Chemical Injuries of the Cornea
Nicholas Colatrella, OD, FAAO, Dipl AAO, ABO, ABCMO
Jeffrey R. Varanelli, OD, FAAO, Dipl ABO, ABCMO

Case 1 Presentation
58 yo WM Dennis L.
- OS blurry and painful but more comfortable today
- pH = 7
- VA cc 20/100 PH 20/40
- L/L, erythema and edema
- Conj = 2-3 + inj
- Defect inferior
- Cornea OS- 95% Epithelial defect w sloughed tissue along edges
- Approx 1/3 limbal involvement
- OD clear
- A/C view hazy but appreciable cell
- Iris details somewhat visible
- Fundus – difficult views appears intact
- T(a) 14

Disclosures
- Allergan Pharmaceuticals Speaker’s Bureau
- Bio-Tissue
- BioDLogics, LLC
- Katena/IOP
- Seed Biotech
- Johnson and Johnson Vision Care, Inc.
- Shire Pharmaceuticals

Case 1 Presentation
58 yo WM Dennis L.
- Was working in IA (consultant) helping to fix a pipe at a laundry facility and got NaOH in OS.
- Wears glasses but took off to see pipe better.
- No safety glasses
- Immed flushed eyes.
- Went to Medical clinic in Iowa and flushed eyes there
- Gave Vigamox but lost
Corneal Epithelium
- 5-6 cell layers thick
- Non-keratinized stratified squamous cells
- No goblet cells
- Conj epithelium consists of stratified columnar epithelium with numerous goblet cells
- Rapidly renewing tissue which loses its surface cells into tear film
- Turnover 4-6 days
- Maintains smoothness of optical surface
- Barrier against micro-organisms
- Maintains deturgescence of stroma
- Regulates metabolic activity of stromal keratocytes
- At limbus thickens to 10 cell layers
- Basal epithelial cells of the limbus

Limbal Stem Cells
- Basal cells lie deep in thickened epithelial cell layer (protected)
  - Tightly attached to underlying BM
  - Rich network of blood supply
  - “Limbal palisades of Vogt”
- Limbal Stem Cells
- Undifferentiated cells which serve as an important source of new epithelium
- Make up 5-15% of cells at limbus and reside in this basal layer

Epithelial Regeneration
- Centripetal and circumferential movement of cells from the peripheral cornea responsible for post traumatic healing
  - Adjacent cells will fill in small defects
  - Limbal cells are called in to fill in large defects
  - Moving centrally at rate 17um/day
- Central defects heal by migration .69-1.46 mm²/hr
- Large defects heal at a faster rate due to increased mitotic activity of TAC
- If complete loss of stem cells and conj regen is required it will be greatly prolonged
- Conjunctival stem cells are located in the fornices region and migrate in a centripetal fashion away from fornices to cover bulbar and tarsal conj

Anatomy
- Corneal Stroma
  - Collagen constitutes 80% of stroma
  - Keratocytes are pluripotential cells of neuroectodermal origin
  - Primarily for maintenance and regeneration of stroma
- Capable of wide variety of fibroblastic activity
- Phagocytosis of collagen fibrils
- Secretion of collagen
- Glycosaminoglycan ground substance
- Collagenase (MMP) and collagenase inhibitors
- Keratocytes are usu static and inactive w/ no appreciable synthesis of collagen or collagenase, unless trauma
- Metabolic function of keratocytes regulated by cytokines from epithelium, inflammatory cells and other keratocytes
- Mobilized from adj areas to repopulate damaged area
- Migration begins on endothelial side
- Keratocyte synthesis of collagen requires ascorbate from the aqueous
- CA-44 typically secretes but damaged by increasing pH

Etiology of Chemical Burns
- Ocular burn injuries
  - Radiant (thermal, UV)
  - Chemical (acid, alkali) – True Ocular Emergency
- Epidemiology
  - Eye injuries account for 4-7% of workplace injuries
  - 84% are chemical burns
  - Location of Chemical Injuries
    - Work place injuries (66%) • Safety glasses are no match for strong chemicals under high pressure
    - Construction sites
    - Chemical plants
    - Machine factories
    - Home-based injuries (33%) • Most serious injuries by lime and drain cleaners
  - School based (1%) • Safety glasses helpful
Etiology of Chemical Burns

