Chemical Injuries to the Eye

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Case Report

A 70 year old male presents in 2010 with mild epiphora, foreign body sensation, and some discomfort to his right eye due to an alkali burn when he was fifteen years old. On exam his best corrected visual acuity was count fingers with eccentric viewing at one foot in the right eye and 20/20 in the left eye. Intraocular pressure readings were 28mm of Hg in the right eye and 20mm of Hg in the left eye. In addition to his alkali burn, his past ocular history was remarkable in the right eye for three failed penetrating keratoplasties (PK), cataract extraction with intraocular lens, and a glaucoma shunt. Slit lamp examination revealed in the right eye a failed graft with complete pannus, corneal scarring with large central band keratopathy, neovascularization, and a tube shunt in the anterior chamber. All structures in the left eye were noted as normal. Topical eye medications being used in the right eye were two drops of prednisolone as needed, one drop of timolol daily, and erythromycin ointment to be applied four times a day.

After several follow up appointments and worsening vision to hand motion OD, the patient underwent a repeat PK and concurrent conjunctival-limbal autograft from the left eye to provide stem cells for the right eye. His post-operative course was notable for persistent epithelial defect, presumably due to insufficient stem cells. This is a typical scenario for patients with chemical eye injuries. This paper will address the clinical features and management of such injuries.
Discussion

A chemical burn is injury and destruction of human tissue caused by exposure to a chemical, usually by direct contact with the chemical or its fumes. Chemical burns can occur in the home, work, or school, and as a result of accident or assault. Although injuries do occur at home, the risk of sustaining a chemical burn is much greater in the workplace, especially in businesses and manufacturing plants that use large quantities of chemicals. (1)

Chemical injuries represent 7-10% of eye injuries. About 15-20% of burns to the face involve at least one eye. While many burns result in only minor discomfort, every chemical exposure or burn should be taken seriously. Permanent damage is possible and can be blinding and life-altering. (3, 4) Chemical exposure to any part of the eye or eyelid may result in a chemical eye burn. Damage is usually limited to the anterior segment of the eye, particularly the cornea, the conjunctiva (the thin mucous membrane that lines the eye), and the sclera or white of the eye. Deeper structures inside the eye such as the lens which helps to refract light may also be affected. (4)

Most chemical burns are caused by either strong acids or strong bases such as hydrochloric acid or sodium hydroxide. Prolonged exposure can severely damage human tissues due to inflammation, which ultimately leads to scarring and disability. Other chemicals like oxidants and certain metals may also produce similar chemical burns. Limiting the time of exposure to any of these chemicals can greatly reduce their damaging effects. (1) A chemical burn
of the cornea and surrounding tissues is an emergent situation requiring immediate irrigation at the site of injury. Chemical burns to the eye can be divided into three categories: alkali burns, acid burns, and irritants.

Alkali burns are the most destructive to ocular tissues because bases liquefy cells (thus no barrier to further injury). Alkalis, chemicals that have a high pH, penetrate the surface of the eye and can cause severe injury to both the external structures like the cornea and the internal structures like the lens. Acid burns result from chemicals with a low pH and are usually less destructive to ocular tissue as the acid coagulates the cells thus reducing penetration into the eye. The exception is a hydrofluoric acid burn, which is as dangerous as an alkali burn. Acids usually damage only the very front of the eye; however, they can cause serious damage to the cornea and also may result in blindness. Irritants are substances that have a neutral pH and tend to cause more discomfort to the eye than actual damage.\(^3,^4\)

Mild to moderate chemical burns may show signs of slight epithelial defects to areas of complete epithelial loss, conjunctival chemosis and/or hemorrhage, anterior chamber reaction, and swelling of eyelids. Moderate to severe burns show signs ranging from corneal edema to opaque corneal tissues, severe chemosis, and a poor or no view of the anterior chamber due to corneal haze. Intraocular pressure may be low, normal, or elevated in acute stages resulting in glaucoma. Pain, foreign body sensation, and a true loss of vision can signify a very serious burn.\(^2\)

Two major classification schemes for corneal burns commonly used in daily practice are the Roper-Hall (modified Hughes) classification and the Dua classification. The Roper-Hall classification is based on the degree of corneal involvement and limbal ischemia. The Dua
classification is based on an estimate of limbal involvement (in clock hours) and the percentage of conjunctival involvement. Each classification scheme has a grading system that evaluates or predicts the prognosis from good to poor of the involved ocular structures. In a randomized controlled trial of acute burns where burns were graded similarly under both systems, the Dua classification was found to be superior to the Roper-Hall in predicting outcome in severe burns.\(^{(5)}\)

**Treatment**

For all chemical injuries, the patient should immediately irrigate the eye copiously with water and continue with irrigation for at least twenty minutes before seeking medical attention. Once at the clinic or emergency room, irrigation with normal saline is usually continued at least another thirty minutes. The Morgan Lens is the most effective method of ocular irrigation. It delivers continuous flow of solution to the injured eye within seconds, freeing medical staff to treat other injuries or transport the patient without interruption. A strip of pH paper may be used to determine the chemical involved by placing the indicator paper in the fornix; resume irrigation if the pH is not neutral (pH should be between 7.3 and 7.7).\(^{(4,7,8)}\)

