

WILDERNESS MEDICAL SOCIETY PRACTICE GUIDELINES

Wilderness Medical Society Practice Guidelines for Treatment of Eye Injuries and Illnesses in the Wilderness

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A panel convened to develop an evidence-based set of guidelines for the recognition and treatment of eye injuries and illnesses that may occur in the wilderness. These guidelines are meant to serve as a tool to help wilderness providers accurately identify and subsequently treat or evacuate for a variety of ophthalmologic complaints. Recommendations are graded based on the quality of their supporting evidence and the balance between risks and benefits according to criteria developed by the American College of Chest Physicians.

Introduction

Although eye complaints constitute approximately 3% of visits to emergency departments each year, their incidence in the wilderness is unknown.¹ Eye problems in the wilderness represent a challenging group of complaints for several reasons: access to proper equipment is limited, access to proper medications may be limited, and most practitioners in the wilderness are not specially trained.² The Wilderness Medical Society (WMS) published a set of guidelines on eye injuries in the wilderness in 2001. A panel was convened at the WMS Mountain Medicine meeting in Park City, Utah, in February 2011 to update those guidelines with the most relevant evidence-based information.

Methods

The panel was convened at the 2011 Wilderness and Mountain Medicine WMS conference in Park City, Utah. The WMS members were selected based on clinical interest, research experience, or ophthalmologic expertise. Relevant articles were identified through the

PubMed and Cochrane Collaboration databases using key word searches with the appropriate terms corresponding to each topic. Studies were reviewed, and the level of evidence was assessed. Data regarding specific wilderness treatment of eye injuries are sparse; therefore, we evaluated the data regarding eye injuries and illness in general and adapted these to the wilderness setting. The panel used a consensus approach to develop recommendations regarding diagnosis, treatment, and prevention of ocular injuries in the wilderness. These recommendations have been graded based on clinical strength as outlined by the American College of Chest Physicians (ACCP) (Table 1) and in conjunction with prior WMS practice guidelines.³

Examination and Equipment

Examination of the eye in the wilderness may be difficult owing to lack of specialized equipment, but many basic elements of the eye examination can be completed in austere settings. Table 2 provides a list of equipment and medications that should be included in both a basic and an advanced eye kit. A basic kit is appropriate for short excursions, whereas the basic plus the advanced kit could be used for prolonged expeditions, especially to remote locations.

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Table 1. Grading recommendations per American College of Chest Physicians

<i>Recommendation grade and description</i>	<i>Benefit vs risk and burdens</i>	<i>Methodologic quality of supporting evidence</i>	<i>Implications</i>
1A: strong recommendation, high-quality evidence	Benefits clearly outweigh risk and burdens or vice versa	RCTs without important limitations or overwhelming evidence from observational studies	Strong recommendation; can apply to most patients in most circumstances without reservation
1B: strong recommendation, moderate quality evidence	Benefits clearly outweigh risk and burdens or vice versa	RCTs with important limitations (inconsistent results, methodologic flaws, indirect, or imprecise) or exceptionally strong evidence from observational studies	Strong recommendations; can apply to most patients in most circumstances without reservation
1C: strong recommendation, low-quality or very low quality evidence	Benefits clearly outweigh risk and burdens or vice versa	Observational studies or case series	Strong recommendation but may change when higher quality evidence becomes available
2A: weak recommendation, high-quality evidence	Benefits closely balanced with risks and burdens	RCTs without important limitations or overwhelming evidence from observational trials	Weak recommendation; best action may differ depending on circumstances or patient's or societal values
2B: weak recommendation, moderate-quality evidence	Benefits closely balanced with risks and burdens	RCTs with important limitations (inconsistent results, methodologic flaws, indirect, or imprecise) or exceptionally strong evidence from observational studies	Weak recommendation; best action may differ depending on circumstances or patient's or societal values
2C: weak recommendation, low-quality or very low quality evidence	Uncertainty in the estimates of benefits, risks, and burden; benefits, risks, and burden may be closely balanced	Observational studies or case series	Very weak recommendations; other alternatives may be equally reasonable

RCT, randomized controlled trial.

Pretrip Planning and Prevention

All people who have a history of any ophthalmologic problems who are participating in wilderness activities should have a complete eye examination within 3 months of any extended trip. Participants should be encouraged to bring all of their own equipment and medications, including glasses, goggles, sunglasses, contacts, lens solution, and any specific medications that they are currently taking or anticipate requiring. Additionally, participants should bring a copy of their lens prescription to aid in the acquisition of new corrective wear if needed or simply bring extra glasses or contacts if they will be in austere settings.

Prevention of eye illness and injuries is paramount. Many eye illnesses are a result of accident, and thus may not be preventable, yet adequate sun and protective eye wear, good hygiene, and proper hand washing can pre-

vent a large number of the conditions addressed in these guidelines.

