Treatment of Ocular Trauma and Vision-threatening Conditions by Deployed Ophthalmologists (Eye Surgeons)

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This Clinical Practice Guideline (CPG) provides information and suggested guidelines for ophthalmologists responsible for managing ocular injuries in a deployed environment without the benefit of multidisciplinary support by fully trained and privileged subspecialty providers. This CPG is based on expert consensus and synthesis of available medical literature.

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INTRODUCTION

This Clinical Practice Guideline (CPG) provides information and suggested guidelines for ophthalmologists responsible for managing ocular injuries in a deployed environment without the benefit of multidisciplinary support by fully trained and privileged subspecialty providers. This CPG is based on expert consensus and synthesis of available medical literature.

BACKGROUND

Ocular Care in the Context of Systemic Polytrauma

Ocular trauma in operational settings can be isolated or part of broader systemic polytrauma. Due to the unique surgical requirements to address ocular trauma, ophthalmologists are essential members of the multidisciplinary trauma team. Early identification of ocular injuries is important to improve outcomes and to allow for evacuation of all vision-threatening injuries so that they are able to receive treatment by an eye surgeon (ophthalmologist) within 24 hours when possible.

The initial stabilization of an injured patient is essential prior to ocular surgical intervention, including:

- Identification and control of life-threatening hemorrhage;
- Establishment of a patent airway for respiratory support; and
- Resuscitation to maintain perfusion and oxygenation.

Ophthalmologists integrated into the trauma team effectively and judiciously advocate for timely evaluation and intervention of vision-threatening conditions.

Initiate teleophthalmology consultation as soon as possible.

Medical personnel and providers at lower echelons of care should initiate teleophthalmology consultation as soon as possible with an ophthalmologist. Teleophthalmology improves and extends ophthalmic care in a combat zone.[1]

Ocular injuries and vision-threatening conditions may be initially evaluated and treated at the point of injury or at any point along the evacuation chain. Providers should become familiar with pre-hospital treatment guidelines available in other Joint Trauma System CPGs. Eye Trauma: Initial Care (CPG ID: 03) and Ocular Injuries and Vision-Threatening Conditions in Prolonged Field Care (CPG ID: 66) offer particularly useful guidance.

Evacuation Reference Timeframes

Recent experience in the treatment of combat ocular trauma has occurred in the context of low-level counterinsurgencies and counter-terrorism conflicts, with infrequent large-scale combat operations. Air superiority and predictable evacuation were common, supporting a sustainable “Golden Hour” standard of care for all trauma. Future operational environments will likely be less predictable. To assist with planning of treatments and interventions, the following convention is used throughout the CPG:

- Rapid Evacuation Anticipated (within 24-48 hours)
- Delayed Evacuation Anticipated (extending to 48-96 hours)
- Prolonged/Unknown Evacuation Anticipated (extending 96 hours or longer)

Discussion of the factors that determine the Medical Rules of Engagement (MedROE) are beyond the scope of this CPG. However, the treatment of local populations (host nations) may be possible and required in some locations, depending on the MedROE as applied to the Area of Responsibility (AOR).

General Expectations by Roles of Care

Role I through III (without an ophthalmologist)

- Follow the recommendations outlined in the JTS CPGs, including Eye Trauma: Initial Care and Ocular Injuries and Vision-Threatening Conditions in Prolonged Field Care.
- Maintain a high index of suspicion based upon the mechanism of injury.
- Assess and document, at a minimum, visual acuity; examine for critical findings.
- Recognize and immediately treat the two traumatic eye emergencies:
    - For chemical injury, irrigate immediately and copiously.
    - For an orbital compartment syndrome, perform emergent lateral canthotomy and inferior cantholysis (full-thickness is acceptable).
- SHIELD AND SHIP vision-threatening eye injuries:
    - Protect injured eyes (both known and/or potential injuries) immediately with a rigid eye shield (i.e., "Eyepro" or "Fox shield").
    - Maintain patient comfort; treat pain and nausea.
    - Do NOT put pressure on an eye suspected of open globe injury (OGI).
    - Give systemic antibiotic prophylaxis to patients with open globe injury (e.g., moxifloxacin 400mg IV or PO).
- Initiate teleophthalmology consultation with an ophthalmologist as soon as possible.
- Evacuate all those with vision-threatening injuries so that they are able to receive treatment by an eye surgeon within 24 hours when possible (either to a Role 3 or a Role 4 facility).

Role III Deployed or Role IV OCONUS (ophthalmologic care):

- Perform a complete ophthalmic examination. Assess and document, at a minimum, all elements of the ocular trauma score (visual acuity, presence or absence of relative afferent pupillary defect (RAPD), presence or absence of globe rupture or perforating injury, presence or absence of endophthalmitis, presence or absence of retinal detachment). If unable to assess elements such as visual acuity, document the reason unable to assess, such as "patient intubated and sedated."
- Perform/order diagnostic testing as indicated, as available.
- Diagnose and treat all vision-threatening injuries.
- Initiate teleophthalmology consultation with subspecialty experts (cornea, glaucoma, retina, oculoplastic) as needed based upon knowledge, skills, abilities and clinical privileging.
- Determine the need for aeromedical evacuation out of theater for US or Coalition service members if subspecialty ophthalmic management or surgery is required.
- Coordinate care of ocular injuries in the setting of systemic polytrauma with the trauma team.

It should be noted that teleophthalmology consultation with an ophthalmologist is recommended before fixed wing transport of a patient with an open globe injury. Typically, the patient is cleared for immediate transport. If available, CT imaging of the orbit in thin slices can identify if there is trapped intraocular air, which could cause an acute rise in intraocular pressure or extrusion of intraocular contents in a depressurized cabin. In this situation, the aircraft commander should be notified that the internal cabin pressure should be maintained between sea level and 2,500 feet to keep gas expansion at or below 10%. Based on that information, the aircraft commander can determine a safe aircraft altitude for the mission. For example, if the transport aircraft is a C-17, cabin altitude can be up to 2,500 feet to allow the aircraft to fly safely at 24,000 feet.

In addition, patients with ocular injuries may not be able to safely navigate inside aircraft due to poor lighting, cramped space and a decrease in visual cues to balance. Consider placing the patient on a litter for safety and, if needed, request a non-medical attendant to help the patient move.

DOCUMENTATION

The Ocular Trauma Score (OTS) is a validated methodology using injury variables to predict outcome of ocular injuries. [2] Use of the OTS assists treating ophthalmologists in triage and management of injuries, as well as informing discussions with injured Service members. OTS should be documented whenever possible in the medical record. OTS methodology and references are located in Appendix A: Ocular Trauma Score. Ocular injuries are best classified using the zones of injury. Zone of injury methodology and reference are located in Appendix B: Ocular Zones of Injury.

