgically explore any eye suspected to be ruptured, identify the extent of injury, and complete a precise closure of the wound. FBs presenting at the injury site during closure should be removed (Figure 13-8). Ensuring that the injury site is clean of debris and well approximated helps prevent infection, sympathetic ophthalmia, and tissue downgrowth. Reconstructive efforts are rarely necessary during the initial repair and should be avoided. Both corneal edema and a greater tendency for ocular bleeding make reconstruction surgery ill-advised in the acutely injured eye. Marked inflammation and vascular engorgement increase the risk of hemorrhage in the first several days following trauma. Delaying reconstruction for several days significantly reduces the risks of surgery. Eyes known or suspected to have a retained FB should be repaired primarily and promptly evacuated to the next level of care for removal of the FB.

Fig. 13-8. Foreign objects, such as this aluminum shard lodged within the sclera, should be removed at the time of initial surgical repair. Intraocular foreign bodies that cannot be visualized directly by the surgeon should not be removed during the initial repair but should be addressed at the 4th-echelon level of care.

When an open globe is suspected, prophylactic intravenous antibiotics should be started as soon as is practical. Most authors recommend antibiotic coverage with a first-generation cephalosporin in combination with an aminoglycoside for wounds that are not heavily contaminated.[22–25] Vancomycin also offers a broad range of coverage and is often substituted for cephalosporin. Intravenous clindamycin should be added to the antibiotic regimen to cover *Bacillus* species if the injury has been contaminated with soil or vegetable matter.

Preoperatively, the ophthalmologist should avoid the use of topical and subconjunctival antibiotics that might enter the ruptured eye and cause retinal toxicity. The concentration of standard topical and subconjunctival antibiotics is roughly 10-fold higher than the toxic threshold level tolerated by the retina. A protective shield should be applied over the injured eye until definitive repair is possible.

The surgeon should never enucleate an eye primarily unless restoration of the globe is impossible. No light perception (NLP) vision should *not* be used as an early enucleation criterion, because several reports of patients with initial NLP indicate that they later recovered some level of vision.[26] Methodical repair can reconstruct many eyes that initially appear unsalvageable.

Step-by-Step Repair

1. Under general anesthesia, gently retract the eyelids of the injured eye with either a lid speculum or eyelid-retraction suture. Pressure on the globe should be avoided.
2. Perform a 360° limbal conjunctival peritomy beginning in a quadrant away from the suspected rupture site and working toward the rupture (Figure 13-9). Care must be taken to avoid engaging the prolapsed tissues or wound edge.

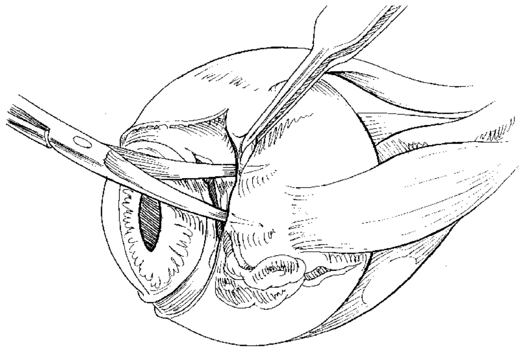

Fig. 13-9. A 360° limbal conjunctival peritomy is performed to explore for globe rupture. Care must be taken in completing the dissection to avoid engaging prolapsed intraocular tissue or wound edges. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

3. Irrigate and identify tissue, cleaning the wound of debris. Handle tissues carefully, as prolapsed uveal tissue may resemble foreign matter or clotted blood and will bleed freely if injured.

4. Gain control of the eye using a 4-0 silk traction suture placed through the limbus distal from the wound or by looping individual rectus muscles with 2-0 silk bridle suture. Before passing the bridle suture beneath the rectus muscle, the sclera must be carefully inspected to avoid manipulation of the rupture site. Extreme care must be exercised in using a muscle hook near the injury to guard against inadvertent wound penetration (Figure 13-10).