**Figure 1.** Morgan Lens consisting of a molded lens with attached tubing and adaptor. (Photograph by Teresa Spohnholz)
Treatment includes a thorough search of the eye for foreign particles, debridement of necrotic tissue, along with topical steroids, cycloplegics, and anti-glaucoma agents for the first two weeks. After two weeks, steroids must be used with caution because they inhibit re-epithelialization. Ascorbate (vitamin C) and citrate drops are useful in moderately severe burns but are not very effective for preventing corneal melting in patients with severe burns or persistent corneal epithelial defects. However, doxycycline can be used to decrease collagenase activity. If symblepharon formation occurs, the adhesions between tissues may be broken by sweeping the fornices with a cotton stick or glass rod under topical anesthetic. \(^{(3,7)}\) This must be done daily until the inflammation subsides and permanent adhesions are prevented.

There are several treatment options available for corneal exposure and persistent epithelial defects. Nonsurgical treatment consists of artificial lubricants, tarsorrhaphy, and/or a bandage contact lens. For progressive corneal melting or perforation, surgical options such as penetrating keratoplasty, limbal stem cell transplants, or amniotic membrane graft may be necessary. It is important to achieve an uninflamed, stable ocular surface prior to penetrating keratoplasty. Limbal stem cell transplantation via conjunctival-limbal autograft from the fellow eye may be performed prior to PK for this purpose. The procedures may be staged or performed simultaneously, but the patient in our case, at age 72, had a repeat penetrating keratoplasty with amniotic graft in 2012 that subsequently failed, and months later required limbal stem cell transplant because of a persistent epithelial defect resulting from the absence of sufficient stem cells to repopulate the epithelium overlying the graft. \(^{(2,7)}\)

Amniotic membrane can be used in cases of partial and total limbal stem cell deficiency. Amniotic membrane is the innermost layer of the placenta and consists of a thick basement
membrane similar in composition to the conjunctiva and an avascular stromal matrix. Amniotic membrane transplants can be surgically attached to the ocular surface by absorbable or non-absorbable sutures. Stem cells for the cornea reside at the corneoscleral limbus. Stem cells have certain unique characteristics, which include longevity, high capacity of self-renewal with a long cell cycle time and a short S-phase duration where chromosome replication and transmission occur, increased potential for error-free proliferation, and poor differentiation. Limbal stem cells also act as a "barrier" to conjunctival epithelial cells and normally prevent them from migrating on to the corneal surface. Under certain conditions, however, the limbal stem cells may be partially or totally depleted, resulting in varying degrees of stem cell deficiency with resulting abnormalities in the corneal surface. Such deficiency of limbal stem cells leads to "conjunctivalization" of the cornea with vascularization, appearance of goblet cells, and an irregular and unstable epithelium. This results in ocular discomfort and reduced vision. Partial stem cell deficiency can be managed by removing the abnormal epithelium and allowing the denuded cornea, especially the visual axis, to resurface with cells derived from the remaining intact limbal epithelium. In total stem cell deficiency, autologous limbus from the opposite normal eye or homologous limbus from living related or cadaveric donors can be transplanted on to the affected eye. Heterologous limbal stem cell transplant is not common because powerful immunosuppressants are required to prevent rejection and these often have severe side effects and require careful monitoring. \(^{(6)}\)

**Management**

After seeing the ophthalmologist within the first 24 hours of being treated for a chemical burn to the eye, continuing care is then determined by the ophthalmologist. Neovascularization, the destruction of goblet cells, and subsequent dry eye are significant problems resulting from
chemical injuries to the eye. The use of chronic lubrication, topical steroids, and autologous serum tears are essential for maintaining a healthy ocular surface. The patient in our case sustained a serious chemical injury and has been checked routinely. At the patient’s last follow up, his vision improved to 20/400 with 90% healed epithelium and no signs of graft rejection. When the epithelium is fully regenerated, his risk of graft infection and melting will decrease significantly. If the patient’s ocular surface stabilizes as a result of the stem-cell transplant, he may have useful vision for many years. He will, however, need ongoing treatment for dry eye and corneal neovascularization.

Figure 2. Slit lamp photo of right eye showing limbal stem cell transplant with amniotic graft and increased clarity of the cornea after an alkali burn. (Photograph by Teresa Spohnholz)
Stem cell transplants offer hope to the thousands of people worldwide every year who suffer chemical trauma to the eye. Postoperative management of patients who undergo limbal stem cell transplantation is one of the most important factors that determine the success rate and outcome. Ocular surface health depends on a stable tear film which can greatly influence the outcome of stem cell transplantation. Chemical eye injuries can be avoided by wearing safety glasses when working with hazardous materials and by keeping products that contain dangerous chemicals out of reach from children.

References


