OCULAR TRAUMA

Connie J. Mattera, M.S., R.N., EMT-P

KNOWLEDGE OBJECTIVES:

Upon completion of the class, each participant will independently do the following with a degree of accuracy that meets or exceeds the standards established for their scope of practice:

1. Identify the anatomical structures of the eye and describe the corresponding physiological functions.

2. Explain the assessment maneuvers for evaluating the structures of the eye, lid, and periorbital area.

3. Describe and define cardinal signs and symptoms of ocular injury.

4. Interpret assessment findings to formulate a paramedic impression.

5. Establish care priorities based on the paramedic impression.

6. Discuss specific ocular injuries including foreign bodies, chemical burns, hyphema, globe perforation, corneal abrasion/laceration, subconjunctival hemorrhage, enucleation, lid injury, tissue avulsion, retinal detachment, orbital fractures, optic nerve injury.

7. Describe the etiology, clinical presentation and emergency management for patients with a central retinal artery occlusion and glaucoma.

CJM: 1/10

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I. Incidence of ocular trauma

A. Approximately 1.2-2.5 million people suffer eye injuries each year in the U.S. of which 500,000 are serious. About 43% occur in the home (U.S. Eye Injury Registry).

B. Over 40,000 are associated with some visual loss and 25,000 result in total blindness.

C. Ocular trauma is the leading cause of visual loss in persons less than 25 years of age and the leading cause for eye-related hospital admissions.

D. The leading causes of eye injuries include household chemicals, workshop and yard debris, battery acid, sports accidents, consumer fireworks, over-exposure to UV radiation, and inappropriate toys and games used without supervision (Am Academy of Ophthalmology, 2002).

E. An estimated 40,000 sports-related eye injuries occur each year. About 90% are preventable by using appropriate sports-specific eyewear.

F. Workplace and MVC ocular injury rates have reduced significantly due to application of general safety measures, more effective safety glasses, mandatory seat belt legislation and use of airbags.

G. Specific ocular surveillance systems include the **National Eye Trauma System** (NETS) and the **United States Eye Injury Registry** (USEIR).

II. Immediate goals in ocular injuries

A. Protection of the intact portions of the visual system and avoidance of further injury to undamaged structures. A total loss of vision in one eye equals a 25% impairment of Visual System and a 24% impairment of Whole Man (Work Eye Injury Registry, 2002).

B. Accurate assessment of the extent of injury and referral of the patient for immediate repair of injured tissues to prevent further damage.

C. Institution of therapeutic measures that first achieve optimal function and secondarily achieve optimal cosmetic results.

III. Anatomy and physiology of the eye

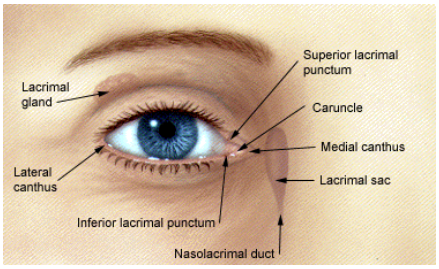
The function of the eye depends on an exact maintenance of anatomical relationships between the eyelids, cornea, anterior chamber, lens, retina, extraocular muscles, and nerves. Permanent deficit in any of these components may result in altered visual function and potentially, loss of the eye.

A. Periocular and orbital structures

1. **Bony orbit**: Provides structure and support for housing the globe. Composed of frontal, maxillary, zygoma, nasal, ethmoid, greater and lesser sphenoid, lacrimal, and palatine bones. These are joined to form a quadrilateral pyramid with a posterior apex.

   Damage to these bones can cause globe injury. Since the globe and orbit are in close approximation to many other important non-ocular structures, serious ocular injury is often seen in the context of serious non-ocular injury.

2. **Eyelids or palpebrae**: Continuation of the facial skin and serve as protective coverings to the eyes, distribute tear film evenly to lubricate the cornea and aid in the removal of excess tears and tear film debris. Eyelids close tightly to protect the eye. Both are lined with conjunctiva.
   a. Orbital portion
   b. Tarsal portion: dense, fibrous, connective tissue measuring 10 mm vertically in the upper eyelid and approx. 3.6 mm in the lower lid. The tarsus is the structural support for the lid.
   c. Fornices: superior and inferior

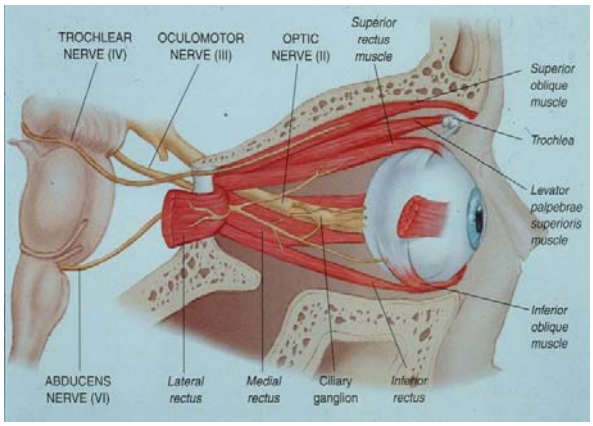


3. **Medial and lateral canthus** (corners of the eye): Points of attachment for upper and lower eyelids.
4. **Eyelashes**: Strong hairs that help prevent foreign particles from reaching the surface of the eye.
5. **Conjunctiva**: Thin, vascular mucous membrane that lines the posterior surface of the eyelids and covers the anterior surface of the sclera. Contains many free nerve endings and is very sensitive.
   a. Bulbar: Outer surface of sclera – white
   b. Palpebral: Lines inner surface of lids - reddish in color

6. **Glands/drainage systems**
   a. **Lacrimal gland**: Located within a depression in the frontal bone, just inside the orbit and superior and lateral to the eyeball, the lacrimal gland has a dozen or more ducts that empty into the pocket between the eyelid and the eye. It continuously secretes tears, distributed across the eye through blinking, that reduce friction, remove debris, prevent bacterial infection, and provide nutrients and oxygen to the conjunctival epithelium (Martini, Bartholomew, & Bledsoe, 2002). Tears are watery, slightly alkaline, and contain *lysozyme*, an enzyme that attacks bacteria. Blinking the eye sweeps the tears to the medial canthus.
   b. **Puncta**: Orifices leading to the lacrimal drainage system in the upper and lower eyelids located about 5 mm from the medial canthus.
   c. **Sebaceous glands:** Associated with the eyelashes as with other hair follicles. Secrete a lipid-rich substance that keeps lids from sticking together.
   d. **Lacrimal caruncle**: Soft mass of tissue located at the medial canthus containing glands that produce thick secretions that contribute to the gritty deposits sometimes found after a night's sleep.