Open Globe Injury and Intraocular Foreign Body (IOFB)

Goal: Obtain watertight closure of the globe. If possible, reestablish normal anatomy. If possible, do not delay primary repair beyond 24 hours. [3-17] If the operational situation permits, closure within 12 hours may decrease the risk of endophthalmitis. [15]

Rapid Evacuation Anticipated

- Follow the recommendations outlined in the Joint Trauma System (JTS) Eye Trauma: Initial Care Clinical Practice Guideline (CPG) and Ocular Injuries and Vision-Threatening Conditions in Prolonged Field Care CPG.
- Maintain a high index of suspicion for open globe injury; treat any suspected injury as open globe until exploration or repair can be performed.
- Perform a complete ophthalmic examination. Assess and document, at a minimum, all elements of the ocular trauma score (visual acuity, presence or absence of relative afferent pupillary defect, presence or absence of globe rupture or perforating injury, presence or absence of endophthalmitis, presence or absence of retinal detachment). If unable to assess elements such as visual acuity, document the reason unable to assess such as “patient intubated and sedated.”
- Place a rigid eye shield immediately.
- Nothing to eat or drink.
- Bed rest with head elevated 30 degrees if possible.
- Avoid maneuvers that increase intraocular pressure.
- Start systemic antibiotics.[18-28]
    - Levofloxacin 750 mg IV/PO q24hrs PLUS Vancomycin 15-20mg/kg IV q8-12hrs OR
    - Moxifloxacin 400 mg IV/PO q24hrs
    - Preferred regimen for prophylaxis is levofloxacin plus vancomycin or moxifloxacin alone based on limited data, expert opinion, and spectrum of antibiotic activity; this provides coverage for B. cereus, gram negative organisms including Pseudomonas aeruginosa, and drug-resistant gram positive organism such as MRSA. Note that vancomycin penetration into vitreous is limited in a healthy eye; weight based dosing may improve levels. Levofloxacin and moxifloxacin have excellent penetration. Levofloxacin has superior gram negative coverage and moxifloxacin has greater gram positive coverage. Either drug, when used alone, does not have reliable MRSA coverage.
- Treat nausea and vomiting aggressively (Ondansetron 4-8 mg IV or Promethazine 50 mg IV).
- Administer tetanus prophylaxis per Infection Prevention in Combat-Related Injuries CPG.
- Provide sedation and analgesia as needed (maintain patient comfort).

- Obtain and review a CT of the head and orbits with thin slices. Identify IOFB on exam and/or imaging.
- Have a high index of suspicion for scleral rupture under subconjunctival hemorrhage. A scleral laceration is not necessarily located adjacent to a conjunctival tear and may therefore be missed if the globe is not properly explored.[29]
- Perform primary repair of open globe injury as soon as possible when the patient is hemodynamically stable. DO NOT delay primary repair beyond 24 hours if possible. Coordination with other services providing care for the patient, especially in a polytrauma setting, is critical.
- For US and Coalition service members, accomplish required documentation for transfer as soon as possible to avoid evacuation delays and communicate with the accepting physician.
- Anticipate the need for pain control during recovery and transfer.

Delayed Evacuation Anticipated

- After primary repair, start topical antibiotics, steroids, and mydriatics.
- Continue systemic antibiotics.
- Monitor the post-operative course with regular eye exams. Assess and document visual acuity if possible, check intraocular pressure, and assess for wound leaks.
- B-scan ultrasonography may be completed after watertight wound closure.
- Monitor for symptoms of endophthalmitis including rapidly progressive decreased vision, eye pain, and red eye.
- Monitor for signs of endophthalmitis including decreased visual acuity, severe anterior chamber reaction, hypopyon, vitreous opacities and haze.

Guidelines for Management of Suspected Endophthalmitis

- If endophthalmitis is suspected, initiate teleophthalmology consultation with a retinal specialist.
- Perform B-scan ultrasonography to evaluate for vitreous opacities and the presence of a retinal detachment.
- Assess available supplies and medications for treatment options.
- Treat with tap and inject if empiric treatment for endophthalmitis is available:
    - Vancomycin 1.0mg/0.1ml AND Ceftazidime 2.0mg/0.1ml
    - Consult with retina specialist if the patient has a penicillin allergy or empiric antibiotic treatment is not available

Prolonged/Unknown Evacuation Anticipated

- After primary repair, continue topical antibiotics, steroids, and mydriatics.
- Continue systemic antibiotics.
- Monitor the post-operative course with regular eye exams.
- Monitor for symptoms and signs of endophthalmitis.

Guidelines for Open Globe Repair

- Perform surgery under general anesthesia if possible.
- Utilize 5% betadine to perform a sterile prep of the periocular region to reduce the risk of infection. The benefits of using 5% betadine on the ocular surface in the operational environment likely

outweigh the risks of intraocular toxicity. The surgeon should consider prepping and draping the patient herself/himself to minimize pressure on the eye.

- Utilize eyelid speculums or eyelid sutures that provide good exposure while minimizing pressure on the globe.
- Gently remove debris and foreign bodies on the ocular surface.
- The goal of repair is watertight closure to reestablish normal anatomy of the eye, if possible.
- In most cases, unless it is obviously necrotic or infected, reposition prolapsed uveal tissue inside the globe. Vitreous can be cut manually using a Weck and scissors to flush with the sclera.
- Avoid incarceration of intraocular tissue during wound closure.
- Do not excise corneal or scleral tissue.
- Consider administering intracameral (zone 1 injury / retinal detachment present) or intravitreal (zone 2 / 3) prophylactic antibiotics to reduce the risk of posttraumatic infectious endophthalmitis
    - Vancomycin 1.0mg/0.1ml AND Ceftazidime 2.0mg/0.1ml
- Explore the globe as indicated to identify the location(s) and extent of the injury:
    - Consider a peritomy, including 360-degrees, for exposure, especially in cases of subconjunctival hemorrhage.
    - Muscle hooks can be used to elevate rectus muscles. Use caution when hooking muscles as the instrument can, if there is a rupture, enter the globe. Consider securing muscles with 6-0 Vicryl on a spatula needle and removing from the sclera for exposure and/or repair if indicated. Do not remove more than three rectus muscles to avoid ocular ischemia.

Guidelines for Closure of Corneal Wounds

- Place interrupted 10-0 nylon deep (90% or full thickness) corneal sutures using a spatula needle perpendicular to the wound.
- Sutures should be placed equidistant with respect to the internal aspect of the wound.
- If the limbus is involved, it should first be aligned and closed.
- The preferred technique for closure may depend upon the injury and surgeon preference. After the limbus is aligned, corneal wounds are often best closed by “dividing the wound in half.” The first suture is placed in the middle of the wound and subsequent sutures divide remaining wound in half.
- Purse-string sutures can be used to close stellate lacerations.
- Bury corneal suture knots.

Guidelines for Closure of Scleral Wounds

- If the limbus is involved, it should be first aligned and closed.
- Place interrupted 8-0 or 9-0 nylon sutures using a spatula needle deep but not full thickness. Alternative is a 6-0 or 8-0 Vicryl suture if nylon is not available, but non-absorbable (nylon) suture is preferred over absorbable (Vicryl) suture because absorbable suture loses tensile strength weeks after repair, which can cause wound dehiscence during secondary repair.
- The preferred technique for closure may depend upon the injury, exposure, and surgeon preference. Large scleral wounds with extension posteriorly are often best closed using a “zipper” technique, where the wound is closed anterior to posterior.
- Secure and remove rectus muscles as needed for exposure.

- Traction sutures can be used but avoid excessive force that would cause expulsion of intraocular contents.
- It may be difficult to expose and close wounds that extend posteriorly beyond the equator. It may cause harm to attempt to repair wounds near the macular or optic nerve. Using traction to gain exposure posteriorly can also cause expulsion of intraocular contents.
- Buried suture techniques can be used to bury knots, but it may not be necessary or possible to bury scleral suture knots for wounds that extend far posterior to the limbus or that will be covered by conjunctiva.