Medical Eye Complaints

ACUTE VISION LOSS IN THE WHITE EYE

Vision loss can occur in both the red and white eye. As these are quite rare, data on these illnesses in the wilderness are very limited; therefore, wilderness management is adapted from clinic or hospital treatments to the wilderness setting as appropriate. There are numerous causes of acute vision loss; regardless of the cause, any vision loss should be considered an emergency, and all patients with vision loss should be considered for emergent evacuation.

Table 2. Basic and advanced equipment and medications

<i>Basic equipment</i>	<i>Basic medications</i>
Light source: ideally would be penlight with blue filter, but bright headlamp is reasonable option	Artificial tears, individual bullet packs to avoid contamination
Fluorescein strips	Erythromycin ophthalmic 0.5% ointment
Cotton-tipped applicators	Proparacaine 0.5% drops
Paperclip for lid retraction	Oral pain medicine
<i>Advanced equipment</i>	<i>Advanced medications</i>
Metal eye shield: can be improvised from anything that will protect eye from further damage	Fluoroquinolone ophthalmic eye drop, such as moxifloxacin 0.5%
Magnifying glass	Prednisolone 1% drops
Fine forceps	Moxifloxacin 400 mg tablets
Small needle, such as 23G or tuberculin syringe	Prednisone 20 mg tablets
Direct ophthalmoscope	Atropine ophthalmic 1% ointment
Wire speculum for lid retraction	Pilocarpine 2% drops Diamox oral 250 mg tablets Topical NSAID, such as ketorolac, diclofenac, or bromfenac eye drops

Equipment: 1C; medications: 1C.
NSAID, nonsteroidal antiinflammatory drug.

CENTRAL RETINAL ARTERY OCCLUSION

Central retinal artery occlusion (CRAO) is an ischemic stroke of the retina, usually due to an embolic event, that causes abrupt vision loss.⁴ Treatment options in the wilderness are limited, but there are case reports to suggest improvement in visual acuity after providing high flow oxygen.⁵ There are also several case studies that report improvement with hyperbaric oxygen therapy. Central retinal artery occlusion is currently an approved indication for hyperbaric oxygen therapy by the Hyperbaric Oxygen Committee of the Undersea and Hyperbaric Medicine Society.⁵ If oxygen or hyperbaric therapies are available, they should be strongly considered for patients with suspected CRAO. A 2009 Cochrane Review found 2 randomized controlled trials evaluating 2 potential treatments for CRAO: pentoxifylline tablets and enhanced external counterpulsation. Both trials showed improved retinal artery flow with their treatments, but neither showed improvement in vision.⁶ These treatments are not available in the wilderness. Evacuation of these patients should be emergent.

Oxygen: 1C

Hyperbaric oxygen therapy: 1C

External counterpulsation: 2B

Pentoxifylline: 2B

Emergent evacuation: 1C

CENTRAL RETINAL VEIN OCCLUSION

Central retinal vein occlusion (CRVO) is a blockage of the venous outflow from the eye leading to profound, painless vision loss. It can be a result of a thrombus, external compression, or vasculopathy, and usually occurs in people aged more than 50 years who have hypertension.⁷ Patients with CRVO will usually have an afferent pupillary defect:⁴ when a light is shone in the normal eye, both pupils will constrict, but when the light is then quickly shone in the abnormal eye, both pupils will dilate. It should be noted that many diseases that causes a unilateral optic neuropathy or retinal problem (such as ischemic optic neuropathy, retinal detachment, and CRVO) can lead to an afferent pupillary defect. It is not necessarily important to differentiate these conditions, but to recognize this abnormal finding.

Although the treatments of CRVO in the hospital are complicated and involve laser treatments and intravitreal steroid administration, it is nevertheless reasonable to start treatment in the wilderness with topical steroids, if available (prednisolone 1%, 2 drops in the affected eye 4 times daily). Evacuation should be emergent, as these patients need specialist care and treatments.

Topical steroid: 1C

Emergent evacuation: 1C

RETINAL DETACHMENT

A retinal detachment is characterized by vision loss or floaters and flashes of bright light in a patient's visual field. The vision loss is often described as a fixed cloudy or curtainlike defect in the visual field. This condition is usually painless. Visual loss is variable, depending on where on the retina the tear has occurred.⁴ These patients should be emergently evacuated, as surgical management may be necessary, and there is no effective field treatment.

Emergent evacuation: 1C

PERIOcular INFLAMMATION

Inflammation of the periorbital region includes preseptal cellulitis, orbital cellulitis, and dacryocystitis.