- **Incidence**
  - 30 per 10,000
  - 82.91% men
  - Occurring in prime of life 16-45 years
  - 90% accidental
    - Alkali make up majority of accidents – 2x acids
    - Automotive battery acid burns are increasingly common – during recharging of lead-acid storage battery (25% sulfuric acid, hydrogen and oxygen gases)
  - 10% intentional
    - Most occurring as a results of assault
      - ½ were chronic alcoholics
        - 32% intoxicated at time of admission

- **Occurring in prime of life** 16-45 years
- **90% accidental**
- **Alkali make up majority of accidents – 2x acids**
- **Automotive battery acid burns are increasingly common** – during recharging of lead-acid storage battery (25% sulfuric acid, hydrogen and oxygen gases)
- **10% intentional**
- **Most occurring as a results of assault**
- **½ were chronic alcoholics**
  - 32% intoxicated at time of admission

- **Luckily most chemical injuries are mild with a good prognosis**

Chemical Injuries of the Cornea

- **Acid- low pH**
- **Alkali- high pH**
- **Irritant- neutral pH**
- **Surfactants – detergents – neither acid or alkali**
  - Cationic, anionic, nonionic, zwitterionic
  - BAK
  - Liquid dishwashing detergent

- **Modifying factors**
  - Duration of contact
  - Solution pH
  - Solution quantity
  - Solution penetrability

- **Irreversible Damage**

Acid Burns

- **Intact corneal epi** affords moderate protection against penetration of dilute or weak acids
  - Little damage seen unless pH < 2.5
  - Acids bind to corneal proteins and act as chemical barrier
  - Severe damage if epi removed
  - Cause protein coagulation in corneal epithelium
    - Also acts as barrier
    - Ground glass appearance
    - Usually non-progressive and superficial
    - Hydrofluoric acid is exception
      - Fluoride ion penetrates stroma
      - Acts as alkali

- **Rates of penetration**
  - Sulfuric Acid - slowest
  - Hydrochloric acid - fast
  - Sulfurous acid – fastest

Alkali Burns

- **Substances that have basic pH**
- **More severe than acid burns**
  - As pH rises, emulsification of lipids in cell membranes occurs
  - Destroying barriers to penetration facilitating deeper penetration to Ant Segment
  - **Injurious effect on stroma involves:**
    - Temporary binding of alkali cations to corneal mucoproteins and collagen
    - Rapid destruction of corneal mucoproteins
    - Hydration of glycosaminoglycans results in stromal haze
    - Increasing as the pH is raised above 11.5
  - **Lipophilic**
  - Penetrate more rapidly than acids
    - Detectable levels in A.C. in seconds to minutes
    - Once external pH is restored to normal can take 30 min - 3 hr to neutralize Alk. Depending on penetration
    - Collagen fibril distortion and shortening, leading to trabecular meshwork alterations
    - Inflammatory mediators released stimulate the release of prostaglandins

- **Low pH**
  - Sulfuric acid
  - Sulfurous acid
  - Hydrochloric acid
  - Nitric acid
  - Acetic acid
  - Chromic acid
  - Hydrofluoric acid
- **3 most common**
  - Calcium Hydroxide Ca(OH)₂ (Lime)
    - Found in plaster, sweep fornix
    - Superficial opacification of cornea
  - Sodium hydroxide NaOH (Lye)
    - Found in drain cleaners
    - Pearly opacification of deep stroma
  - Potassium hydroxide KOH (Caustic Potash)
    - Found in household cleaners
    - Deep tissue injury, corneal edema,endo damage, cataracts
- **Fireworks - Combined chemical and thermal injury**
Alkali Burns

- Cause saponification of cell membrane fatty acids
- Stimulates inflammatory response

Liquefactive necrosis

- Rates of penetration
  - Calcium hydroxide (Lime) - slowest
  - Potassium hydroxide (Caustic Potash) - faster
  - Sodium hydroxide (Lye) - even faster
  - Ammonia hydroxide (Ammonia) - fastest
    - Found in aqueous in 5 sec of contact

Causative Agents - Irritants

- The following liquid products are harmless to the eye:
  - bubble bath
  - cosmetics, deodorant
  - foods (e.g. lemon juice)
  - hair conditioner, hair spray
  - hand lotion
  - laundry detergent (liquid)
  - medications
  - shampoo
  - shaving cream
  - soap
  - sunscreen
  - toothpaste

- The following substances will cause transient irritation:
  - hydrogen peroxide
  - rubbing alcohol
  - vinegar

- Mace and pepper spray are used in personal protection devices. Eye exposure results in marked eye pain and tearing. Usually these symptoms subside in 30 minutes and there is no lasting damage.