B. **Extrinsic eye (oculomotor) muscles**: Originate on the surface of the orbit and control the position of the eye.

1.	Medial rectus:	Eye rotates toward the nose	CN III
2.	Inferior rectus:	Eye looks downward	CN III
3.	Inferior oblique:	Eye looks upward and to the side	CN III
4.	Superior rectus:	Eye looks upward	CN III
5.	Superior oblique:	Eye looks down and to the side	CN IV
6.	Lateral rectus:	Eye rotates laterally away from nose	CN VI



C. **Eyeball (Globe)**

1. Each eye is roughly spherical with a diameter of about 2.5 cm (1 inch). The length from the apex of the cornea to the point at which the optic nerve exits the sclera is approximately 24.5 mm. The globe weighs 7.5-8.0 g and has a volume of 6.5 ml. It occupies 1/5th of the orbital volume. It shares space with the extrinsic eye muscles, the lacrimal gland, the various cranial nerves and blood vessels that service the eye and adjacent areas of the orbit and face, and orbital fat that provides padding and insulation (Martini, Bartholomew, & Bledsoe, 2008).

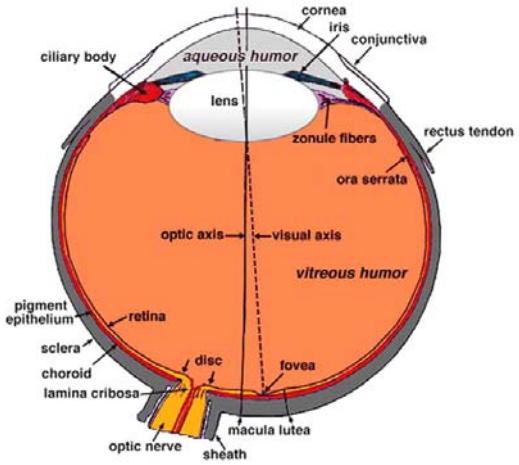


Fig. 2. Sagittal horizontal section of the adult human eye.

2. **Wall of the eye has three distinct layers or *tunics***

a. Outer ***fibrous tunic***: Outermost layer covering the eye; composed of the sclera and cornea

(1) Provides mechanical support and some physical protection
(2) Serves as an attachment site for extrinsic eye muscles
(3) Assists in the focusing process

b. Intermediate ***vascular tunic***: Contains numerous blood vessels, lymphatics, and all of the intrinsic eye muscles, iris, ciliary body, and the choroid.

c. Inner ***neural tunic*** or retina

3. **Sclera**

a. Dense, fibrous connective tissue that contains both collagen and elastic fibers. It forms the outer layer of the globe, and is composed of epithelial cells.

b. Thickest over the posterior and thinnest over the anterior surface

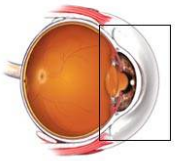
c. Extrinsic eye muscles insert on its surface

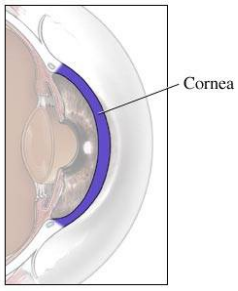
d. Its posterior surface contains nerves and small blood vessels that penetrate to reach internal structures. On the anterior surface, these vessels lie under the conjunctiva. Because the capillary network carries so little blood, there is no obvious color, so the white of the collagen fibers is visible (thus forming the white of the eye).

e. **Functions**

(1) Protect the internal ocular structures
(2) Act as the structural skeleton of the globe

4. **Cornea**


Cross section of the eye



a. Transparent, avascular, concave dome continuous with the sclera that covers the iris (11.5 - 12.5 mm across).

b. It ranges in thickness from 0.7 mm peripherally to 0.5 mm centrally.

c. Collagen fibers are organized into a series of layers that permit the transmission of light through the cornea, pupil and lens to the retina. It is covered by a thin layer of epithelium overlying a basement membrane (Bowman's membrane).

d. Innervated by the sensory limb of CN V (trigeminal nerve). Because the cornea is so richly innervated beneath the corneal epithelium, the pain of corneal injury is often greater than that of iritis or conjunctivitis. Topical anesthesia freely penetrates the cornea, but not the inner aspect of the eye. Therefore it has little effect on pain caused by deeper problems.

5. **Limbus**: Circular margin where the conjunctiva meets the cornea

6. **Iris**: Circular, contractile muscular disc that is an extension of the ciliary body that is located anterior to the lens. It contains pigment cells that produce the color of the eye and two layers of smooth muscle. The iris controls the amount of light reaching the retina by dilating and constricting its muscles to change pupillary size in response to impulses mediated by CNs II & III. When there are no pigment cells in the iris, light passes through it and bounces off its inner surface of pigmented epithelium. The eye then appears blue. In order, persons with gray, brown, or black eyes have increasing numbers of pigment cells in the body and surface of the iris (Martini, Bartholomew, & Bledsoe, 2002).