Preseptal cellulitis is an infection limited to the space anterior to the orbital septum, which includes the super-

ficial tissue surrounding the eye and the eyelids. Orbital cellulitis is more extensive and involves the soft tissues in the bony orbit (deep to the orbital septum). Clinically, preseptal cellulitis presents with swelling and inflammation of the eyelid without involvement of the eye itself. Orbital cellulitis presents with inflammation within the orbit, including bulging of the eye (proptosis), swelling of the conjunctiva (chemosis), painful extraocular movements, and possible visual disturbance.⁸ Additionally, patients with orbital cellulitis may be systemically ill and have a fever. Periorbital cellulitis, while isolated to the preseptal space, is often associated with marked swelling, which makes the differentiation of preseptal from orbital cellulitis difficult.

Preseptal cellulitis can be caused by spread from sinusitis, conjunctivitis, or blepharitis. Causes that may be more commonly encountered in the wilderness include trauma and insect bites.⁸ Orbital cellulitis is usually caused by a sinus infection.⁹ Additionally, preseptal cellulitis can spread and cause orbital cellulitis. There are limited data regarding management of these entities in the wilderness. Rapid identification of orbital cellulitis is paramount, as orbital cellulitis is a true medical emergency. Failure to treat this infection quickly can lead to blindness, intracranial infection, and possibly death. Initial management of both conditions requires antibiotics that cover *Staphylococcus aureus*, *Streptococcus pneumoniae*, and *Haemophilus influenzae*.⁸ Consideration should also be given toward coverage of anaerobes and methicillin-resistant *S aureus* (MRSA).⁹

Treatment of both preseptal and orbital cellulitis should begin with amoxicillin/clavulanate 875 mg orally, 2 times daily for 10 days, but if that is not available, then oral fluoroquinolones (such as moxifloxacin) may be substituted.¹² If the practitioner is certain that an infection is isolated to the preseptal space, evacuation can be nonemergent. However, if there is any question that the infection may involve the orbit, or a presumed preseptal cellulitis is not responding to antibiotic treatment, evacuation should be emergent.¹⁰

Dacryocystitis is an infection of the lacrimal sac that typically arises from obstruction of the lacrimal duct, which causes pooling of tears in the lacrimal sac and subsequent infection.⁴ It presents as pain, swelling, and redness over the lacrimal duct, which is located at the nasal corner of the eye. The most common pathogens involved are *S aureus*, *Streptococcus* species, and *H influenzae*.¹¹ Dacryocystitis can be treated initially with oral antibiotics as well as warm compresses, if available. The preferred antibiotic is amoxicillin/clavulanate 875 mg orally, 2 times daily for 10 days, but if that is not included in your kit, oral fluoroquinolones (such as moxifloxacin) will likely suffice.¹² If this condition

worsens, the patient should be evacuated, nonemergently.

Antibiotics: 1C

Emergent evacuation for orbital cellulitis: 1C

Nonemergent evacuation for periorbital cellulitis: 1C

Acute Red Eye

There are numerous conditions that can cause redness of the eye, and the severity of these conditions can range from mild to severe. There are 3 main tests that can be quickly and easily accomplished to help make the diagnosis: fluorescein staining, relief of pain with anesthetic drops, and pupillary status.¹⁰ These tests can be easily performed in the wilderness if the supplies are available.

The medical causes of the red eye can be broadly divided into conditions that are fluorescein positive (corneal ulcer or erosion, herpes keratitis), and those that are negative. Those that are negative can be further divided into conditions that resolve with an initial dose of topical anesthetic (conjunctivitis, blepharitis, ultraviolet [UV] keratitis) and those that do not (acute angle-closure glaucoma [AACG], iritis, scleritis).

ACUTE ANGLE-CLOSURE GLAUCOMA

Acute angle-closure glaucoma is caused by a blockage of aqueous outflow from the eye resulting in increased intraocular pressure (IOP). Symptoms include deep and severe pain, blurry vision, halos around lights, headache, and often nausea and vomiting.¹³ Signs of this diagnosis include a nonreactive pupil that is mid dilated (4 mm to 6 mm), decreased visual acuity, “steamy” or “hazy” cornea, and a red eye.¹⁴ Measurement of IOP in the field is often impossible owing to the absence of measurement devices, but gentle palpation of the globe through a closed lid may reveal a taut globe indicating elevated IOP.^{13,15,16} The palpation should be done very gently and also in comparison with the normal eye. AACG is a medical emergency and requires emergent evacuation, as the definitive treatment is surgical. Standard treatment of AACG includes timolol 0.5%, 1 drop in affected eye 2 times daily, topical steroids such as prednisolone 1%, 1 drop 4 times daily, and oral acetazolamide (Diamox), 500 mg 2 times daily.^{4,17} Pilocarpine 1% to 2%, 1 drop every 15 minutes for 2 doses should be given 1 hour after other treatments have been given. Additionally, patients should be advised to lie flat for at least 1 hour.¹⁷