Guidelines for Use of Tissue Glue

- Glue can be used for small corneal wounds or complex large corneal wounds that cannot be closed with sutures alone.
- Fibrin glue with or without amniotic membrane(s) may work for slow wound leaks. Fibrin glue takes time to prepare and does not adhere as long as cyanoacrylate glue.
- There are several techniques described to apply cyanoacrylate glue. Just prior to application, dry the wound with a Weck-Cel sponge or cotton tip applicator. Apply only a small amount of cyanoacrylate glue. Place a bandage contact lens after application of the glue.
    - The handle of a Weck-Cel can be used to apply a small amount of cyanoacrylate glue.
    - Cyanoacrylate glue can be applied with a thin tectonic scaffold such as the non-sticky part an eye drape or a Tegaderm cut to serve as an external scaffold for the glue. [30, 31] A skin biopsy punch can be used if available to cut the tectonic scaffold. Slightly oversize the tectonic scaffold to appropriately cover the edges of the leak.

Guidelines for the Use of Temporary Patch Grafts

- Scleral patch grafts or glycerin-preserved cornea can be used as a temporary patch graft, if available. For glycerin-preserved tissue, the tissue must be soaked in balanced salt solution or normal saline for 15 minutes prior to suturing. [32] The tissue can be manually cut into the desired shape or a skin biopsy punch may also be used as circular or crescent-shaped patch grafts. Use interrupted 10-0 nylon sutures to secure the patch graft.
- When there is no available preserved patch graft, small corneal tissue loss can be closed with the double tectonic patch technique or autologous tenons patch graft. [33, 34]

Guidelines for management of IOFB

- Continue systemic antibiotics
    - Levofloxacin 750 mg IV/PO q24hrs PLUS Vancomycin 15-20mg/kg IV q8-12hrs OR
    - Moxifloxacin 400 mg IV/PO q24hrs.
    - Preferred regimen for prophylaxis is levofloxacin plus vancomycin or moxifloxacin alone based on limited data, expert opinion, and spectrum of antibiotic activity; this provides coverage for B. cereus, gram negative organisms including Pseudomonas aeruginosa, and drug resistant gram positive organisms such as MRSA. Note that vancomycin penetration into vitreous is limited in a healthy eye; weight based dosing may improve levels. Levofloxacin and moxifloxacin have excellent penetration. Levofloxacin has superior gram negative coverage and moxifloxacin has greater gram positive coverage. Neither drug will have reliable MRSA coverage when used alone.
- Early teleophthalmology consultation with retina subspecialist.
- Do not attempt to remove IOFB in an austere environment without vitreoretinal capabilities.

- Arrange aeromedical evacuation to a Role 4 with vitreoretinal capability.

Guidelines for the Management of Lens Capsule Violation

- If the lens capsule has been violated, it is best to leave the lens intact during primary repair.
- Monitor intraocular pressure and inflammation with regular eye exams.
- Treat elevated intraocular pressure with medical therapy. First line treatment is topical intraocular pressure lowering medications. Consider oral acetazolamide or neptazane as needed, if not contraindicated by hemodynamic concerns.
- Treat intraocular inflammation with topical steroids and use mydriatics to prevent synechiae formation.
- Surgical removal of the lens in an austere environment is only recommended if intraocular pressure cannot be controlled medically.

Aeromedical Evacuation Considerations

- Initiate teleophthalmology consultation with an ophthalmologist as soon as possible.
- Management of concomitant injuries is crucial during flight.
- After open globe injury, rotary wing aeromedical evacuation may be accomplished in theater without prior clearance by an ophthalmologist.
- Teleophthalmology consultation with an ophthalmologist is recommended before fixed wing transport of an open globe injury. Typically the patient is cleared for immediate transport. If available, CT imaging of the orbit with thin slices can identify if there is trapped intraocular air, which could cause an acute rise in intraocular pressure or extrusion of intraocular contents in a depressurized cabin. In this situation, the aircraft commander should be notified that the internal cabin pressure should be maintained between sea level and 2,500 feet to keep gas expansion at or below 10%. The aircraft commander can determine a safe aircraft altitude for that mission based on that information. For example, if the transport aircraft is a C-17, cabin altitude can be up to 2,500 feet and allow the aircraft to fly safely at 24,000 feet.
- Vibration and turbulence can also be increased during flight. Pain related to traumatic injuries is exacerbated by vibration and adequate pain medication is required.
- Decreased visual input will increase the risk of motion sickness. Vomiting can increase the risk of further injury. Antiemetics can help to mitigate this risk.
- The need to Valsalva or perform similar maneuvers to equalize middle ear pressure can further injure the eye and surrounding structures, particularly the inferior orbit which overlies the maxillary sinuses. Adequate rapid acting decongestants (i.e., Afrin) can be used.
- Air handling systems on board the aircraft result in a very low relative humidity. Generous use of medications to lubricate the eye may be necessary.
- Patients with eye injuries cannot generally safely navigate inside aircraft due to poor lighting and cramped space and decrease in visual cues to balance. Consider placing the patient on a litter for safety and a non-medical attendant to help patient move if needed.

Retrobulbar Hemorrhage/Orbital Compartment Syndrome

Goal: Prevention of visual loss from increased intraorbital/intraocular pressure.

Rapid Evacuation Anticipated

Initial treatment remains lateral canthotomy/cantholysis (LCC). This may have been completed/attempted at an earlier role/stage of care. Begin with lateral canthotomy with inferior cantholysis. Perform superior

cantholysis if adequate relief of orbital compartment syndrome is not achieved. Always verify complete cantholysis.

Delayed Evacuation Anticipated/LCC Insufficient

- Patients must be monitored for recurrence, which may present within 24 hours. Re-bleed may be treated in conjunction with critical care providers with medical decompression [35-37] if the patient is otherwise hemodynamically stable:
- Acetazolamide: 500mg IV initial dose, followed by 250mg PO 4 times per day (Note: contraindicated in patients with sickle cell trait).
- If acetazolamide is not available or is insufficient, either 3% hypertonic saline 250mL IV or mannitol: 1g/kg IV over 30–60 minutes can be used to decrease IOP.
- Further surgical decompression, if LCC is insufficient or recurrent bleeding/progression occurs, may include:
  - Upper and lower lid skin crease incision with dissection through the orbital septum to allow fat prolapse.
  - One or 2-wall orbital decompression if appropriate oculoplastic/orbital ENT, OMFS or neurosurgical skills are available; otherwise orbital floor infracture (technique as described in the VCE Frontlines, Winter 2018) may be attempted, although effectiveness has not been established and is in doubt.

Prolonged/Unknown Evacuation Anticipated

Continue monitoring vision and IOP. Lid resuspension should not be attempted until all orbital swelling has resolved (typically 2 weeks) and is usually unnecessary.

Aeromedical Evacuation Considerations

Monitor IOP in patients at risk for delayed OCS. Consider prophylactic LCC in patients who are at risk of OCS in flight (including pneumo-orbita) prior to evacuation.

Orbital Fractures

Goal: Prevention/mitigation of destabilizing or vision-threatening complications. [38-40]

Generally, orbital fractures do not require definitive repair under expeditionary conditions. Orbital trapdoor fractures may rarely pose a threat to hemodynamic stability via the oculocardiac reflex effects, although these may be managed in consultation with anesthesiology; for instance, with the use of muscarinic antagonists. Orbital fractures are associated with OCS and in the setting of systemic anticoagulation may predispose to delayed OCS vision-threatening complications. The deployed provider should be aware of these possibilities and of the necessary treatments.