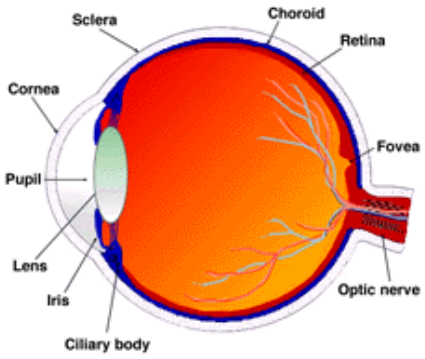
7. **Pupil**: Typically is a round central opening in the iris

Fig. 1. View of the human eye

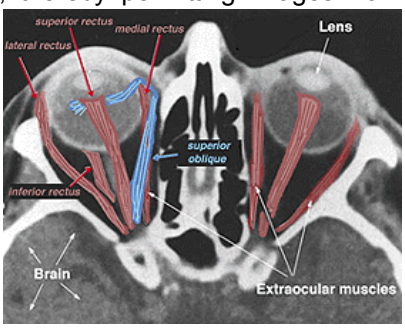
a. **Parasympathetic stimulation**: Rapid reflex constriction of the pupil in response to bright light.

b. **Sympathetic stimulation**: Slower pupillary dilation in response to a reduction in light levels

8. **Ciliary body**: Along its outer edge, the iris attaches to the anterior portion of the ciliary body which is composed primarily of a ring of ciliary muscle that projects into the interior of the eye. It begins at the junction between the cornea and sclera and extends to the anterior edge of the retina. Posterior to the iris, the suspensory ligaments of the lens attach to folds called the ciliary processes. These fibers position the lens so light passing through the pupil goes through the center of the lens. Responsible for producing aqueous humor and for changing the shape of the lens.



9. **Lens**: Disc-shaped structure approximately 9 mm in diameter and 4 mm thick, containing transparent crystalline matter, suspended immediately behind the iris and anterior to the vitreous by suspensory ligaments that connect it to the wedge-shaped ciliary body. The lens is highly elastic and contraction or relaxation of the ciliary body changes its thickness and shape, thereby permitting images from varied distances to be focused on the retina.



   Its shape changes for near and far vision, becoming flatter for far vision. The ability to change shape deteriorates with age explaining need for reading glasses after 40...

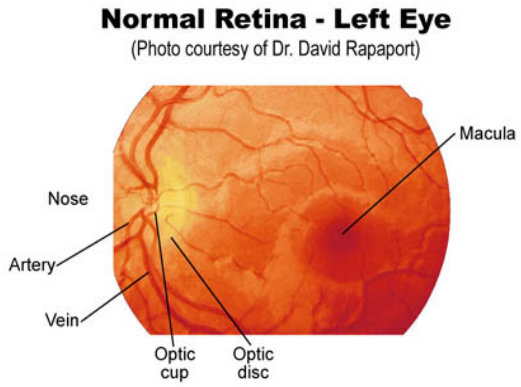
10. **Choroid:** Layer of vascular channels that separates the fibrous and neural tunics posterior to the ciliary body. This layer delivers oxygen and nutrients to the retina.

11. **Retina:** Consists of a thin outer pigment layer and a thick inner layer of neural retina. The pigment layer absorbs light after it passes through the receptor layer. The neural retina contains photoreceptors that respond to light, supporting cells and neurons that perform preliminary processing and integration of visual information, and blood vessels supplying tissues that line the posterior cavity. The sensory network transforms light impulses into electrical impulses via *rods* and *cones*. Rods do not discriminate among colors. They enable us to see in poor lighting conditions. Cones provide color vision. They give sharper, clearer images but require more intense light.

    a. **Macula lutea** (or yellow spot): Avascular region where the visual image arrives after passing through the cornea and lens. The area of greatest concentration of cones is located in the central portion, called the **fovea** (shallow depression). All color and sharpest vision better than 20:200 is located here.

    b. **Optic disc**: A circular region just medial to the fovea. It measures 1.5 mm across and becomes the origin of the optic nerve, which is formed from the convergence of axons from 1 million retinal ganglion cells. The central depression or cup usually averages ⅓ of the disc diameter. Blood vessels that supply the retina (central retinal artery and vein) pass through the center of the optic nerve and emerge on the surface of the optic disc (Martini, Bartholomew, & Bledsoe, 2008). The disc has no photoreceptors or other retinal structures. Light striking this area is not perceived, so it is commonly called the ***blind spot***.

    c. **Optic nerve** - Sensory impulses are transmitted through the optic nerve (CN II) to the occipital lobe for conscious interpretation. Injury to the optic nerve and retina are most responsible for permanent visual loss in cases of trauma.



12. **Chambers of the eye:** The eye is hollow. The ciliary body and lens divide the interior into two **cavities**:

    a. **Anterior cavity**

        (1) **Divided into two chambers**

            (a) **Anterior chamber**: Extends from the cornea to the iris

            (b) **Posterior chamber**: Extends from the iris to the ciliary body and lens.

        (2) **Contents**: Filled with **aqueous humor** produced by the ciliary processes and secreted into the posterior chamber. The fluid circulates within the anterior cavity, passing from the posterior to the anterior chamber through the pupil. It leaves the anterior chamber near the edge of the iris through the canal of Schlemm that returns the fluid to the venous system. The anterior cavity holds about 125 microliters of fluid. Interference with secretion, circulation, or absorption can change the pressure within the eye. Glaucoma is caused by an elevation in ocular pressure and can produce blindness by distorting the retina and the optic disc.

    b. **Posterior cavity** or *vitreous chamber* contains the gelatinous vitreous body. Helps to maintain the shape of the eye and holds the retina against the choroid.

13. **Vascular supply**

    a. **Arterial**: The ophthalmic (central retinal) artery is the main vessel that supplies blood to the globe and orbit and is the first branch off of the internal carotid after it enters the cranial cavity. Emboli from the internal carotid artery can enter the ophthalmic artery, producing visual problems. Facial and maxillary arteries feed the lower lid, medial canthus and inferior orbit.

    b. **Venous**: Blood returns through the inferior and superior ophthalmic veins. Venous draining through the cavernous sinus is an important route for the intracranial spread of infection. There are no lymphatics in the orbit, but the eye lid has a rich lymphatic system.

IV. Assessment and management of ocular trauma

Many patients presenting with ocular trauma have other associated trauma to the head and neck with facial and skull injuries that may delay recognition of ocular damage.