Medical management: 1B

Surgical management: 1A

Emergent evacuation: 1C

IRITIS

Nontraumatic iritis (also called anterior uveitis) is inflammation of the iris that is inflammatory or infectious. Many symptoms are similar to previously noted conditions including pain, redness of the conjunctiva, blurred vision, and photophobia. The patient may also have a history of iritis, which is a good clue to the diagnosis. One important examination finding is photophobia with shining of a penlight in the unaffected eye (consensual photophobia).¹⁴ Standard therapy for iritis includes corticosteroids, such as prednisolone 1% eye drops, 1 drop into the affected eye every hour if severe, every 4 hours if mild.¹⁸ If drops are unavailable, or if the condition is worsening, oral steroids can be given, prednisone 40 mg to 60 mg oral daily. If there is concern for herpetic lesions or other serious infection, steroids should be avoided. In this case, a topical nonsteroidal antiinflammatory drug (NSAID) may be beneficial. Cycloplegic (mydriatic) drops, such as atropine, are a key component to pain control as they relieve ciliary spasm.¹⁸ Place 1 drop in the affected eye 2 times daily. Evacuation should be emergent, as iritis can be complicated by scarring of the pupil and elevated IOP, leading to decreased vision or blindness.¹⁰

Topical steroids: 1C
Systemic steroids: 2C
Mydriatic drops: 1C
Topical NSAID: 2C
Emergent evacuation: 1C

HERPES KERATITIS

Herpes keratitis is diagnosed by a dendritic staining pattern on fluorescein examination. Often, patients have had previous episodes of ocular herpes infections.¹³ Treatment includes oral or ophthalmic preparations of trifluridine or acyclovir, although these are often not included in expedition kits.¹⁹ Participants should be encouraged to bring their own medicine if they have a history of this condition. Steroids should be avoided for patients with suspected herpes keratitis.²⁰ While some texts advocate debridement of herpetic lesions with a cotton-tipped swab, that has not been proven to be efficacious and should only be done by experienced providers if deemed necessary.¹⁹

Oral or ophthalmic antivirals: 1A

CONJUNCTIVITIS

Among fluorescein-negative medical eye conditions, conjunctivitis, blepharitis, and UV keratitis can usually

be treated in the field, and are typically not serious. Conjunctivitis is the most common cause of a red eye.¹³ Common etiologies include allergies, viruses, and bacteria. Conjunctivitis always involves the palpebral conjunctiva, and the examiner must look under the lid to evaluate for this inflammation. The hallmark of allergic conjunctivitis is itching. Bacterial conjunctivitis gives a purulent discharge whereas viral conjunctivitis tends to give a watery discharge. Treatment of allergic and viral conjunctivitis is primarily supportive, and bacterial conjunctivitis is treated with antibiotics. Although bacterial conjunctivitis is usually a self-resolving condition, studies have demonstrated that use of antibiotics results in faster clinical and microbiological remission.²¹ There are no studies showing superiority of any one antibiotic over another; therefore, choice should be based on availability.²² Erythromycin ointment, 1-cm ribbon, placed in the lower conjunctival sac 3 or 4 times daily for 7 days is a reasonable option. It is important to note that viral conjunctivitis is extremely contagious, and proper hand washing is essential in wilderness settings to avoid spread throughout a group or to the contralateral eye.²³

Topical anesthetic eye drops are diagnostically beneficial and provide acute relief for corneal ulcers, herpes keratitis, and conjunctivitis; however, it is important to note that they should not be used chronically as they are toxic to the corneal epithelium.²³

Topical or systemic antibiotics: 1A
Hand washing: 1C

Altitude and the Eye

The environmental conditions at altitude, including hypoxia and low atmospheric pressure, pose several problems for the eye and may result in problems both for the previously healthy eye and for the patient with a history of ocular pathology. Because the cornea receives most of its oxygen from the ambient air, the cornea becomes hypoxic at altitude and may not function normally.²⁴ In addition, patients with a history of intraocular gas bubbles should not go to high altitude owing to expansion of the gas bubble at decreasing atmospheric pressure. Patients should consult with their ophthalmologist regarding the safety of traveling to altitude.