Rapid Evacuation Anticipated

The primary goal is evaluation of the globe for concurrent injuries; concurrent OCS should be assessed prior to obtaining imaging. Consider antibiotic prophylaxis for patients with high risk of infection. Oculocardiac reflex, extraocular muscle entrapment, significant early enophthalmos, or optic nerve compression may require emergent surgical intervention, possibly together with other members of the Head and Neck team. If orbital implants are not accessible, focus surgical management on releasing trapped extraocular muscles and decompression of the optic nerve. All patients should be advised to avoid Valsalva. The need to Valsalva or perform similar maneuvers to equalize middle ear pressure can further injure the eye and surrounding structures, particularly the inferior orbit which overlies the maxillary sinuses. Adequate rapid acting decongestants (i.e., Afrin) can be used.

Delayed Evacuation Anticipated

Monitor for possible complications while awaiting transport. Delayed repair of orbital fractures has been shown to have great outcomes up to a month following initial injury, supporting the transfer to a higher echelon of care for definitive treatment.

Prolonged/Unknown Evacuation Anticipated

Orbital fracture repair may be considered in facilities with adequate equipment, supplies, and providers privileged to perform repairs. Lack of follow-on care should be anticipated when treating host nation personnel.

Aeromedical Evacuation Considerations

Monitor IOP in patients at risk for delayed OCS. Consider prophylactic LCC in patients who are at risk of OCS in flight (including pneumo-orbita) prior to evacuation. (The data supports the view that orbital fractures should only be repaired by qualified specialists, a view also sustained by the fact that orbital injury repair is often in thought and in practice discretionary.)

Impaled Ocular/Orbital Foreign Bodies

Goal: Prevention/mitigation of destabilizing or vision-threatening complications.[41, 42]

Several considerations exist when dealing with retained intraorbital foreign bodies (IOrFB). Factors such as suspected composition, location, evidence of damage to ocular structures and potential penetration beyond the orbit must be weighed against the significant risk of exploratory surgery and the practical difficulties of locating small IOrFBs during surgery.

In general, organic IOrFBs (e.g., tree branches, wood splinters, etc.) should be removed if accessible without risk to the globe in order to prevent a severe inflammatory and/or infectious response. Because organic materials may be difficult to detect on standard CTs, a high index of suspicion based on history is necessary. MRIs are occasionally indicated once the presence of metallic foreign bodies has been ruled out. Inorganic IOrFBs include metallic and non-metallic objects, with non-metallic being further broken down into glass, plastic, rocks/debris,etc.

Metallic FBs generally cause damage by direct trauma; they can also cause inflammation (e.g., copper) or siderosis. Small metallic FBs may be observed for years without trouble. In rare instances (unlikely in combat ocular trauma) metallic composition and magnetic properties may be ascertained (e.g., BB gun pellet). However, in cases of unknown metal composition the patient and the medical team must be cautioned about the presence of such FBs and the use of MRIs. There have been no known cases of systemic lead intoxication from retained IOrFBs. However, studies of retained lead fragments in other locations vary, with some showing normal blood levels and others showing elevated lead levels in the blood. Therefore, if projectile fragments are present at the time of primary enucleation, efforts should be taken to remove such fragments. If, on the other hand, the globe is preserved, such FBs may be observed.

The need to remove a metallic IOrFB prior to an MRI was a frequent cause of delayed IOrFB presentation in a recent review. [40] Metallic IOrFBs that may have passed through the lacrimal sac or sinuses have been implicated in cases of infection. [41] Therefore, antibiotic prophylaxis is recommended in all cases of IOrFBs. Finally, in order to rule out occult globe rupture, the presence of an IOrFB must prompt a full bilateral ophthalmic exam.

Removal of embedded IOrFBs that are judged to be vision problematic or even life-threatening may require the involvement of ENT/OMFS and/or Neurosurgery based on the affected non-orbital structures. Small inorganic FBs may be safely observed.

* Of note, lead is not ferromagnetic and aluminum is not radiopaque on CTs.

(These injuries should be approached with neurosurgery, maxillofacial surgery and otolaryngology, as available, due to frequent concurrent craniofacial injuries.)

Rapid Evacuation Anticipated

The primary goal is evaluation and treatment of the globe and adnexa for concurrent injuries; organic IOrFBs should be removed if accessible without risk to the globe.

Delayed Evacuation Anticipated

Initiate teleophthalmology consultation with oculoplastics specialist to determine best interventions; close monitoring for extension of injury or change in visual acuity/function.

Prolonged/Unknown Evacuation Anticipated

Initiate teleophthalmology consultation with oculoplastics specialist to determine best interventions; close monitoring for extension of injury or change in visual acuity/function.

Aeromedical Evacuation Considerations

Ensure continuation of systemic antibiotics if started; plan for adequate protective bandaging to prevent extension of injury during transport in cases of exposed/impaled FBs.

Orbital Cellulitis

Goal: Prevention/mitigation of destabilizing, vision-threatening, or life-threatening complications. [43-45]

Although not necessarily traumatic, orbital cellulitis still occurs in the deployed setting and requires immediate treatment with broad-spectrum antibiotics. These include:

- Ampicillin-sulbactam 3 g IV q6 hours OR piperacillin-tazobactam 4.5 g IV q6h PLUS
- Vancomycin 15-20 mg/kg IV per dose q8-12 hours, maximum 2 g for each dose
- Consider systemic steroids: Solu-Medrol once fungal source ruled out and evidence of response to antibiotics

Orbital cellulitis is most commonly caused by the extension of adjacent sinusitis; however it may be caused by spread of odontogenic infection or trauma. Infection may also occur after orbital surgery. A fungal source should be considered if a patient is immunosuppressed or has uncontrolled diabetes mellitus. Rarely, it may also occur from endogenous spread in the setting of septicemia. Cranial neuropathy, bilateral involvement, and contralateral vascular congestion suggest cavernous sinus thrombosis, which is life-threatening.

Monitor with serial examinations to include vision, pupillary exam, color vision, extraocular motility, and exophthalmometry while also closely tracking the patient's neurological status. To determine the source and if there is an abscess necessitating surgical drainage, obtain urgent CT head and orbits. Drain all sinus-based abscesses in conjunction with an otolaryngologist, ensuring the wide opening of the abscess pocket into the sinuses and reestablishment of sinus drainage. Emergent surgery should occur if there is optic nerve compromise or orbital compartment syndrome and LCC may be valuable if definitive surgery is delayed (see management of orbital compartment syndrome). Surgery should occur within 24 hours when possible for other cases.

Evacuate all U.S. personnel to Role 4. For local nationals, continue to monitor and treat.

Aeromedical evacuation considerations

Ensure continuation of systemic antibiotics and steroids during transit.

Rapid Evacuation Anticipated

- Initiate broad spectrum antibiotics:
- Ampicillin-sulbactam 3 g IV q6 hours OR piperacillin-tazobactam 4.5 g IV q6h PLUS
- Vancomycin 15-20 mg/kg IV per dose q8-12 hours, maximum 2 g for each dose
- Consider systemic steroids: Solu-Medrol once fungal source ruled out and evidence of response to antibiotics

Delayed Evacuation Anticipated

Initiate teleophthalmology consultation with oculoplastics specialist to determine best interventions; close monitoring for extension of infection or change in visual acuity/function.