A. **Chief complaint/history of present illness**: Because the nature of eye emergencies ranges from minor to severe, history taking may be done simultaneously with the eye exam. Whenever time permits, obtaining an accurate, detailed history can aid in the rapid treatment and evaluation of the patient. Important details to include:

1. **Nature of complaint**: traumatic vs. non-traumatic

   a. **Non-traumatic**: Usually divided into complaints of vision, appearance or sensation. Obtain details regarding the rapidity of onset, duration, intermittence and frequency. Note associated symptoms.

   b. **Traumatic**: Blunt, penetrating, sharp or explosive; thermal, UV; time and course of events. Ask about any change in vision, and if so, was it immediate, sudden or gradual? If chemical burn, ask if it was toxic, acid or alkali. Determine any treatment rendered prior to arrival.

2. **HPI** - Detailed description of symptoms: Obtain OPQRST details about onset, provocation (what object or item caused the injury - magnetic?)/palliation, quality, region/recurrence, severity, and date and time of injury.

   a. Visual changes from baseline: Blurred, double, or deficits in acuity or visual fields

   b. Symptoms in one or both eyes?

   c. **Diplopia (double vision)**

      (1) Diplopia may indicate trauma to the globe with muscle entrapment or nerve deficit, peripheral or central

      (2) Monocular diplopia usually indicates a refractive error in the eye itself

      (3) Binocular diplopia, present only when both eyes are open, is the result of a deficiency in the movement of the eye

   d. Redness
   e. Tearing, drainage
   f. Pain
   g. Note associated complaints/symptoms other than decreased vision

B. **SAMPLE History**

1. **Allergies**
2. **Medications**: Regular use of eye medications or over-the-counter remedies including drops or ointments. Use of anticoagulants or aspirin. Include licit and illicit drug use, as they can affect pupillary size and reactivity.
3. **Past ocular history**

   a. In self or family: cataracts, glaucoma. Any ocular disease or visual loss prior to trauma?
      (1) Blurred vision that does not improve with blinking
      (2) Diplopia
      (3) Sectorial visual loss
      (4) Spots before eyes, curtain over the visual field?
      (5) Halos or rings around lights
      (6) Photophobia

   b. **Baseline visual acuity**; ever worn glasses or contact lenses? How long? If contacts are worn: hard, soft, extended wear? For reading, driving, distance?

   c. History of ocular pain
   d. Eye injury or surgery? When?
   e. Excessive tearing, crusting, discharge?
   f. Burning (inflammation)
   g. Relevant occupational hazards; dust, chemicals, metalwork
      (1) Use of protective devices
      (2) Use of safety glasses, if traumatic injury

4. **Past medical history in self or family**
    a. Heart disease, hypertension
    b. Diabetes
    c. Sickle cell disease
    d. Liver disease
    e. Vascular disorders
5. Last oral intake; tetanus
6. **Events surrounding the incident:** Details regarding probable size, velocity, and chemical constituency of pellets or projectiles; determine treatment rendered prior to arrival.

C. **Physical exam**

1. **Remove and store contact lenses**: All lenses must be removed as part of the trauma assessment/management.
    a. **Hard contact lenses**: Remove with suction cup lens remover. Place in normal saline and label container left and right.
    b. **Soft contact lenses**: Remove by pinching the lens together and pulling away from eye. Place immediately in 0.9 NS and label containers L and R.
2. **Signs and symptoms**
    a. Pain: duration, intensity, location
    b. Visual changes from normal: Blurred, double, partial, no vision. Always check both eyes.
    c. Anatomic disruptions: Look for obvious deformities, lacerations
    d. Functional deficits: Is movement of globe or lid impaired?
3. **External structures** - Inspect from top to bottom; medial to lateral canthus
    a. **Orbit and periorbital structures**: Often, one needs only to visually inspect the patient's face. However, bony palpation of the orbital rim can detect deformities and pain. Orbital rim should be smooth, without deformities or irregularities. Insect/palpate for the following:
        (1) Ecchymoses, laceration
        (2) Periorbital edema, masses, asymmetry of tissue
        (3) Tenderness and crepitus
        (4) Position of the eye within the orbit and in comparison with the opposite side.
            (a) **Enophthalmos**: Relative recession (backward or downward displacement) of the globe into the bony orbit. Frequently seen after orbital fracture.
            (b) **Exophthalmos (**eye bulging out)
            (c) The pupils should be on same horizontal plane. If one eye is lower than the other suspect orbital floor fracture. Eyes should be in line with top of ear. Is gaze focused on you?
        (5) Globe intact? If not, what type of fluid is present? What is the shape of the eye?
        (6) Eyebrow size and extension
    b. **Lids: Examine closed and open**
        (1) Symmetry
        (2) Ecchymoses
        (3) Laceration/lesion: While serious by themselves, they can also be associated with penetrating trauma to the globe. Look for prolapse

of orbital fat.

(4) Edema, inflammation

(5) Ability to spontaneously lift and close lid to cover the superior limbus of the iris by 1 mm - 3 mm

(a) **Ptosis:** If the lid cannot open or lift up and covers more of the iris than the other side or extends over the iris, this indicates a congenital or acquired weakness of the levator (plus Muller's) muscle or paresis of a branch of the third cranial nerve.

(b) If the lid cannot close, suspect trauma to CN VII which innervates the orbicularis muscle. Ex.: Bell's palsy.

(6) Surface growths or internal masses; never palpate an injured eye

c. **Lashes and sebaceous glands**

(1) Crusting, scaling
(2) Hair loss
(3) Pus, blood, CSF from puncta

4. **Anterior segment**: This examination includes the conjunctiva, cornea, anterior chamber, iris and lens

a. **Conjunctiva** - Use a penlight. **Inspect for the following:**

(1) Degree and depth of redness/injection
(2) Foreign body, embedded material
(3) Laceration
(4) Chemosis or hemorrhage
(5) Rust ring; black defect
(6) Pus

b. **Sclera**

(1) Should be white. Abnormal colors: jaundiced, bluish (Marfan's syndrome), injected
(2) Wounds
(3) Black defect

c. **Cornea**; should be smooth, round, clear, glistening and free of lesions. Inspect for the following:

(1) Blood
(2) Clouding/opacity; could indicate acute glaucoma, edema from trauma, foreign body in the anterior chamber, or infection
(3) Abnormal pigment
(4) Irregular light reflection if irregular in size or shape
(5) Abrasion/laceration
(6) Foreign body

d. **Anterior chamber**: should be clear and deep with the iris well separated from the posterior corneal surface. If blood (hyphema) or white cells (hypopyon) are present, serious injury has occurred.