ALTITUDE AFTER RADIAL KERATOTOMY, LASER-ASSISTED STROMAL IN-SITU KERATOMILEUSIS, OR PHOTOREFRACTIVE KERATOTOMY

Hypoxia at altitude causes edema and thickening of the cornea.^{25,26} Although this thickening has been shown not

to cause visual disturbances in healthy eyes, it can be problematic for patients who have undergone radial keratotomy (RK), laser-assisted stromal in-situ keratomileusis (LASIK), or photorefractive keratotomy (PRK). Radial keratotomy involves making incisions into the cornea, weakening its stability. The edema caused by the hypoxia of high altitude results in a flattening of these corneas, causing increased far-sightedness.²⁴ The results can be a significant decrease in visual acuity. The amount of vision change partially depends on the amount of residual myopia that a patient has at sea level, but is difficult to predict before altitude exposure. Although most of these changes will resolve with return to normal altitude, it is recommended that patients who have had RK have various levels of correction available during their excursion. The cheapest option may be to wear glasses under goggles and to bring several levels of corrective glasses. The best option, however, would be to bring several levels of prescription goggles in the event of decreased visual acuity at altitude. Patients should consult with their ophthalmologist to obtain various strengths of eye wear.

Eyes that have received LASIK and PRK undergo fewer refractive changes at altitude. There have been 2 studies demonstrating blurring of vision at altitude, and 2 studies demonstrating no change. A recent study of 12 climbers with LASIK-treated eyes noted no visual changes with changing altitude, despite dry eye associated with high altitude mountaineering being a known complication of LASIK.²⁷ Similarly, post-PRK patients seem to have excellent vision at altitude. There has only been 1 study of this PRK population, and it demonstrated no significant change in vision at altitude.²⁸

Caution at high altitude if history of RK: 1C

Safety of LASIK/PRK at altitude: 1C

Extra goggles/glasses if history of RK: 1C

HIGH-ALTITUDE RETINAL HEMORRHAGE

Another important physiologic effect seen in the eye at altitude involves increased retinal blood flow and subsequent retinal vein dilation¹⁰ that can lead to retinal hemorrhages, which have been well described since the 1970s.²⁹ The percentage of climbers experiencing retinal hemorrhages ranges from 4% to 82%, depending on the study.²⁹ Most cases of retinal hemorrhage do not cause visual disturbances, unless the hemorrhage involves the macula. Patients with retinal hemorrhages can continue ascending if no visual disturbances are present, but should be instructed to descend in the setting of altered vision.¹⁰ Additionally, the presence of high altitude retinal hemorrhage has been associated with

acute mountain sickness and should alert providers to the possibility of high altitude pulmonary edema or high altitude cerebral edema developing in patients who have high altitude retinal hemorrhage.

Descent if visual changes: 1C

Diving and the Eye

The hyperbaric environment can cause a number of effects on the eye. The primary concerns regarding dive medicine include ensuring that patients have normal visual acuity while diving, and making sure that patients who have an intraocular gas bubble due to surgical procedures do not dive. Divers who normally require corrective lenses should dive with prescription goggles or soft contact lenses. Diving after refractive surgery such as LASIK and PRK is safe.³⁰ Diving after RK carries a hypothetical risk of corneal incision rupture, although in practice, that is not seen, and diving is therefore considered safe. Additionally, divers who have had RK cannot dive for 6 months postoperatively to ensure adequate wound healing of the corneal incisions. Divers with a history of any type of eye surgery should always consult with their ophthalmologist before diving.³¹

Safety of diving after refractive surgery: 1C

OCULAR AND PERIOcular BAROTRAUMA

A complete description of the mechanism and pathophysiology of barotrauma are beyond the scope of this review; however, in brief, when air in a closed space is exposed to higher atmospheres of pressure, it is compressed. If this occurs while diving with a facemask, the lids, skin, and eyes can be drawn out into the mask. This force can be very strong and cause significant injury, resulting in periorbital ecchymosis, edema, subconjunctival hemorrhage, and potentially, hyphema. The prevention of ocular and periorbital barotrauma can be achieved by frequently filling one's mask with exhaled air from the nose to increase the volume of air in the mask.³¹⁻³³

Mask pressure equalization: 1C

Traumatic Eye Injuries

The treatment of traumatic ocular emergencies in the wilderness hinges on rapid assessment, stabilization, and evacuation. Often eye injuries do not occur in isolation and may be associated with other potentially life-threatening injuries. Periorbital and ocular traumas consist of many disorders, but these guidelines are limited to the

most commonly encountered conditions in the wilderness. Ocular trauma is responsible for approximately 3% of emergency department visits in North America annually³⁴ and is a leading cause of preventable blindness worldwide. Its true incidence in the wilderness is unknown as epidemiologic data are absent from the literature.