Causative Agents – In the home

- Fish bile has been shown to cause 14% of ocular chemical burns in Norway
- In India severe ocular alkali burns have occurred as a result of bursting of chuna packets (edible calcium hydroxide paste), a popular additive to chewing tobacco in India
- In 2009 40% of chemical burns involving children’s eyes under 5 years old were because of washing detergent capsules
  - The liquid detergent is a mixture of three active agents
    - anionic detergent (20-30%)
    - non-ionic detergent
    - cationic surfactant
dissolved in water to give an alkaline solution

Causative Agents – Self inflicted

Treatment - Irrigation

- Irrigation
  - Tetracaine
  - Lid speculum
  - Physiological saline
  - Tap water better?
  - Borate buffer (greater reduction in aqueous pH)
  - Amphoteric substances (Diphoterine or Previn solutions)
    - Available at many workplaces and hospitals, esp Europe
  - Paracentesis and reformation of the anterior chamber with phosphate buffer if w/in 15 min, not after 30 min
**Treatment - Irrigation**

- Time is of the essence with chemical injuries
- Always recommend immediate irrigation.
- The longer hazardous materials remain in the eye, the more severe the damage.
- Irrigate with water under low pressure for 15 minutes.
- Use the best option that is immediately available.
  - A sink faucet
  - Hose without a spray nozzle
  - Shower to flush both eyes at the same time if needed.
- Try to keep the water tepid or at room temperature.
- Do not delay irrigation for contact lens removal.
- Contacts can be removed after irrigation.

**Exam**

- Only after irrigation and neutralization of pH should an examination be performed
- Inspect and sweep inferior and superior fornices
  - Cotton swab / Glass rod
- IOP
  - Digital
  - Tonopen
  - iCare
- Check MSDS
  - www.msdsonline.com
- Local poison control center
  - www.aapcc.org
  - 1-800-222-1222

**Limbal Ischemia**

- Blanching of the vessels at the limbus
- Injected is good
- White is bad

**Classification Schemes**

- Original classification scheme by Hughes et al. 1946
  - Based on clinical findings during acute phase
- Modified by Thoft 1979
  - Divides chem injuries into 4 categories
- Pfister in 1983
  - Mild, mild-mod, mod, severe, very severe
- Bagley et al. 2006 classification scheme by
  - Depth of corneal injury
  - Involvement of corneal endothelium

Across the pond
- 1964 Ballen
- 1965 Roper-Hall
- 2001 Dua - 6 Grades / conjunctiva
**Classification Schemes**

- Determine extent of damage to corneal epithelium, limbus, and conjunctiva
- Determine presence or absence of limbal ischemia
- Depth of penetration
- Toxicity of substance
- Determine quality of view through cornea
- Gauge ultimate prognosis

Grade I
- Involves corneal epithelium only
- Limbal stem cells spared
- Cornea remains clear
  - Epithelium denuded
  - No opacity
  - No limbal ischemia
- Prognosis: Excellent for full recovery of normal corneal appearance and function

Grade II
- Partial loss of limbal stem cells
- Focal limbal ischemia
  - < 1/3 of limbus
- Cornea is hazy, but anterior segment structures are visible
- Prognosis: Good
  - Concerns:
    - Persistent epithelial dysfunction
    - Conjunctivalization
    - Haze
    - Neovascularization

Grade III
- Extensive limbal ischemia
  - 1/3 to 1/2 of limbus
- Loss of most limbal stem cells
- Stromal haze limits visualization of iris and lens
- Prognosis: Guarded
  - Surgery needed for visual rehabilitation

Grade IV
- Complete loss of corneal epithelium and limbal stem cells
- Loss of proximal conjunctival epithelium
- Opaque cornea
  - No view of iris or pupil
  - Porcelainization
- Limbal ischemia (more than 50%)
- Ischemic necrosis of proximal conjunctiva and sclera
- Prognosis: Extremely poor
  - High risk for sterile ulceration and corneal melt
  - Even with most aggressive tx limbal stem cell death most likely too advanced