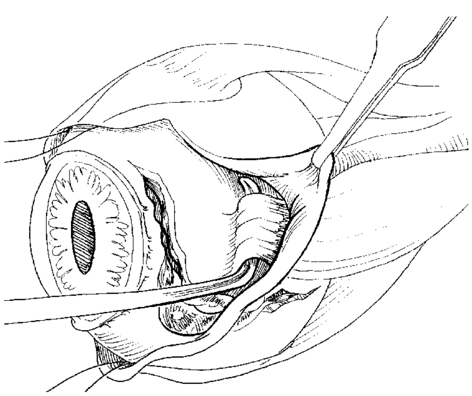

Fig. 13-10. Globe rotation is greatly facilitated by placement of 2-0 silk traction sutures beneath the rectus muscles or 4-0 silk suture through the limbus. To avoid inadvertent wound penetration, extreme care must be exercised in using a muscle hook under the rectus muscle. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

5. Identify the path and course of the rupture. Carefully remove any foreign material lodged within the wound. Inspect tissue before considering removal of any clotted blood or debris from the scleral wound, because the tissue actually may be choroid or retina. Send any excised tissue to pathology for identification. Attempt to reposit all viable exposed tissues.

6. Proper wound exposure greatly aids in both the identification and the repair of the injury. If the injury cannot be adequately exposed using traction sutures, the surgeon should consider tagging and temporarily reflecting a rectus muscle to enhance globe rotation (Figure 13-11). A 5-0 double-armed Vicryl suture woven through the muscle tendon, incorporating "locking bites" on either end, secures the muscle before the tendon is cut from the sclera.

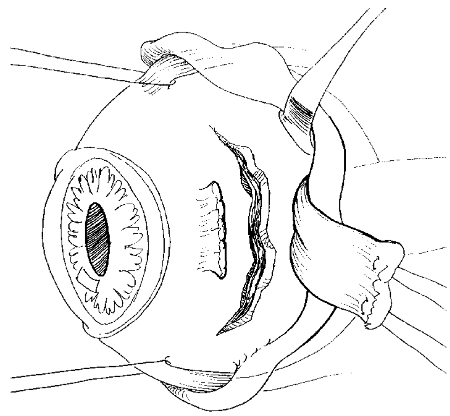

Fig. 13-11. In certain circumstances, reflecting a rectus muscle provides superior wound exposure and can greatly improve globe rotation. Before transecting the muscle from its scleral insertion, a double-armed 5-0 Vicryl suture should be woven through the muscle tendon with "locking bites" taken on either end. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

7. Injuries through the limbus should be approximated with a 9-0 nylon interrupted suture to maintain tissue orientation.

8. Close the corneal wound with 10-0 nylon (see Chapter 9, Sharp Trauma of the Anterior Segment).

9. Inspect the scleral wound edges for corresponding defects and begin the posterior repair by approximating these landmarks. Repair sclera with 8-0 nylon in an interrupted or baseball suture pattern by passing the needle through each side of sclera separately to a depth of 75% of the scleral thickness (Figure 13-12). Try to avoid passing the

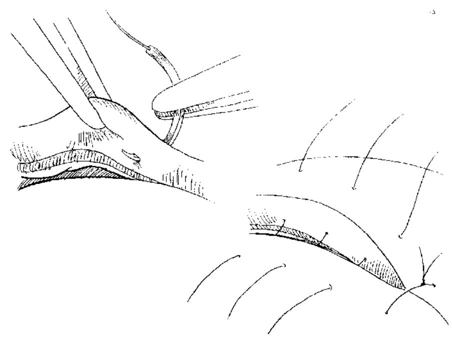

Fig. 13-12. The sclera is repaired with an interrupted or baseball suture pattern passed through each side of the sclera to a 75% depth. Closure is facilitated when an assistant can depress choroid and vitreous while the wound is approximated and tied. Drawings prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

needle through the full thickness of sclera, as this maneuver often results in uveal incorporation within the closure. The assistant uses a spatula to depress choroid and vitreous while the surgeon approximates the wound edges and the sutures are tied.

10. Vitreous should be cut flush with the choroidal tissue using either an automated vitrectomy instrument or a cellulose sponge and fine scissors (Figure 13-13). Vitrectomy cut rates of 400 to 600 cuts per minute are optimal to remove vitreous and reduce the tendency to incorporate uvea or retinal tissue within the vitrectomy port. The vitrectomy instrument should not be placed directly into the eye, thus avoiding retinal injury, but may be used along the wound to remove residual vitreous as the wound is approximated. Vitreous and clotted blood will likewise adhere to a cellulose sponge, allowing the surgeon to exert gentle traction on the tissues and trim them close to the wound with fine scissors.