PERIOCCULAR TRAUMA

Eyelid lacerations: Falls, branches, rocks, or animal bites can cause eyelid lacerations. Eyelid lacerations can be classified as simple or complex. Simple lid lacerations are often horizontal, partial thickness, and do not involve the lid margin. This type of laceration can be managed with irrigation and typical wound care and has an excellent prognosis.³⁵

Eyelid lacerations that are complex, namely, full thickness, involve the lid margin, or medial/lateral end of the palpebral fissures, require evacuation and emergent ophthalmologic evaluation and repair, ideally within 36 hours.^{35,36} Immediate treatment consists of prompt irrigation, and the application of antibiotic ointment with shielding to protect the eye as evacuation commences. If an associated ruptured globe is suspected, there should be no further examination, manipulation, or irrigation of the eye. Treatment should be as outlined in the section on ruptured globe.

Wound care: 1B

Antibiotic ointment: 1B

Eye shield: 1C

Emergent evacuation if complex eyelid laceration: 1B

ORBITAL FRACTURES

A direct blow to the face or orbit may cause fractures of any of the 7 facial bones that form the orbit. Orbital fractures can lead to significant ocular injury and subsequent visual impairment in approximately 17% of cases.³⁷ Thus, it is important for the wilderness provider to be able to perform a basic ophthalmologic examination to screen for severe injury including entrapment of ocular muscles, and pupillary or vision derangements. If signs of entrapment or visual derangements are present, then emergent evacuation is required.

Clinically significant retro-orbital hemorrhage can cause a compressive optic neuropathy and is a true ophthalmologic emergency. Signs include markedly elevated IOP, vision loss, and an afferent pupillary defect. If within the wilderness practitioner's scope of training and practice, an emergent lateral cantholysis and canthotomy may restore vision in patients with compressive optic

neuropathy from retro-orbital hemorrhage. Therefore, emergent, expert management both in the field (with a cantholysis/canthotomy procedure, if indicated) and emergent evacuation to the closest emergency center are essential.

Based on consensus review in both maxillofacial and ophthalmologic practice patterns, patients with suspected orbital fractures should avoid blowing their nose until cleared to do so by a specialist. Patients may find relief from congestion through the use of nasal decongestant sprays, and if systemic steroids are available, they may be used to decrease orbital edema.^{38,39} Beyond this basic medical management, emergent evacuation is imperative if signs of ocular muscle entrapment, traumatic vision loss, or suspected globe rupture are present.

Orbital fractures

Nose blowing: 1C

Decongestant sprays: 1C

Systemic steroids: 2C

With entrapment or visual derangements, emergent evacuation: 1B

Retro-orbital hemorrhage

Lateral cantholysis: 1B

Emergent evacuation: 1B

OCULAR TRAUMA

Globe rupture. Globe rupture or an open globe results from trauma and is an ophthalmologic emergency that requires emergent evacuation from the wilderness.

A soft eye often characterizes an open globe, although palpation of the eye must be avoided in globe rupture as it may cause progression of the injury. If the anterior segment is involved in the rupture, the iris may prolapse into the wound, causing an irregular or a keyhole shaped pupil. Such a change in pupil shape is extremely suggestive of a serious anterior segment injury that is in need of emergent evacuation for an ophthalmology consultation.

The complications of globe rupture are endophthalmitis, defined as infection and inflammation of the contents of the globe, or potential vision loss, or both. In a review, lacerations of the globe that failed to self-seal and did not have intraocular tissue prolapse were at higher risk for endophthalmitis developing.⁴⁰ It has also been shown that primary repair more than 24 hours from injury is an independent risk factor in developing endophthalmitis.⁴⁰

Treatment of endophthalmitis generally requires antibiotics and corticosteroids that can be administered by a variety of routes.⁴⁰ Due to the likelihood of contamination after globe rupture in the wilderness setting, a strong pathophysiologic rationale exists for the early administration of broad-spectrum antibiotics, if available, that

will cover *Clostridium* species, *S aureus*, *Streptococcus* species, and *Pseudomonas* species. It must also have good eye penetration, which makes moxifloxacin, 400 mg orally once daily, a good antibiotic choice. Topical antibiotics should be avoided. In the wilderness, the patient's eye should be shielded to avoid further injury. A pressure patch should not be used as it can result in the expulsion of the intraocular contents. All foreign bodies, if large enough to be visualized should be left in place and splinted with a shield until evaluated by a specialist.⁴¹

Shielding: 1C
Early antibiotics: 1B
Steroids: 1B
Emergent evacuation: 1A

HYPHEMA

A hyphema is a collection of blood in the anterior chamber between the iris and the cornea, generally after trauma. The collection of blood is usually an isolated finding, but can accompany a dislocated lens, ruptured globe, or retinal injury. The majority of hyphemas resolve without treatment, but patients need to be monitored for secondary complications including cornea staining, rebleeding, and acute elevation in IOP. Therefore, this condition in the wilderness requires emergent evacuation.⁴²

There is no difference between ambulation and complete rest on the risk of secondary hemorrhage or time to rebleeding.⁴² Despite this report, in the wilderness, based on the current pathophysiologic understanding of hemostasis, activity should be restricted to walking only.