Prolonged/Unknown Evacuation Anticipated

Initiate teleophthalmology consultation with oculoplastics specialist to determine best interventions; close monitoring for extension of infection or change in visual acuity/function

Aeromedical Evacuation Considerations

Ensure continuation of systemic antibiotics and steroids during transit.

Lid & Adnexal Injuries

Goal: Prevention/mitigation of vision threatening complications

Significant swelling, common in military trauma, can worsen the appearance of the wound, simulating the appearance of tissue loss. In a complex laceration where tissue loss is suspected, the first order of business is to attempt to realign anatomic landmarks such as the eyelid margin and the eyebrow. In many such instances, sections will fall into place allowing good anatomic closure. In cases where tissue loss is confirmed, various techniques are available. When <25-30% loss of full-thickness of the eyelid has occurred, direct closure is usually possible; a canthotomy and cantholysis allows medial mobilization and closure of defects <40%. If grafts are utilized they must be applied to a vascular bed. The main goal of any repair remains protection of the cornea.

Lid/adnexal lacerations in the setting of blast injury/combat trauma may require lengthy or staged repair. In the setting of systemic polytrauma, sufficient irrigation and tissue preservation may be the only available option. Late repair of lid/adnexal lacerations at a higher level of care under controlled conditions may be needed for superior outcomes and to decrease the possibility of complications (ptosis, lid retraction). Traditional guidance for canalicular lacerations directed repair within 24-48 hours of injury. Recent studies (Chiang et al, Bai et al) demonstrated high anatomic and functional success rates with late (secondary) reconstruction. Identification and documentation of canalicular lacerations for later repair is required if immediate repair is not achievable. Evacuation to the next level of care should not be delayed to complete canalicular repair. It is acceptable to delay reconstruction if the complexity is beyond capacity/capabilities of the current level of care.

Rapid Evacuation Anticipated

Irrigate wound and assure globe protection if adequate repair is not feasible. In the absence of intraocular/open globe injuries, protect tissues with wet gauze and shield.

Delayed Evacuation Anticipated

Monitor status of globe; complete repair if time/supplies/facilities allow.

Prolonged/Unknown Evacuation Anticipated

Follow principles of closure: avoid/minimize debridement and assure coverage of the globe. In situations with extensive tissue loss, rotational grafts or lid-sharing procedures may need to be completed. Teleconsultation with an oculoplastics surgeon can assist with the planning and execution of these procedures.

Aeromedical Evacuation Considerations

The prevention of corneal exposure is critical. Dressing change instructions may be required for unrepaired lid/adnexal lacerations to prevent tissue desiccation.

Chemical Injuries

Goal: Irrigate immediately and copiously. After a physiological pH is achieved, mitigate further damage to the ocular surface and corneal clarity. [46, 47]

General Guidelines for Initial Care of Chemical Injury

- Follow the recommendations outlined in the JTS Eye Trauma: Initial Care CPG.
- Begin irrigation immediately.
  - Irrigate with normal saline or lactated Ringer's if available.
  - Acceptable to use water or any neutral irrigation solution (best solution choice is normal saline or lactated Ringer's).
  - Use Morgan Lens (first choice if available) or nasal cannula hooked to IV tubing for continuous irrigation.
- Use a minimum of 2 liters irrigation if unable to check pH. Some chemical injuries require up to 10 liters.
- Apply topical anesthesia with tetracaine, proparacaine or lidocaine as needed to maintain patient comfort during irrigation.
- Do NOT try to neutralize acid with base or base with acid.
- Remove visible acidic or basic foreign bodies with a cotton tip applicator (CTA).
- Remember to inspect the conjunctival fornices for retained foreign bodies. Irrigate or sweep fornices with a CTA.
- Assess and document vision if possible.

General Guidelines for the Management of Chemical Injury after Physiological PH is Achieved

Severity classification is at Appendix C.

- Mild and Moderate Burns (grades I-II)
  - Aggressive ocular surface lubrication
    - Preservative-free artificial tears q1h while awake and as needed
    - Ointment qhs
  - Consider prednisolone acetate 1% q.i.d. for 7-14 days, especially if alkali injury.
  - Consider cycloplegic (cyclopentolate 1% or 2% b.i.d.) if anterior chamber inflammation, pain, or photophobia. Avoid phenylephrine because of its vasoconstrictor effects.
  - If intraocular pressure is elevated, first line treatment is oral medications if not contraindicated by hemodynamic concerns to avoid toxicity to the ocular surface. Treat with acetazolamide 500mg PO initial dose, followed by 250mg PO q.i.d. If additional IOP control is required, start timolol 0.5% b.i.d and then dorzolamide 2% t.i.d. Avoid alpha-agonists because of their vasoconstrictor effects.
  - Start topical antibiotic drops if there is an epithelial defect (moxifloxacin q.i.d. or trimethoprim/polymyxin B q.i.d.).
- Severe Burns (grades III-VI)
  - Initiate teleophthalmology consultation with cornea specialist.
  - Aggressive ocular surface lubrication.
    - Preservative-free artificial tears q1h while awake and as needed.
    - Ointment qhs.
  - Prednisolone acetate 1% q2h while awake for 7-14 days.

- Cycloplegic (cyclopentolate 1% or 2% b.i.d.).
- Intraocular pressure lowering medications, as outlined above, if IOP is elevated.
- Topical antibiotic drops (moxifloxacin q.i.d. or trimethoprim/polymyxin B q.i.d.).
- Doxcycline 100mg PO b.i.d.
    - If kidney function is normal, start ascorbic acid 500mg PO b.i.d., if available.
    - Consider ascorbate 10% drops q1h while awake, if available.
    - Debride necrotic tissue if it contains foreign debris.
    - Consider soft bandage contact lens.
    - Consider amniotic membrane sutured or glued to the palpebral conjunctiva, ocular surface, and possibly eyelid margins. [48]
    - Consider amniotic membrane ring (ProKera).
    - Consider temporary tarsorrhaphy if healing is delayed.
    - If corneal melting occurs, initiate teleophthalmology consultation with cornea specialist and consider cyanoacrylate glue or temporary patch graft.

Rapid Evacuation Anticipated

Initiate treatment based on degree of injury

Delayed Evacuation Anticipated

Continue treatment based on degree of injury; initiate teleophthalmology consultation with cornea specialist as needed.

Prolonged/Unknown Evacuation Anticipated

Continue treatment based on degree of injury; initiate teleophthalmology consultation with cornea specialist as needed.

Aeromedical Evacuation Considerations

No altitude restrictions. Continue therapy throughout transport.

Thermal Burns

Goal: Prevent secondary corneal ulceration and perforation. Minimize chronic ocular surface disease and eyelid scarring.

Rapid Evacuation Anticipated

- Ocular Surface Burn: Identify, document, and treat ocular surface burns.
    - Aggressive ocular surface lubrication.
    - Preservative-free artificial tears q1h while awake and as needed.
    - Ointment q.i.d. and prn.
    - If there is an epithelial defect, start topical antibiotic ointment (erythromycin or bacitracin q.i.d.) or drops (moxifloxacin q.i.d. or trimethoprim/polymyxin B q.i.d.).
    - Consider cycloplegic (cyclopentolate 1% or 2% b.i.d.).
    - If severe, initiate teleophthalmology consultation with cornea specialist.
        - Consider soft bandage contact lens.
        - Consider amniotic membrane sutured or glued to the palpebral conjunctiva, ocular surface, and possibly eyelid margins.

- Consider amniotic membrane ring (ProKera).