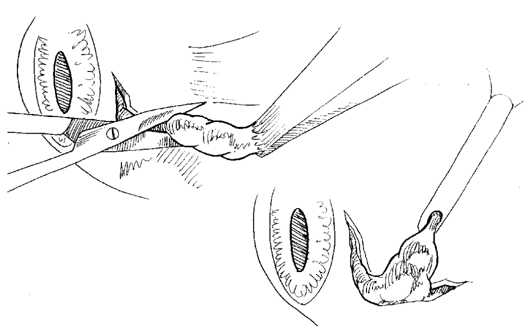

Fig. 13-13. Vitreous should be cut flush with the choroidal tissue using either a cellulose sponge and fine scissors or an automated vitrectomy instrument. Care must be taken to avoid cutting the choroid or retina during this procedure. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

11. When wounds extend beneath the rectus muscle, the muscle should be tagged with a double-armed 5-0 Vicryl suture and reflected from its scleral insertion. Following the scleral repair, the rectus muscle should be reattached by making partial-thickness scleral passes with the Vicryl sutures that attach the muscle to its original position.

12. Wounds should be repaired posteriorly as far as is practical without putting excessive pressure on the globe. Exposure may be greatly enhanced by reflecting one of the rectus muscles (as mentioned above). Posterior wounds should be left unrepaired, as manipulation to expose the area may result in expulsion of the intraocular contents. The nonsutured posterior wound generally becomes watertight by 10 days following the globe repair.

13. When scleral tissue is missing from the wound, the eye cannot be closed without creating significant deformation of the globe. To avoid globe irregularity and still seal the wound, a tissue patch may be fashioned and sewn over the defect using multiple interrupted sutures to span the gap. Banked sclera, fascia lata, preserved pericardial tissue, or scleral buckle material may each be used in this fashion to close the wound. With an interrupted horizontal mattress suture pattern, the wound is compressed and will likely achieve watertight closure (Figure 13-14). Smaller leaks may be sealed with cyanoacrylate tissue adhesive (tissue glue),

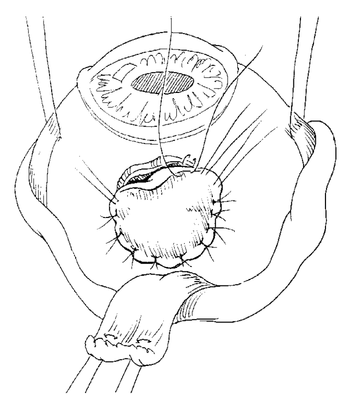

Fig. 13-14. When, owing to missing tissue, a scleral wound cannot be sealed, a patch graft can be fashioned from banked sclera, fascia lata, preserved pericardium, or scleral buckle material, and used to oversew the wound. By using interrupted horizontal mattress sutures through the graft and globe, the wound is compressed and a watertight seal can be obtained. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

applied with cotton-tipped applicators after the wound has been temporarily dried. Tissue adhesive should never be applied to wounds that are actively leaking or bleeding, because adhesion will not occur.

14. Once the identified laceration is repaired, thoroughly examine the remainder of the globe for any additional injuries.
15. Reform the globe using a balanced salt solution injected through the anterior chamber or pars plana (away from the rupture site). Check for wound leaks along the sutured wound and ensure that the eye maintains inflation. The surgical goal of wound closure is to achieve a strong, watertight wound repair that can withstand additional reconstructive surgery within days of the initial repair.
16. Close the conjunctiva using interrupted 7-0 Vicryl or 6-0 plain gut suture and bury knots to avoid ocular irritation.
17. Administer prophylactic subconjunctival antibiotic away from the wound repair. If a posterior rupture site remains open, subconjunctival antibiotics should be avoided.

Because of the difficulty in distinguishing pain and inflammation of trauma from early endophthalmitis, the initial diagnosis of endophthalmitis is often overlooked or delayed. Posttraumatic endophthalmitis has been reported in up to 7.9% of ocular injuries with retained FBs.[19] Patients should therefore routinely receive intravenous, topical, and subconjunctival antibiotics. The use of prophylactic intravitreal antibiotics is controversial and is generally reserved for cases of suspected early endophthalmitis or eyes with markedly contaminated FBs.