5. **Iris**: Should be flat and smooth. In trauma, may show tears and holes. These may cause pupil irregularities. If torn, suspect ruptured globe.

6. **Lens:** Should be transparent. Not uncommon to have post-traumatic cataracts develop which if often visible on penlight exam. In severe trauma, lens may dislocate to float free in the vitreous or settle on the retina.

7. **Cranial nerve assessment**

a. **CN II (Optic nerve)**

(1) **Visual acuity:** Never delay eye irrigation for chemical burns in order to obtain visual acuity. This is vital from both the medical and legal standpoint.

(a) Test each eye separately; shield eye that is not being tested

(b) **Note their best (corrected) vision.** If they normally wear eyeglasses or contact lenses, have them wear them during the assessment.

(i) Can read print (near card at 12 to 14 inches)

(ii) If patient cannot read largest print, see if they can perceive hand motion 1 ft. in front of the eye.

(iii) If patient is unable to see hand motion, document if they can perceive light with or without the ability to determine the direction from which it is projecting.

(iv) No light perception (NLP)

(c) **Partial differential diagnosis of post-traumatic loss of vision**

(i) Lid swelling; blood or foreign material covering cornea; corneal damage
(ii) Hyphema; vitreous hemorrhage
(iii) Traumatic cataract; injury to the lens
(iv) Central retinal artery or vein occlusion (from markedly increased orbital pressure or embolus)
(v) Traumatic retinal edema and hemorrhages of retina from direct or contrecoup blow to head
(vi) Retinal detachment
(vii) Avulsion of optic nerve by trauma of lateral orbital wall or contrecoup blow to head
(viii) Indirect trauma to optic nerves and/or chiasm (traumatic optic neuritis)
(ix) Intracranial interruption of visual pathways (hemorrhage/ foreign body)
(x) Cortical blindness from hematoma, ischemia, or anoxia (patient may be unaware of blindness)
(xi) Acute (angle-closure) glaucoma precipitated by emotional trauma of recent trauma
(xii) Hysteria
(xiii) Malingering
(xiv) Dislocation of intraocular lens
(xv) Dislocation or loss of contact lens

(2) **Visual fields:** Have the patient cover one eye and focus on your face. Raise one or two fingers in the upper and lower right and left visual fields and ask the patient to identify the number of fingers you have presented. Repeat the test for the other eye. The visual deficits will depend on whether there is disruption to one of the optic nerve branches before or after the optic chiasm or directly in the chiasm.

(3) A fundoscopic exam is usually not performed in the field. The purpose of the exam is to inspect the major retinal vessels to the

optic disc assessing for constriction, dilation, thickening, sheathing, or bright intravascular objects (atheromatous emboli). The disc is examined for color, contour, and margins.

b. **CN III: Pupil size, shape (deformity or defect), equality**

(1) Have patient look at a distant object (prevents pupillary constriction that occurs when one looks at a near object). Note the size and shape of each pupil. Compare one side to the other to assess for symmetry.

(2) Pupils should be round, symmetric, midpoint, and equal in size. Previous ocular surgery, injuries and medication can affect the pupils, so accurate history taking is essential.

(3) **Causes of pupil asymmetry**

(a) About 15% of the population has pupils of different sizes called *anisocoria*. If this is physiologic, the pupils should remain asymmetric in both bright and dim light.
(b) Horner's syndrome: pupil asymmetry is accentuated in dim light
(c) Traumatic mydriasis (prolonged abnormal pupil dilation) or miosis (constricted pupil) from direct blow
(d) Rupture of iris sphincter
(e) Unilateral use of topical drugs
(f) Intraorbital trauma
(g) Acute intraocular inflammation with spasm or atony
(h) Intracranial third-nerve palsy
(i) Iritis
(j) Unilateral blindness
(k) Stroke
(l) Pontine lesions

(4) **Pupil reactivity to light**

(a) Direct and consensual. Shine a bright light source into one eye at a time from the side, taking care not to hold the penlight directly within the visual axis because of the accommodation reflex. Both pupils should briskly constrict and remain constricted as long as the light stimulus is present.

(b) **Afferent defect** *(nice to know)*: When a bright light is directed at the healthy eye, both pupils should constrict. As the light is briskly swung over to the damaged eye, both pupils will widen. As the light is returned to the healthy eye, both pupils will constrict. This test can be performed even if only one pupil can be assessed. In ambient light, even if the optic nerve of one eye has been completed transected, the pupils should be equal because the consensual response of the damaged eye to the good eye will result in equal pupils. Therefore, the swinging light test is important.

c. **CN III, IV, IV: Extraocular movements (EOMs):** Assess ocular motility by having the patient fixate on a penlight or other object which is moved in each of the cardinal directions of gaze to evaluate nerve and muscle function. The eyes should move an equal amount in each gaze direction. Assess for range of each eye, symmetry, dysconjugate gaze or pain on movement. Many disease processes affect eye mobility. Common causes include orbital edema, muscle entrapment and cranial nerve damage.

(1) Conjugate gaze: Eyes move together
(2) Dysconjugate gaze: Eyes do not move together
(3) Gaze palsy: One eye is not able to move symmetrically or looks to one side

II. **Chemical injury (burns)**

A. Apart from history, the diagnosis of chemical burn is usually based on the presence of swollen eyelids with marked conjunctival swelling and redness

B. **Etiology**

1. **Acids**: When acids come in contact with the eye, tissue proteins are released and form a protective barrier to prevent further penetration of the eye, so these types of injuries are usually limited to the external surface of the globe. Generally less serious than alkali burns because they do not cause progressive destruction of ocular tissues or collagen swelling (ex.: exploding car battery).