- *Periocular burn*
  Debride any grossly necrotic tissue; apply topical antibiotic dressing for partial thickness burns. Early excision and skin grafting may be required for deep burns.[49]

- *Early Lagophthalmos*
  Occurs secondary to periocular edema and patient sedation/intubation. Ensure cornea is protected with aggressive lubrication (erythromycin ophthalmic ointment or sterile petrolatum every 2 to 4 hours) and moisture chamber goggles, or food-grade polyethylene film.

- *Orbital Compartment Syndrome (OCS)*
  Most important risk factors for development of OCS after a thermal burn are >25% Total Body Surface Area (TBSA), aggressive fluid resuscitation (>5.5 ml/kg/%TBSA), and periocular burns. This occurs secondary to orbital congestions from extravascular fluid. Risk begins within 6-12 hours of the burn, and can occur up to 72 hours after the burn during resuscitation. High risk patients need orbit check q 6 hours for first 3 days. [50] If OCS is suspected, perform inferior canthotomy/cantholysis. Additional IOP reduction can be achieved through upper lid canthotomy/cantholysis. If further decompression is needed, a lower lid transcutaneous incision can be used to access the orbital floor. A straight, firm instrument (periosteal elevator, tenotomy scissors) can then be used to fracture the orbital floor into the maxillary sinus. Medical decompression is not recommended in this setting.

Delayed Evacuation Anticipated

- Continue to monitor for development of lagophthalmos and OCS; high risk patients need orbit check q 6 hours for first 3 days.

- If OCS is suspected, perform canthotomy/cantholysis, upper lid canthotomy/cantholysis or orbital infracture; medical decompression will likely be contraindicated during resuscitation.

- Revise treatment plan as appropriate to clinical condition.

Prolonged/Unknown Evacuation Anticipated

- Exposure keratopathy due to cicatricial eyelid retraction/ectropion typically occurs 30-45 days after the burn. Priority interventions are directed toward corneal protection with aggressive lubrication or moisture chamber goggles. Amniotic membrane devices or therapeutic scleral lenses may be used if available. Suture tarsorrhaphy may provide sufficient protection but may be difficult due to cicatricial lid retraction and should not be under tension.

- Definitive treatment of late complications often requires scar release and skin grafting procedures. Teleconsultation with an oculoplastics trained provider is recommended prior to addressing late complications.

Aeromedical Evacuation Considerations

Consider early OCS treatment in patients with early increases in orbital volume or IOP, as well as discuss head-up nursing for these patients. Direct food-grade polyethylene film for corneal exposure prevention as indicated.

Severely Disrupted Globe

Goal: Effective utilization of surgical resources and prevention of sympathetic ophthalmia (SO).

The primary goal is always to preserve an injured eye with any potential vision. Unfortunately, combat/blast trauma may render an eye unsalvageable at the point of injury. Even in the setting of an unsalvageable eye in the majority of cases primary eye removal should be deferred if possible in U.S. and Coalition personnel until a higher level of care is available.

Modern studies demonstrate a low overall risk of sympathetic ophthalmia (SO; 0.3 - 3% in the 20th century, 0.3-0.9% more recently) and call into question the need to prophylactically remove eyes. A number-needed-to-treat calculation demonstrated that it would take from 1000 to nearly 10000 enucleations to prevent a single

case of legal blindness (20/200 or worse) from SO (Bellan). Due to the severity of combat injuries, a high percentage of eyes were removed primarily during OIF.

Outcome surveys of repaired eyes following perforating injuries and retained IOFBs treated at Walter Reed AMC during OIF and OEF revealed no cases of SO (WR papers; single unpublished case OF ADSM s/p multiple retina surgeries with eventual enucleation 3 years later, and SO a few months after enucleation; treated aggressively with immunosuppression at TAMC). The classic recommendation to enucleate the injured eye within 2 weeks appears to arise from limited 19th century observations and is not supported by current literature.

Once a patient presents with SO symptoms, there is evidence that prompt (within 2 weeks) removal of the inciting eye results in better visual outcome in the sympathizing eye (Reynard). Application of corticosteroid and immunosuppressive therapy to SO provide support for retention of good vision in the uninjured eye if SO were to arise. However, systemic immunosuppressive therapy carries with it a risk of complications and side effects.

Therefore, these options are best left for discussion with a subspecialist if evacuation out of theater is feasible. In summary, primary eye removal for the purpose of SO prevention is not necessary but is a reasonable option when the globe is irreparable.

Rapid Evacuation Anticipated

- Evaluation/repair/protection of the contralateral eye is the priority.
- Hemostasis and infection prevention should be accomplished if enucleation/evisceration is not possible.

Delayed Evacuation Anticipated

If the clinical situation permits, evaluating visual function with the patient awake may assist the patient with the process of loss of the eye before enucleation/evisceration.

Prolonged/Unknown Evacuation Anticipated

- If enucleation/evisceration is the procedure of choice, consider the need for a primary orbital implant. The risk of infection and subsequent exposure/extrusion is likely to be higher with implants placed primarily in the context of trauma. Delayed orbital implantation 3 months after primary evisceration, in a higher echelon of care is associated with good outcomes.
- For patients without access to higher echelons of care, the question of whether to use a smooth implant, a porous implant or a porous implant either wrapped in a smooth material or covered in dissolvable smooth coating has not been settled.
- Some military SMEs have raised concerns about using porous implants in possibly contaminated wounds such as after blast trauma. However, no combat trauma data to corroborate or refute such a recommendation has been published.
- A recent AAO Ophthalmic Technology Assessment (OTA) (2017) found that “regardless of implant type infection was exceptionally uncommon after enucleation.” Porous implants offer the advantage of biointegration, thus theoretically reducing migration that can be seen with smooth implants. However, the rough surface of porous implants can lead to breakdown of conjunctival surface and possible exposure of the implant. Wrapping porous implants in smooth coating or using coated porous implants offers the “best of both worlds approach” but may not be available in theater.
- Rates of extrusion ranged from 0-7% for nonporous (smooth) implants and 0-1.3% for porous, with exposure rates of 0-5.6% in studies cited in the OTA. Divergent rates found in the literature may point to technique being a key factor. Proper sizing of the implant should help reduce the rate of complications.
- Evisceration is a viable option in both trauma and infection. Familiarity with technique may influence surgeon preference. Caution should be used in non-trauma blind eyes if seeing local nationals. An occult intraocular tumor must be ruled out prior to an evisceration being performed.

- In patients with unknown access to follow-on care such as a local national, a dermis fat graft may be the preferred option. [51] In countries where Acinetobacter infections are common, caution is advised if using porous orbital implants. Consider packing and deferring to higher echelon of care if orbit is grossly contaminated with soil/debris. Consider dermis fat grafting if local national/unable to evacuate patient out of theater. [52]

Aeromedical Evacuation Considerations

No altitude restrictions required.

Blunt/Closed Globe Injury

Goal: Identification and mitigation of vision-threatening complications.

Similar to a high suspicion for Open Globe Injury, a high suspicion must be maintained for Closed Globe injury/contusion injury. This occurs frequently in blast trauma. [53, 54] Injuries may not be readily apparent if not associated with injury to the lids/adnexa, orbit, or surface of the eye.

In patients with systemic injury due to blast exposure, including with no obvious ocular injury, every attempt should be made to complete an ocular evaluation to identify injuries requiring immediate care and to document injuries that will need further evaluation and treatment at higher levels of care.