Factors associated with poor visual outcomes in scleral laceration include poor initial visual acuity, afferent pupillary defect, vitreous hemorrhage, and wounds extending posterior to the rectus muscles or greater than 10 to 12 mm in length.[27,28] The initial sensory status of the eye is more important in foretelling outcome than are anatomical factors. Eyes injured by limited sharp laceration or small FBs tend to have a more favorable prognosis than eyes ruptured by blunt compression or large foreign objects.[27]

POSTSURGICAL CONSIDERATIONS

Postoperative Care

Following wound repair and stabilization, the patient should be evacuated to the 4th echelon for observation and reconstructive care. Particular attention should be directed toward observing signs of endophthalmitis, sympathetic ophthalmia, and retinal detachment. Intravenous and topical antibiotics are continued for the first 3 to 5 days, then tapered if no signs of infection are evident. Aggressive use of topical steroids reduces anterior segment inflammation, corneal edema, and fibrin formation. The use of tissue plasminogen activator (tPA) in the treatment of total hyphema or anterior segment fibrin should be avoided when possible because of the increased risk of inducing secondary vitreous hemorrhage.[29] When the posterior chamber view is limited by corneal edema or blood, the retinal status may be assessed postoperatively through periodic B-scan ultrasonography.

Pathophysiology of Posttraumatic Retinal Detachment

Severely traumatized eyes with posterior penetration or rupture commonly develop retinal detachment. Traumatic retinal breaks may lead to detachment at the time of injury or weeks after the trauma, once liquefied vitreous has gained access to the subretinal space. A more onerous form of retinal detachment may develop days to weeks following the injury in response to fibrocellular proliferation and membrane contraction.

Following severe, penetrating trauma, a prominent inflammatory reaction occurs in the posterior segment. The presence of both intravitreal hemorrhage and inflammation stimulates the proliferation of myofibroblasts within the vitreous gel, resulting in the formation of fibrocellular membranes.[30] Serum components including fibronectin and platelet-derived growth factor enhance cell migration and proliferation of these membranes.[31,32] As the fibrocellular membranes mature and contract, traction develops across the vitreous, pulling the retina centrally and anterior. Severe traction results in the retina's being pulled into a funnel configuration with dense membranes located centrally.

In most ophthalmology textbooks written before 1985, cryotherapy was reported to reduce the risk of subsequent retinal detachment in penetrating trauma by surrounding the wound with a form of retinopexy. Although the benefit of this procedure has never been established, experimental models indicate that the application of cryotherapy to a lacerated eye promotes the formation of a fibrocellular response and induces complex retinal detachment.[33] Although cryotherapy may create a strong posttraumatic chorioretinal adhesion in some cases, the risk for fibrocellular membrane proliferation and vitreous hemorrhage make the use of this tool inadvisable in the setting of globe rupture.

Timing of Secondary Surgical Intervention

In considering the surgical repair of posttraumatic retinal detachment, scleral buckling alone is generally insufficient to overcome the traction generated by the fibrocellular response. Vitrectomy and membrane peeling are, therefore, essential elements of retinal repair and serve to restore retinal architecture by reducing retinal traction. The addition of an encircling band at the time of surgery redirects tractional forces that may develop during the postoperative period and reduces the risk for subsequent macular detachment (Figure 13-15).[34] In most reported case series, placement of an encircling band at the time of vitrectomy repair reduced the risk for subsequent retinal detachment by more than 50%.[35–37]

The decision of when to surgically intervene in the posterior segment of a traumatized eye remains controversial. Indications for vitrectomy in the posttrauma setting include

- removal of an FB,
- repair of retinal detachment,
- removal of lens fragments,
- removal of hemorrhage,
- surgical exploration, and
- treatment of endophthalmitis.

The urgency of such procedures varies from patient to patient and must be carefully weighed against the increased surgical risks of early intervention.