2. **Alkalis**: Cause breakdown of the fatty acids in the epithelial cell membranes (emulsification) causing collagen denaturation. They destroy the surface tissues, affecting the eyelid, conjunctiva and mucous secreting cells. Once the epithelium is damaged, the chemical rapidly penetrates the cornea and anterior chamber. When the pH is 8.0 or higher an alkaline chemical keratitis is present. If pH > 11.5 there is intraocular penetration. (Ex.: drain cleaners containing lye, lime, ammonia, and airbag propellant gasses such as sodium hydroxide. The higher the pH the worse the injury.)

C. **Morbidity and prognosis for eye**

1. Depends on the pH of the agent and the duration of ocular exposure. The are often very serious, because even after apparent removal of the agent, lodgment of tiny particles within the cul-de-sac may continue and cause progressive damage to the eye

2. It may take 48-72 hours to make an accurate assessment of burn damage. For alkali burns, the degree of corneal opacification and perilimbal blanching correlate with prognosis.

3. Corneal opacification (clouding) occurs due to disruption of the regularly spaced collagen network by direct chemical damage, reactive edema, and damage from lysosomal enzymes. Burns at the limbal region are the most unfavorable, as they produce vascular damage with extensive thrombosis and eventually ischemic necrosis.

D. **Clinical presentation: acute phase**

1. Severe pain and diminished or blurred vision
2. Conjunctival chemosis and injection
3. Possible limbal blanching
4. Localized edema
5. Denuding of corneal epithelium (corneal grafts don't take)
6. Loss of corneal transparency

E. **Emergency management**: **Do not delay treatment** while trying to determine nature of the fluid

1. Rapidly remove contact lenses

2. Rapid visual acuity for light perception only while preparing to irrigate

3. Instill tetracaine drops if severe pain/spasm. Research by a group of New Mexico physicians suggests that a patient's response to local anesthesia may predict the complexity of a corneal lesion. Those that receive significant pain relief probably have an uncomplicated corneal lesion. Patients with a diagnosis of conjunctivitis, iritis, corneal ulcer, hyphema, glaucoma, or subconjunctival hemorrhage typically

had less pain initially and got little relief from tetracaine.

4. **Immediate and profuse eye irrigation with the most immediately available neutral solution**. In the field, this is usually normal saline. Aim the stream from the inner to outer canthus. Don't attempt to neutralize the chemical agent. Evert the eyelids to flush the cul-de-sac. Continue into the hospital. Irrigation should continue until the pH has returned to normal (7.3 to 7.7). Repeat pH testing should be done 30 minutes after irrigation is stopped. If rising, caregivers should suspect trapped particulate matter that is releasing additional chemicals and irrigation should be repeated.

III. **Penetrating/perforating injuries** (ruptured globe): Major cause of traumatic visual loss due to damage of intraocular structures caused by the force required to rupture the globe. Require immediate careful attention and prompt surgical repair at the hospital to prevent possible loss of the eye.

A. **Etiology**

1. Children: running with sharp objects in the hand or unsafe playground games or toys
2. Adults: Acts of violence, injuries in the workplace (Criss, 00)

B. **Penetrating injuries** are those that cause disruption of the outer coats of the eye without interrupting the anatomic continuity of the whole eye, thus preventing prolapse of internal ocular contents. The most obvious would be an impaled object.

C. **Perforating injuries** are those that result in complete anatomic disruption of the sclera or cornea. Such wounds may or may not be associated with prolapse of internal structures.

D. **Clinical assessment/presentation**

1. Pain
2. Change in pupil shape (tear-drop pupil pulls to site of rupture)
3. Unequal pupils; may be dilated and nonreactive on affected side
4. Black defect (choroid prolapse into defect) or obvious vitreous prolapse
5. Injected sclera, subconjunctival hemorrhage
6. Leakage of vitreous humor
7. Decreased visual acuity to hand movements or light perception
8. Hyphema
9. Iris prolapse
10. Dislocated lens, traumatic cataract
11. If patient's lids are swollen, use great caution in pulling lids apart to prevent extrusion of the eye

E. **Emergency management**

1. Never remove an impaled F/B; stabilize the object and transport as a time-sensitive patient
2. **DO NOT** manipulate the eye, instill eye drops, or apply ointments to an open globe
3. Do not attempt to remove any blood clots, foreign bodies or tissue from the eye
4. **Eye shields:** An eye shield should be applied when pressure on the globe might result in loss of vitreous or aqueous humor. A metal shield or cup should rest on the bone of the brow and the cheek; it should not exert pressure on the eye. The patient must not be able to touch or rub the eyelids.
5. Unilateral vs. bilateral shielding: Local custom. Based on recommendations from the University of Illinois Eye Trauma Center, the NWC EMSS does not shield an uninjured eye.
6. Analgesics and sedatives may be needed
7. Don't let patient bend, stoop, strain, or move his or her head suddenly
8. Keep patient NPO

9. Reduce patient's anxiety through therapeutic communication

IV. **Hyphema**

A. **Definition:** Accumulation of blood in the anterior chamber

B. **Etiology**: Usually caused by severe blunt, and less often, perforating trauma to the eye resulting in the rupture of blood vessels in the anterior chamber. Bleeding occurs from the angle where the iris meets the cornea leading to hemorrhage. Loss of blood is self-limited as vascular pressures and intraocular pressures equilibrate. In rare instances, hyphema may occur spontaneously as a complication of an ocular or systemic disorder.