Specific Injury Types

Hyphema

Rapid Evacuation Anticipated

Hyphema should be identified, documented, and treated including the assessment and management of intraocular pressure using methods consistent with the patient's clinical condition (hemodynamic stability, concurrent injuries).

Delayed Evacuation Anticipated

Monitor for worsening of clinical condition. Consider anterior segment washout/clot removal.

NOTE:

- Tranexamic acid (txa) is not standard treatment for hyphema but may reduce the risk of rebleeding and can be used in multitrauma and traumatic brain injury patients as otherwise indicated. [54]
- Topical atropine 1% and frequent (at least 6 times daily in the first 48 hours) topical corticosteroids (prednisolone acetate 1% or dexamethasone 0.1%) reduce the risk of rebleeding and corneal blood staining.
- Topical ocular antihypertensives and systemic acetazolamide should be used to lower elevated intraocular pressure; however, topical and systemic carbonic anhydrase inhibitors should be avoided in patients with sickle cell disease or trait as they may cause sickling and worsen/elevate IOP.

Prolonged/Unknown Evacuation Anticipated

Careful anterior chamber washout will usually reduce normalized IOP refractory to medical therapy. If IOP remains persistently elevated above 40 mmHg for >24 hours, trabeculectomy with releasable sutures may be considered in patients unresponsive to medical intervention and at risk for vision loss.

Lens Dislocation (Traumatic Ectopia Lentis)

Although uncommon, ectopia lentis can occur following blunt trauma to the eye or orbit, or head trauma not otherwise involving ocular structures. Anterior dislocation of the lens may lead to traumatic glaucoma or corneal decompensation secondary to corneal endothelium damage. Posterior dislocation may be managed conservatively and surgical intervention delayed, unless violation of the lens capsule is present. [56]

Rapid Evacuation Anticipated

Urgent surgical intervention is indicated in cases of pupillary block glaucoma, persistent uveitis, or lens-corneal touch causing corneal decompensation. (Hani) Medical management of increased intraocular pressure and

intraocular inflammatory response until advanced surgical techniques to optimize visual outcomes are available (such as capsular support devices and capsular tension rings). [56]

Delayed Evacuation Anticipated

Consider lens extraction if medical management is ineffective, or if there is threat of corneal decompensation.

Prolonged/Unknown Evacuation Anticipated

Consider lens extraction if intraocular pressure cannot be controlled through medication, or if there is threat of corneal decompensation.

Aeromedical Evacuation Considerations

Manage as for other lens injury, with the additional observation that supine posture should be considered in cases of posterior dislocation with increased intraocular pressure with pupil block. Protect the injured globe and prevent further damage with a rigid shield. Recommend elevation of the patient's head 30–45° as possible with overall condition. Assure no nonsteroidal anti-inflammatory drugs are recommended. Prevent further injury with antiemetics (ondansetron 4mg ODT/IV/IO/IM every 8 hours, as needed).

Vitreous Hemorrhage

Rapid Evacuation Anticipated

- Evaluate for concomitant posterior segment traumatic injuries (retinal tear, retinal detachment, commotio, choroidal rupture, traumatic maculopathy).
- Perform ultrasonographic evaluation of any areas of the retina not clearly visible for retinal tears and detachments.
- Protect the eye with rigid shield, elevate the patient's head to 30-45° and limit activities of high head or eye motion, as practicable.
- Avoid NSAIDS, if possible.

Delayed/Prolonged Evacuation Anticipated

Continue activity restrictions and head elevation, if able; re-evaluate for retinal tears or detachment approximately every 48 hours with biomicroscopy and/or ultrasonography.

Traumatic Optic Neuropathy (TON)

Goal: Prevention of vision loss.

Traumatic optic neuropathy may be direct or indirect and may therefore be associated with globe injury or with traumatic brain injury. Intracranial injury (including intra/extra-axial hematomas) and globe injuries should therefore be excluded or managed first.

Effective treatment of TON is, at best, extremely limited (except when associated with OCS, as above). Given the results of the CRASH study, high-dose corticosteroids should never be offered by ophthalmologists to patients with concomitant TBI or if the TON is older than 8 hours. [56] In the vast majority of cases, we recommend observation alone. Corticosteroids are not an appropriate treatment for TON. [58]

Urgent CT imaging of the orbits with fine cuts is recommended as evidence of optic nerve compression by a bony fragment or a hematoma in a patient with poor vision and a RAPD should prompt consideration of decompression by drainage of the hematoma or removal of the bony fragment, although this course of action also does not have a supportive evidence base.

Rapid Evacuation Anticipated

Identify and manage concomitant TBI, globe injury and OCS. Obtain CT imaging with fine cuts of the orbits if available.

Delayed Evacuation Anticipated

Conservative management.

Prolonged/Unknown Evacuation Anticipated

Conservative management.

Aeromedical Evacuation Considerations: No restriction.

Retinal Tear/Detachment without Open Globe Injury

Goal: Prevention of macular detachment. Prevention of retinal detachment/extension of existing detachment.

Rapid Evacuation Anticipated

(24-48 hours/systemically stabilizing procedures, vision threatening/destabilizing):

- Retinal tear: Evaluate with indirect biomicroscopy and/or ultrasonography for any early retinal detachment. As clinical and tactical situations dictate, initiate limitations on activities that shake the head (running, jumping, etc.) or have repetitive eye motions (reading, videogames, etc.). Perform laser retinopexy, if available.
- Retinal detachment: Document extent of RD and macular status. Activity should be bed rest with transfers acceptable if practicable. Strict limitations on activities with repetitive eye motions. Maintain head position with the tear in the most dependent position reasonable (clock hour of tear most dependent position possible). If macula-on RD consider double eye padding both eyes to reduce eye movements. [59, 60]

Delayed Evacuation Anticipated (48-96 hours/as per rapid evacuation) and ***Prolonged/Unknown Evacuation Anticipated*** (96 hours or longer/as per rapid evacuation)

- Retinal Tear: If available, perform laser retinopexy or cryoretinopexy as soon as practicable. Monitor every 48 hours with dilated fundus exam for retinal detachment. Maintain activity restrictions as much as possible.
- Retinal detachment: Maintain positioning as above. Repeat dilated fundus examination every 48 hours for progression of retinal detachment or new pathology. Document if macular status changes and timing. If macula-on RD, consider double eye padding both eyes to reduce eye movements.

If suspicions center on retinal detachment (e.g., cut in visual field, decreased vision, positive RAPD), initiate supplemental oxygen as available; this may improve visual outcomes. [61]

Aeromedical Evacuation Considerations

No altitude restrictions required.

PERFORMANCE IMPROVEMENT (PI) MONITORING OF OGI

Intent (Expected Outcomes)

- Patients will have complete ophthalmic examination performed. At a minimum, all elements of the ocular trauma score are assessed and documented (visual acuity, presence or absence of relative afferent pupillary defect, presence or absence of globe rupture or perforating injury, presence or absence of endophthalmitis, presence or absence of retinal detachment). If unable to assess elements such as visual acuity, the reason unable to assess such as "patient intubated and sedated" is documented.
- Appropriate systemic antibiotics administered for open globe injury.
- Primary repair of open globe injury performed within 24 hours if possible. If unable to perform within 24 hours, reason for the delay is documented.
- Watertight closure of the globe achieved with primary repair of open globe injury. If unable to achieve watertight closure, the reason is documented in operative report. The absence of wound leaks and confirmation of watertight closure of the globe is documented in post-operative exams.