Available evidence regarding the use of cycloplegics or corticosteroids in traumatic hyphema is lacking.⁴² Historically cycloplegics (atropine 1%, every 8 hours) and topical corticosteroids (prednisolone acetate 1%, 4 times a day) have been used to decrease inflammation and improve a patient's comfort, and should be considered for this purpose.⁴²

If clinical signs of increased IOP are present, such as headache, nausea, or vomiting, or if the affected globe is taut under palpation in comparison with the unaffected eye, then addition of topical or systemic IOP-lowering medications are indicated.¹⁵ In the wilderness setting, acetazolamide may be available and can be used for this purpose at a dose of 500 mg orally twice daily.⁴³ Analgesics and antiemetics should be used as clinically indicated to keep the patient comfortable and to minimize emesis, which can elevate IOP and worsen bleeding.^{15,42,44} Patient positioning should keep the head ele-

vated above 30 degrees at all times. There is no difference between a single patch versus a binocular patch on the risk of secondary hemorrhage or time to rebleeding.⁴²

Given the risk of rebleeding, NSAIDs should be avoided.⁴⁴ Although no direct evidence is available, near work or tasks (eg, reading) are also not recommended as the accommodation reflex moves the iris and can worsen rebleeding. A rigid shield is not effective in preventing rebleeding, but may be used to prevent further trauma.⁴² If a hyphema is found, emergent evacuation for expert consultation is recommended.

Activity restriction: 1C
Corticosteroids or cycloplegics: 1C
IOP-lowering medications: 1A
Acetazolamide: 1B
Analgesics and antiemetics: 1C
Use of a rigid shield: 1B
Avoidance of NSAIDs: 1B
Emergent evacuation: 1B

CORNEAL ABRASION

Corneal abrasions are one of the most frequently encountered ocular conditions and are most commonly caused by a foreign body, a direct blow to the eye, or the use of contact lenses. If corneal foreign body is evident, then prompt removal is recommended. It is important to consider open globe injury with any corneal trauma. If open globe is suspected or deep corneal epithelial defects are apparent, then evacuation is emergent.

Corneal abrasions should be treated with topical antibiotics (such as erythromycin ophthalmic 0.5% ointment 1 cm every 8 hours),^{45,46} cycloplegics (such as atropine 1%, 1 drop every 8 hours),⁴⁶ NSAIDs (such as ketorolac 0.5%, 1 drop every 8 hours),⁴⁷ and frequent use of artificial tears.⁴⁶ Sunglasses may help reduce photophobia, but there is no evidence to support eye patching for corneal abrasions. Bandage soft contact lenses can provide significant relief, restore depth perception, and improve function, but should be used only if 1) there is no retained corneal foreign body, 2) they are used in conjunction with a prophylactic topical antibiotic drop, and 3) they are removed within 24 to 48 hours. Topical anesthetic eye drops are diagnostically beneficial and provide acute relief for corneal abrasions and ulcers—but it is important to note that they should not be used chronically as they are toxic to the corneal epithelium.¹⁸

Topical antibiotics: 1A
Cycloplegics: 1A
NSAIDs: 1A
Artificial tears: 1C
Sunglasses: 1C

Avoidance of patching: 1A

Emergent evacuation for open globe or deep epithelial defects: 1C

CORNEAL ULCERS

Corneal ulceration differs from abrasion in that the cause of acute ulceration is often infectious. Additionally, whereas a corneal abrasion is damage to the surface epithelial tissue of the cornea, ulceration involves deeper layers of the cornea. Signs include significant pain in the eye, white or gray infiltrate on the cornea on penlight evaluation, and an epithelial defect on fluorescein examination.¹⁰ Risk factors for ulceration include previous corneal abrasion as well as contact lens wear, particularly with improper care of contact lenses or continued use over prolonged periods. Emergent treatment is important, as ulcers can enlarge, causing decreased visual acuity and corneal scarring or perforation. If corneal ulcer is present then, contact lenses must be discontinued.

If the patient is within 4 hours of an ophthalmologist's evaluation, it is preferable that the ophthalmologist obtain a culture before initiating treatment. If the patient is more than 4 hours from an expert evaluation, then empiric treatment should begin. Empiric treatment includes fourth-generation fluoroquinolone eye drops, such as moxifloxacin 0.5%. The patient should be loaded with the drops by instilling 1 drop every 5 minutes for the first 30 minutes, then 1 drop every 30 minutes for 6 hours, followed by 1 drop every hour until the patient is able to see an ophthalmologist.^{48,49} Oral fluoroquinolones are warranted for wilderness cases if nothing else is available (such as moxifloxacin, 400 mg daily for 7 days). Cycloplegic medication (such as atropine 1%, 1 drop every 8 hours) can also be given to prevent synechial formation and decrease pain in severe cases. Evacuation should be emergent.¹⁰

Antibiotics, topical: 1B

Antibiotics, systemic: 1C

Cycloplegic: 1B

Evacuation: 1C

CHEMICAL EYE INJURIES

Chemical eye injuries in the wilderness are limited to case reports and case series, the most robust of which is related to the spitting cobra (genus *Naja*), primarily found in Africa. Other chemical injuries have been incurred through skunk musking, jellyfish stings, and exploding or spraying of cooking gases.