In the first several days following significant ocular trauma, the eye is inflamed and tends to bleed easily and profusely if surgically damaged. The vitreous gel is firmly attached to the retina in most cases and difficult to remove, enhancing the risk of bleeding. Corneal edema is commonly present and may necessitate the use of a temporary keratoprosthesis for surgical visualization. Hyphema, if present, requires surgical evacuation for visualization posteriorly. Additionally, an eye with one or more penetrating injuries may have posterior exit wounds that interfere with maintaining fluid control during the procedure.

After 7 to 14 days of observation, the eye is less inflamed and the tendency to bleed is significantly reduced.[34] A spontaneous vitreous detachment occurs by this time in most patients and greatly enhances the ease of vitrectomy surgery. The cornea and anterior chamber often clear spontaneously, avoiding the need for a keratoprosthesis. Posterior penetration wounds usually self-seal by this time, allowing for proper intraocular pressure control during vitrectomy.

Most surgeons agree with early intervention for retained IOFBs to limit their potential toxicity and prevent encapsulation. Additionally, endophthalmitis in the trauma setting warrants early vitrectomy and intravitreal antibiotics. The timing of surgical intervention for other conditions, including retinal detachment, remains controversial. Some authors[38,39] have advocated early vitrectomy to reduce the risk of intraocular membrane formation by removing the scaffold for cellular proliferation. Although these authors have reported improved surgical outcomes with early vitrectomy, comparison groups were either not reported or not comparable to the delayed surgical group. Other investigators have reported either serious choroidal bleeding with early surgery,[40,41] or no statistically significant visual difference between early or late vitrectomy for cases of retinal detachment, or IOFB following penetrating trauma.[42]

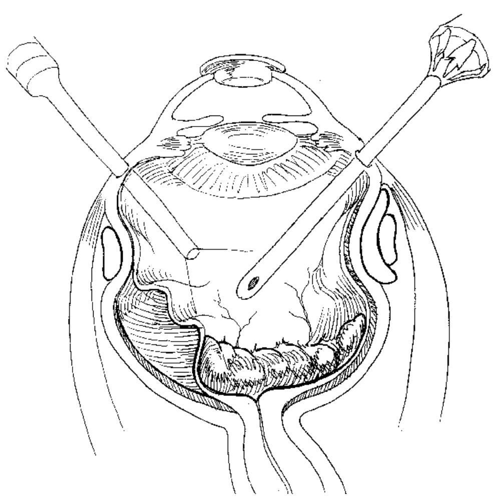

Fig. 13-15. The repair of a complex retinal detachment following penetrating trauma generally requires the removal of intravitreal fibrocellular membranes using vitrectomy and membrane peeling techniques. The addition of an encircling band reduces the risk for subsequent retinal detachment by redirecting tractional forces within the eye. A temporary keratoprosthesis aids intraocular visualization for eyes with persistent corneal edema or severe corneal scarring. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

SUMMARY

The fragmentation munitions used by combatants in modern warfare have generated a high incidence of multiple traumas, with ocular casualties comprising 13% of all injuries during recent conflicts. Aside from projectile injury, combat is associated with globe rupture from sharp laceration, blunt contusion, and secondary shock wave injury. The implementation of fragmentation weaponry has resulted in a substantial number of bilateral ocular penetration injuries, many of which could have been avoided through the proper use of protective eyewear. The social and economic consequences of wartime ocular injuries have been enormous, as reflected by the fact that 75% of soldiers suffering ocular injury during the Vietnam War were unable to return to active duty.

Restoring sight to injured patients begins with timely recognition of the ocular injury and completion of a precise, well-approximated closure of the ocular wound at the 3rd echelon of care. The first repair of the globe is the most important, setting the stage for further reconstruction efforts once inflammation, corneal edema, and visualization have improved. Following the primary globe repair, patients are typically evacuated to the 4th echelon, where additional evaluation and IOFB removal takes place. Although early surgical intervention is warranted for IOFBs and endophthalmitis, other reconstruction efforts are usually delayed for 1 to 2 weeks.

The visual prognosis for patients managed in this manner depends primarily on their initial visual acuity, the mechanism of injury, and the extent of damage. Complications that can further jeopardize visual outcome include endophthalmitis, hemorrhage, retinal detachment, tissue downgrowth, and sympathetic ophthalmia. Proper wound closure, appropriate use of antibiotics, and timely reconstruction efforts help limit additional damage to the eye during the healing process and optimize the soldier's chance for visual recovery.

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