C. **Demographics**

1. Incidence: 17-20/1000 population/year
2. M:F 3:1
3. 70% < 20 y/o
4. 60% sports related

D. **Frequency and severity**

1. 60% Grade 1: Small; 1/3 of the anterior chamber (AC)
2. 20% Grade 2: Moderate; 1/3 – ½ AC
3. 20% Grade 3: Severe; Greater than ½ to near total AC
4. Grade 4: Total or *"eight-ball"* hyphema

E. **Clinical presentation**

1. Decrease in visual acuity if the blood covers the pupil (25%); patient may report seeing red, moving spots that seem to drift in front of the eye
2. Note color: red indicates new bleed, brown is characteristic of older blood
3. Gravity and clotting mechanisms will eventually cause the blood to settle inferiorly, giving the hyphema a crescent shape
4. Pain, nausea, vomiting; may be indicators of uncontrolled elevation of intraocular pressure causing angle recession and acute glaucoma

F. **Clinical significance**: Suspicion of accompanying globe rupture

G. **Examination**

1. **History**: Trauma, bleeding, use of anticoagulants
2. ABCs, mental status
3. Visual acuity
4. Rule out F/B, open globe, laceration
5. Evaluate iris; active hemorrhage, tears
6. Height of hyphema
7. **Emergency management**: Aimed at limiting acute complications (Acute: ocular hypertension, secondary hemorrhage)
   a. Sit up 30° - 45° to facilitate settling of the hyphema into the inferior portion of the anterior chamber and away from the visual axis
   b. Place shield over involved eye to help prevent rebleeding
   c. No reading should be permitted
   d. Sedate the patient if overly anxious
   e. Non-aspirin containing analgesics
8. Major complication: Rebleeding 3-5 days later

V. **Lid injuries**

A. **Etiology**: Blunt or sharp trauma to the orbital region may lead to significant functional and structural abnormalities. Lid injury is the lowest priority when evaluating ocular trauma.

B. Types of lid injuries: lateral vs. medial to punctum

C. **History:** Determine the time, circumstances, and type of injury, assess the possibility of F/B

D. **Clinical significance**: These may be associated with serious ocular injuries not apparent at first examination. Injuries to the lids can be serious because these structures protect the eyes and keep them moist, acting like windshield wipers to wash away foreign matter. An injured eyelid can lose its ability to cover the eye adequately, resulting in drying of the eye, infection or clouding of the normally clear cornea.

E. **Clinical presentation**: edema, ecchymosis, asymmetrical eyelid, exposed eyeball, bleeding, and possible laceration to tear ducts.

F. **Exam**

1. Check for corneal/globe injury
2. Document ptosis
3. Note any abnormality of eyelid contour
4. Describe the amount of edema, ecchymosis, and erythema
5. Avulsion injuries may result in loss of lid skin or deeper tissue. Measure and document the size and extent of the lesions.

G. **Emergency management**

1. Cover wound with saline-soaked sterile dressing
2. Assess for globe injury
3. Assess visual acuity
4. Apply cold packs to decrease swelling and pain
5. **Notes**

a. Vertical traction should be avoided near the lid margin to avoid late ectropion

b. Bring in all avulsed tissue, even if the viability is questioned

c. Be alert for injury to the margin, canthal tendons, lacrimal drainage system, deeper lid structures or the globe. These require special repair.

VI. **Retinal detachment**: Separation of the retina from its source of blood supply via tear, fold or rent. Subretinal fluid accumulates under the neurosensory layer. Minimal to moderate trauma may cause retinal detachment.

A. Etiology: 15% due to trauma

B. **Clinical presentation**

1. Painless visual field deficit or decrease in vision. May be described as a darkening/haziness or a curtain being drawn over the visual field.
2. Photopsia (**flashes of light or sparks**); spider webs
3. **"Floaters"** or black dots

C. **Emergency management**

1. Keep patient quiet and supine with both eyes patched
2. Retinal attachment can only be accomplished by surgery which is successful in about 80% of the cases

VII. **Thermal burn**

A. **Etiology**: Flash burn, fiery explosion, walks into a cigarette, etc. Almost always associated with facial burns. Even severely burned patients may avoid direct injury to the cornea and conjunctiva due to protection by the eyelids. Burns due to toxic chemicals, hot liquids, and molten metal behave much like alkaline burns. Iron has a higher melting point (1200° C) and causes more damage than other metals (lead, tin, zinc, melting point below 1000° C). Arc welding injuries common without protective eyewear.

B. **Clinical exam**: May require local anesthetic

1. Visual acuity

2. Pupillary exam
3. External exam: lid spasm, edema, orbital cellulitis
4. In explosions: must R/O perforating injuries, F/B
5. Cornea will slough and regenerate in 4-5 days in children; 3-4 wks in adults

C. **Treatment**

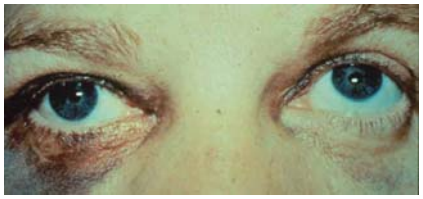
1. Cool burn and then apply dry, sterile dressing
2. Bandage with contact lens in place. Note: the contact lens will not remain moist if lids are not functioning properly, and frequent artificial tears and ointments may be necessary.

VIII. **Orbital (blow-out) fracture**

A. **Etiology**: **Etiology**: When blunt force is applied to the eye, the orbital contents are pushed posteriorly and intraorbital pressure suddenly rises. The orbital floor is also the roof of the maxillary sinus. It is thin and may fracture. Immediately after impact, the edges of the fracture may separate briefly and come back together. At the moment of separation, the contents of the lower orbit may prolapse into the fracture space and become trapped as the bone comes together. If the inferior rectus muscle is entrapped, the patient cannot look upward. Suspect blowout fracture with adjacent facial bone fracture.

B. **Clinical presentation**: Effects depend on the size and location within the orbital cavity

1. Periorbital pain, pain on upward gaze, point tenderness along orbital ridge, swelling, ecchymosis, crepitus if sinus cavity is involved
2. **Abnormal EOMs**: Eyes may be aligned on downward gaze, but attempted elevation of the eyes causes double vision (diplopia) with vertical separation of images.