Performance/Adherence Measures

- Population at risk with documented elements of ocular trauma score.
- Administration of appropriate antibiotics for open globe injury.
- Time to primary closure of open globe injury.
- Watertight closure achieved and documented during primary repair.
- Watertight closure assessed and documented in post-operative exams.

Data Source

- Department of Defense Trauma Registry (DoDTR)
- Defense and Veterans Eye Injury and Vision Registry (DVEIVR) – provides longitudinal vision outcomes

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APPENDIX A: OCULAR TRAUMA SCORE

Table 1. Computational method for deriving the Ocular Trauma Score

Initial Visual Factor	Raw Points	
A. Initial raw score (based on initial visual acuity)	No Light Perception =	60
	Light Perception or Hand Motion =	70
	1/200 to 19/200 =	80
	20/200 to 20/50 =	90
	≥ 20/40 =	100
B. Globe rupture		-23
C. Endophthalmitis		-17
D. Perforating injury		-14
E. Retinal detachment		-11
F. Relative afferent pupillary defect (RAPD)		-10

Table 2. Estimated probability of follow-up visual acuity category at 6 months

Raw Score Sum	OTS score	NLP	LP/HM	1/200 to 19/200	20/200 to 20/50	≥ 20/40
0 – 44	1	73%	17%	7%	2%	1%
45 – 65	2	28%	26%	18%	13%	15%
66 – 80	3	2%	11%	15%	28%	44%
81 – 91	4	1%	2%	2%	21%	74%
92 – 100	5	0%	1%	2%	5%	92%

Use of the Ocular Trauma Score

1) On initial examination, assign an initial raw score based on the initial visual acuity (VA) –Table 1. For example, for Light Perception (LP) or Hand Motion (HM) 70 raw points would be assigned.
2) From this initial raw score, subtract points for each of the factors (starting with the worst prognosis and ending with the least poor prognosis): globe rupture, endophthalmitis, perforating injury (with both an entrance and an exit wound), retinal detachment, and relative afferent pupillary defect (RAPD).
3) Once the raw score sum has been calculated, find the corresponding estimated probability of follow-up visual acuity category at 6 months (Table 2.). [61, 62]

APPENDIX B: OCULAR ZONES OF INJURY

When classifying an injury, one always uses the highest zone injury. For example, a corneo-scleral laceration extending to the rectus muscles would be a Zone 3 open-globe injury not a Zone 1, 2, and 3 injury. Again, in a closed globe injury with a conjunctival abrasion, lens dislocation and a retinal detachment, this would be a Zone 3 closed-globe injury, not a Zone 1, 2 and 3 injury. [63]

Open-Globe Injury

Zone 1- Cornea and Limbus

Zone 2- Limbus to 5mm posterior into sclera

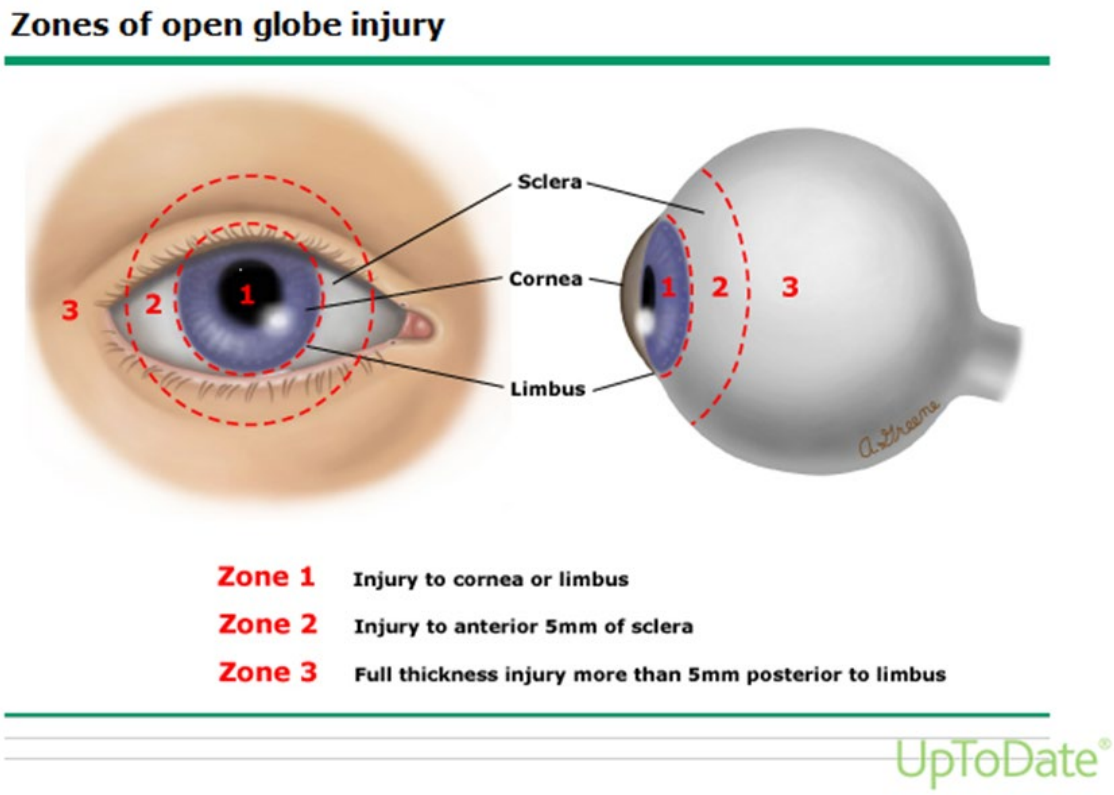
Zone 3- Posterior to 5mm from the limbus

Closed-Globe Injuries

Zone 1- External anterior segment including conjunctiva, sclera and cornea

Zone 2- Internal anterior segment including the lens, zonules and pars plicata

Zone 3- Posterior segment including vitreous, retina, optic nerve, choroid and ciliary body.



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APPENDIX C: CLASSIFICATION OF OCULAR CHEMICAL INJURY SEVERITY

Ocular Chemical Injury Severity from Blanch et al. Ocular Trauma in the Oxford Handbook of Ophthalmology 5TH Edition (in press)

Table 3. 4/5 Roper-Hall and Dua combined classifications of ocular surface burns, highlighting severity of corneal limbal and conjunctival involvement

Grade	Corneal appearance*	Limbal involvement (clock hours)**	Conjunctival involvement (%)**	Prognosis**
I	Clear Cornea	0	0	Very good
II	Hazy cornea: iris details visible	≤3	≤30	Good
III	Hazy cornea: iris details obscured	>3–6	>30–50	Good
IV	Opaque cornea: iris details obscured	>6–9	>50–75	Good to guarded
V	Opaque cornea: iris details obscured	>9–12	>75–<100	Guarded to poor
VI	Opaque cornea: iris details not seen	12 (total)	100 (total)	Very poor

Adapted from *Roper-Hall MJ. Thermal and Chemical Burns. Trans Ophthalmol SOC UK 1965;85:631–653 with permission from Elsevier and **DUA HS ET AL. A New Classification of Ocular Surface Burns. BR J Ophthalmol 2001;85:1379–1383 with permission from the BMJ.

This information can also be presented in component form, e.g., 4.5/40 indicates 4.5 clock hours of limbus and 40% conjunctiva involved. Conjunctiva refers to bulbar conjunctiva up to, and including, the fornices.