Grade IV
McCulley et al divided the clinical course into 4 distinct phases

Immediate (Day 0)
- Grades I-IV (V and VI)

Acute (Days 1 to 7)
- Intermediate/early repair (Days 7 to 21)
- Late repair (After day 21)

Epithelial regrowth begins
- Keratocyte activation begins in response to injury
  - Allows initiation of collagen synthesis
  - Little or no collagen breakdown occurs
  - First wave of cell infiltration occurs
  - Decrease inflammation

Avoid topical medications damaging to epithelium

Continuation of epithelial migration
- Re-epithelialization – Grade I
- PED – Grade II
- Delayed in Grade III
- Non-existent Grade IV
- Epithelial surface inflammation may be present
- Dissociated collagen and collagenase production

Collagen breakdown vs. collagen synthesis
- Dictates potential for corneal melting
- Goals: maximize collagen synthesis and minimize collagenase activity

Second wave of inflammatory cell infiltration
- Important in Grade II/III to hit early with Pred
- Debridement Grade IV

Grade 4 alkali burn 10 days after initial injury. Cornea is beginning to show some clearing centrally, however, a significant epithelial defect and ocular surface inflammation remains

- Clinical suspicion of a confirmed total limbal stem cell loss should develop by the end of the early repair phase if there is no epi inside limbus

Encourage epithelial healing
- proper corneal phenotypic transdifferentiation
- Augment Collagen synthesis while minimizing collagen breakdown
- Sterile ulceration
- Control 1st and 2nd wave of inflammation
- Prevent infection

Epithelial recovery will be slowed due:
- persistent inflammation
- enzymatic products of degranulating PMN leukocytes
- stimulation of keratocyte collagenase by leukocyte cytokines

Corneal stromal inflammation persists as long as the epithelial defect remains, or as long as necrotic conjunctival tissue provides a foci of inflammatory infiltration

all contribute toward sterile enzymatic digestion of the corneal stroma during 2-3 post injury weeks

Grade IV: poor prognosis, eyes usually not saved
- Continued absence of epithelium from cornea and conj
- Continued evidence of proximal conjunctival and limbal ischemia and necrosis
- Progressive sterile enzymatic destruction may have already been initiated in the early repair phase
- Evidence of anterior segment necrosis, retroconjunctival membranes, PAS, cataracts, GLC, hypotony and phthisis bulbi
Inflammation Control

- First Wave occurs 12-24 hours after chem injury with infiltration of peripheral cornea with PMN and mononuclear leukocytes.
- Resulting from:
  - Blood elements from injured vessels in conj and uvea
  - Necrotic tissue of bulbar and tarsal conj
  - Chemotactically attracted byproducts of epi and stromal tissue
- Second, more aggressive wave of inflammatory cell infiltration begins at 7 days and peaks when corneal repair and degradation are maximal (bet 14-21 day)

Prompt debridement of necrotic bulbar and tarsal conj tissue eliminates source of infiltration on enzymatic signals

Aggressive Tx of 1st wave infiltration is imperative to dec incidence of corneal ulceration & Pv 2nd Wave

Corticosteroids help by:
- Reduce cell infiltration and stabilize PMN membranes
- Know SE of Interfere w stromal wound repair by impairing keratocyte migration and collagen synthesis
- Key to successful use is to maximize their antiinflamm effect during 1st 7-10d when risk-benefit favorable

Progesterational steroids – 1% topical medroxyprogesterone
- Medroxyprogesterone Acetate 0.5% or 1% Ophthalmic Suspension - less potent but min effect on stromal repair & collagen synthesis

10% Ascorbate – Topical Vit C
- Ascorbic Acid 10% Ophthalmic Suspension $87.85/10ml

10% Citrate – Topical – Calcium chelator
- Sodium Citrate 10% Ophthalmic Solution $69.10/10ml

TCN / DCN
- Autologous Serum
- N-Acetylcysteine (Mucomyst)
- Acetyl Cysteine 5-20% Ophthalmic Solution $77.95-97.70/10ml
- Oral NSAID

Oral NSAID
- 4th generation FQ

Topical sodium ascorbate 10% and Citrate
- oral vitamin C ? Limited value
- Oral tetracycline
- Preservative free tears
- Glaucoma meds as needed
- Systemic Diamox / Neptazane
- Topical NSAIDs and BCL?