The spitting cobra can eject its venom several meters into the eyes of its victim.⁵⁰ The venom can cause severe chemosis, blepharitis, and corneal irritation. Opacification with corneal and subconjunctival neovascularization (termed the "corneal opacification syndrome") often leads to blindness and is most often associated with the black cobra (*N nigricollis*).^{51,52} There is some evidence from rabbit studies that tetracycline drops and systemic heparin have a protective effect in guarding against corneal opacification syndrome.⁵¹ Currently, there is no indication for topical or intravenous antivenom administration.⁵³

Prevention of chemical injuries is the most important tenet in this category, as treatment in the wilderness is largely supportive for such injuries. In general, rapid, large-volume irrigation and analgesia are the mainstays of treatment.⁵³ Ultimately, after chemical eye injury, emergent evacuation and expert consultation are encouraged.⁵³

Large-volume irrigation: 1C

Topical antibiotics: 1C

Evacuation: 1C

Animal-related bites and envenomations—systemic and topical antibiotics: 1C

Emergent evacuation: 1C

ULTRAVIOLET KERATITIS

Ultraviolet keratitis is a self-limited, inflammatory disorder of the cornea caused by UV rays. Symptoms of severe pain, burning, and tearing with a red eye 6 to 12 hours after exposure to UV rays should raise suspicion of this condition. Although no prospective studies have looked at treatment of UV keratitis specifically, treatment is similar to that for corneal abrasions. That includes topical antibiotic ointments, antiinflammatory drugs, and cycloplegics. (See previous section regarding dosing.) Artificial tears and patching are not recommended. Systemic analgesia is also recommended if severe pain is present. Evacuation should commence in a nonemergent manner if treatment is not available in the wilderness setting. Prevention is the mainstay of treatment, with adequate sunglasses with side-shields being the most important mechanism for prevention.⁵⁴

Sunglasses: 1C

Topical antibiotics: 1C

Cycloplegics: 1C

NSAIDs: 1C

Artificial tears: 1C

Nonemergent evacuation: 1C

CORNEAL FROSTBITE

Corneal frostbite has been described only in case reports and book passages. Its treatment would follow similar guidelines as for other corneal epithelial disorders, including those listed under treatment for UV keratitis.^{55–57}

Topical antibiotics: 1C

Cycloplegics: 1C

NSAIDs: 1C

Artificial tears: 1C

TRAUMATIC IRITIS

Traumatic iritis is acute inflammation of the anterior uveal tract that can occur after trauma. In the wilderness, the diagnosis is made from a history of pain and photophobia that is often consensual. Inflammation can occur in the absence of visible ocular trauma.¹⁴ This condition is often self-limited, and topical steroids (such as prednisolone acetate 1%, 1 drop every 2 hours while awake for the first week and then tapered slowly) as well as NSAIDs (such as ketorolac 0.5%, 1 drop every 8 hours)⁵⁸ can reduce inflammation, while cycloplegics (such as atropine 1%, 1 drop every 8 hours) can make the patient more comfortable until the inflammation is resolved.⁵⁹ Evacuation should commence in a nonemergent manner if treatment is not available in the wilderness setting.

NSAIDs: 1B

Oral steroids: 1B

Topical steroids: 1B

Cycloplegics: 1B

Nonemergent evacuation: 1C

SUBCONJUNCTIVAL HEMORRHAGE

Bleeding between the conjunctiva and sclera causes a collection of blood that appears bright red. Although impressive looking, this condition will resolve in days to weeks without treatment.⁵⁹ Unless there are signs of a ruptured globe or basilar skull fracture, no backcountry treatment or evacuation is required.

Conclusions

Wilderness eye injuries encompass a diverse group of illnesses that often require specialized equipment, medications, and expertise. This review provides an evidence-based overview of the most commonly encountered eye injuries; however, evidence regarding wilderness treatment is limited to case reports and

extrapolation of clinical and hospital care, and is often based on available supplies and treatments rather than on the most evidence-based interventions. However, with the proper tools and physical examination skills, most providers can determine the need for further intervention or evacuation in cases of ocular pathology in the wilderness.

Disclosures

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