3. Paralysis of upward or vertical gaze indicates possible EOM entrapment.
4. Visual changes may result from a hematoma forming around the optic nerve or retinal damage from the force of the blow (Criss, 00)
5. If significant orbital fat is entrapped, the eye may appear sunken (enophthalmos) if not obscured by local swelling
6. Subconjunctival air or hemorrhage; chemosis
7. Hyperesthesia or paresthesias over the infraorbital nerve distribution depending on degree of nerve stretching or tearing. Ask the patient if his or her cheek or upper lip is numb on the side of injury.
8. Facial asymmetry
9. Rim fx. may be palpable; a fx. posterior to the rim may not be palpable
10. Nosebleed (epistaxis) on the same side

C. **Emergency management**

1. Caution patient not to blow his nose
2. Apply cold pack if no globe rupture
3. May be asked to shield the eye to protect it from further damage. The NWC MD does not recommend bilateral shielding or bandaging.
4. Analgesics

IX. **Corneal/conjunctival foreign bodies**

A. **Etiology**: Typical F/Bs: dirt, dust, glass or cinders, or fragments that fly into the eye when working without protective goggles. If metal, identify the type of metal if possible. Iron and copper common. BB pellets etc. also common. Most F/Bs do not penetrate and result in ocular irritation. However, view them as a possible indicator of concurrent intraocular or intraorbital F/B. This is especially important in the setting of grinding or hammering metal upon metal in the absence of protective eyewear.

B. **History:** Question patient about the use of safety goggles, the nature of the F/B, and if there was metal striking metal

C. **Clinical assessment/presentation**: Carefully examine the eyebrows and eyelashes and remove any debris that could fall into the eye (Criss, 00). Inspect conjunctiva and evert the lids to search for additional F/B. If vertical linear abrasions are seen suspect occult F/B under the lid.

1. Obtain visual acuity
2. Observe unaffected eye first for comparison
3. Pain, foreign body sensation; may worsen with blinking
4. Photophobia
5. Blurred vision
6. Always suspect penetration in velocity injuries e.g., hammer and chisel
7. Key feature is the finding of the F/B, a rust ring, or both
8. Conjunctival injection, mild anterior chamber reaction
9. Eyelid edema
10. There may be a small white infiltrate around the F/B if it has been in the cornea for greater than 24 hours.

D. **Emergency management**

1. Topical anesthetics: Tetracaine 0.5% 1 gtt
2. Evaluate whether it is in the visual axis
3. **Conjunctival FB**: Easily removed with gentle irrigation with NS or moistened cotton-tipped applicator.
4. **Corneal FB**: Requires removal under the slit lamp at the hospital
5. Check for **corneal abrasion**
6. Systemic analgesics; may need **morphine** if iritis is severe
7. **Cyanoacrylate (Krazy Glue)**: Immediately irrigate with warm water for at least 15 minutes. Do not pry lids loose or try to remove residual glue in the field. Acetone or ethanol solutions should **not** be used in the eye. Mineral oil can be applied to the eyelid if available. Will cause corneal abrasions once removed from the eye.

X. **Corneal abrasions**

A. **Etiology**: Scratch or tear in the corneal epithelium resulting from a direct or tangential impact, contact lenses, and/or exposure to ultraviolet light. F/Bs can scratch the cornea at various depths. All of these objects may be microbially contaminated and the possibility of infection should always be considered. Patients with contact lenses are at particular risk for gram negative infections such as *pseudomonas* and treatment differs from a routine abrasion.

B. **Clinical presentation**: tetracaine aids in the exam if no signs of penetration

1. Pain mild to severe and foreign body sensation that is worsened by blinking
2. Copious tearing (epiphora)
3. Possible decrease in visual acuity if over the pupil
4. Irregular corneal light reflex
5. Diffuse conjunctival redness
6. Photophobia
7. Lid spasm (blepharospasm)

C. **Examination**

1. A corneal abrasion may be associated with serious ocular injury. Vision should be checked and recorded.
2. Evaluate patient for retained foreign body by everting the eyelid. If the cornea has vertical linear abrasions, a F/B is likely.
3. Examine the anterior chamber for the presence of a hyphema that may result from blunt trauma and may require different treatment.

D. **Emergency management**

1. Elevate head of stretcher 45 degrees
2. **Non-contact lens wearer:** Pressure patch eye to help alleviate pain and limit eyelid movement. Use two pads with tape running from bone to bone in a diagonal fashion. A pressure patch is not usually indicated when microbial infection is suspected or a significant risk (contact lens wearers) is present. Caution patient about loss of depth perception.
3. **Contact lens wearer: DO NOT PATCH**

XI. **Subconjunctival hemorrhage**

A. **Etiology**: Very common; caused by leaking of blood from delicate vessels between conjunctiva and sclera. Can be initiated by sneezing, coughing, or lifting heavy objects. They can also be caused by trauma to the eye or surrounding tissues.

B. **Clinical presentation**: Blood-red eye that does not change in appearance when the patient changes position; looks terrible, but is painless. Does not change visual acuity. Non-emergency if non-traumatic origin.

C. **Emergency management**: Usually self-limiting, spontaneously resolves in 1 to 2 weeks, however, always suspect possible ruptured globe

XII. **U.V. radiation burns**

A. **Etiology**: Uncommon, yet may be seen in head and neck tumors treated with radiation, those who use tanning beds with the corneas unprotected, arc welders, and repeated direct exposure to sunlight as in mountain climbers and skiers.

B. **Clinical presentation**

1. A flash exposure can cause temporary blindness from overstimulation of the retina (Criss, 00)
2. Superficial punctate keratitis, corneal epithelium sloughs
3. Pain, 3-6 hours after exposure
4. Increased tearing, burning, eyes feel full of sand
5. Superficial swelling of cornea

C. **Emergency management**

1. Patching, cold compresses, lubrication
2. Anesthetic eye drops to relieve pain
3. 12-36 hour recovery period
4. Permanent scarring is rare; Long-term exposure may permanently thin the surface layer of the cornea, reducing the eye's natural defense mechanism

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Eye Fun Facts:

- You blink every 2-10 seconds. As you focus on each word in this sentence, your eyes swing back and forth 100 times a second; every second the retina performs 10 billion computer-like calculations.
- The human eye can perceive more than 1 million simultaneous visual impressions and is able to discriminate among nearly 8 million gradations of color.
- Having two eyes instead of just one provides us with stereo vision and depth perception. Each of our eyes views an object from a slightly different angle. Our brains put the different images together into one three-dimensional image.
- The iris of the eye provides better identification than a fingerprint. A scan of the iris has 256 different unique characteristics. A fingerprint has only 40 (LWW.comInsider - December 2001).