Grade I Medical Management

- Antibiotic ointment QID
- Cycloplegia for comfort
- Preservative free tears
- Topical corticosteroids when epithelium healed
  - prednisolone acetate 1% QID with taper
- Follow up every 1-2 days
- Supportive therapy to ocular surface

Grade II – III Medical Management

Control inflammation
- Intensive topical corticosteroids x 1wk then hold off x 1mo
  - prednisolone acetate 1% hourly/ Durezol q2h
- Other considerations
  - Cycloplegia
    - Do not use phenylepherine and other adrenergic drugs should not be used, owing to their vasoconstrictive action leading to the worsening of limbal ischemia
  - Oral narcotics
  - Oral NSAID
  - 4th generation FQ
  - Topical sodium ascorbate 10% and Citrate
  - oral vitamin C ? Limited value
  - Oral tetracycline
  - Preservative free tears
  - Glaucoma meds as needed
  - Systemic Diamox / Neptazane
  - Topical NSAIDs and BCL?
**Grade II – III Medical Management**

- Topical NSAIDs and BCL have limited benefit
- There is little role for topical non-steroidal agents in a severe chemical injury. Their anti-inflammatory power is dwarfed by that of the recommended topical corticosteroids and they have the potential to cause issues with epithelial healing.
- Bandage contact lenses are of marginal utility in the acute management of chemical burns, as the eye is usually too inflamed to tolerate a foreign body on its surface and does not cover the defect.

**Medical Management**

- **Autologous Serum**
  - Use first described in 1984 by Fox et al
  - Unpreserved, non-antigenic
  - Utilizes patient's own blood serum
  - Blood is drawn and serum is spun down and mixed with artificial tears.
  - Doesn't contain red blood cells and clot factors
  - Replaces individualized antibodies

- **Umbilical Cord Serum**
  - Compared to AS, UC serum
  - Higher concentration of essential tear components
  - Many growth factors such as Epidermal Growth Factor, Vitamin A, and Transforming growth factor-β, and neurotrophic factors such as Substance P, insulin-like growth factor-1, and nerve growth factor
  - Study - by month 3, the extent of limbal ischemia with cord serum showed dramatic improvement
  - Serum and artificial tears, respectively (P = 0.008). More patients had clear corneas with cord serum compared with autologous serum and artificial tears (P = 0.048).

- **PTK**
  - Study of rabbit corneas treated with HCl and NaOH exhibited immediate epithelial defects that slowly healed over time.
  - In PTK-treated corneas, the re-epithelialization rate was accelerated compared with that of controls.
  - After corneal chemical damage, 193-nm excimer laser PTK accelerates epithelial wound healing.

**Surgical Management**

- If epithelial healing falters or comes to a complete halt or progressive corneal melting occurs, then surgical maneuvers recommended
  - Therapies
    - Debridement
    - Cyanoacrylate
    - Perforation seal
    - RGP's
    - Augmented tenoplasty
    - PTK
    - Tenoplasty
    - AMT
    - LSCT
    - PK
  - Avastin for corneal neo
  - Keratoprosthesis
  - Simple mask O2 therapy

**Hard Contact Lens**

- Glued to stroma
- Serves as artificial epithelium and protects cornea from early complications
- Helps prevent conjunctivization
- Avoids keratoplasty
**Surgical Management**

- Amniotic membranes
  - Innermost of 3 membranes forming the fetal membrane
  - Translucent membrane composed of an inner layer of epithelial cells, basement membrane that is connected to a thin connective tissue membrane by filamentous strands.
  - Avascular and acellular. It will facilitate epithelial healing acting as a basement membrane
  - Combined action with other cytokines is supposed to stimulate epithelialization and SC proliferation
  - Acts as barrier for efflux of immune cells giving anti-inflammatory properties
  - Reduces intolerable pain
  - Temporizing measure for LSCT and inhibit fibrosis
  - Does not re-establish the ocular surface or prevent ulceration in severe burns

**Sutureless Amniotic Membranes**

- Easy to insert in the office, bed side, and OR
- Monitor healing by fluorescein and IOP by Tonopen™ without removal
- Does not interfere with antibiotic penetration

**Available Sutureless Membranes**

**Tape-sorrhaphy**

- A tape over the lid crease. Narrows the eye opening, Keeps ProKera centered, and Minimizes discomfort

**Surgical Management**

- Limbal Stem Cell Transplantation
  - Involves harvesting two crescents of peripheryal limbal epidermal equivalent
  - Involves harvesting two crescents of peripheryal limbal epi w corresponding sec of conj from the limbus
  - Autologous - autograft
  - Close relative - allograft
  - Expand in culture in vitro
  - Success is dependent on medical control of inflammation
  - Can be performed as early as 3 weeks after injury
  - Only technique available to re-establish a normal corneal phenotype
  - Re-establishment of intact epi is also an effective means of minimizing ulceration

**Grade IV lime burn (a)** At presentation, right eye had total limbal ischemia, 100% epithelial defect and superior conjunctival necrosis (b) After 2 months of AMT granulomas pyogenicum, PED, corneal vascularization, and symblepharon were noted.
Keratoprosthesis
- Artificial corneas approved for use in the United States
  - AlphaCor® artificial cornea
  - Dohlman-Doane or Boston Keratoprosthesis (Boston KPro).
  - Oculaid Keratoprosthesis

Ocular Sequelae
- Advanced glaucoma
- Eyelid destruction
- Synechiae
- Cicatricial entropion - months
- Ectropion
- Ankyloblepharon
- Descemet membrane detachment
- Retinal detachments

Case 1 Presentation
58 yo WM Dennis L.
- Dx – Grade II Alkali burn of cornea and conjunctiva
- Plan – debride loose tissue
  - Vigamox Q4h OS
  - Pred Forte Q1h OS
  - Atropine BID OS
  - Ciloxan ung QHS OS
  - NP Art Tears Q1h OS
- NO topical NSAID or BSCL
- Rx topical citrate and ascorbate through compounding pharm

Case 1 Presentation
58 yo WM Dennis L.
- Day 1
  - OS blurry and painful but more comfortable today
  - pH = 7
  - VA cc 20/200 PH 20/40
  - L/L erythema and edema
  - Conj – 2-3+ inj –
    - Defect inferior
  - Cornea OS 95% Epithelial defect w sloughed tissue along edges
  - Appropriate limbal involvement
  - OD clear
  - A/C view hazy but appreciable cell
  - Iris details somewhat visible
  - Fundus – difficult views appears intact
  - T(a) 34

Alternative Treatment Options
- Study by Sharifipour et al
- Looked at oxygen therapy vs. conventional therapy
- Main outcome measures:
  - improve perilimbal ischemia
  - healing time for epithelial defect
- Secondary outcome measures:
  - VA
  - corneal transparency
  - vascularization
  - complications


Hypopyon and corneal epithelial defect following acid chemical burn.
Case 1 Presentation

58 yo WM Dennis L.

- Day 8
  - Unable to come in at last visit
  - Eye bothers pt more in AM than PM
  - Certain moments it will hurt.
  - VA cc 20/50 PH 20/40
  - Ta = 9mmHg
  - Corneal defect closed in 360 leaving residual central defect. Descemet fold and haze noted in stroma
  - CPM. Cut Pred to BID RTO 2 day

- Day 16
  - Went out of town. Unable to come in last week.
  - Vision seems to be improving
  - VA cc 20/80 PH 20/50
  - Ta = 20mmHg
  - Corneal defect finally resolved. Haze noted in stroma
  - D/C Atropine, D/C Vigamox
  - Cont Ciloxan ung TiD, tears q1h, inc PF QID
  - RTO 7 day

Case 1 Presentation

58 yo WM Dennis L.

- Day 60
  - Feeling better. Vision definitely better.
  - VA cc 20/25 PH 20/20
  - MR -0.50 -0.75 x 90 20/20
  - Ta = 14mmHg
  - Punctate keratopathy. Inf nasal stromal scar
  - D/C Ciloxan ung Cont Refresh PM BID tears q4h, PF QD
  - Plugs for PED

Summary

- Its impossible to over-irrigate
- Debride necrotic conjunctival tissue immediately
- Properly control stromal inflammation and institute immediate medical management
- Address persistent limbal stem cell dysfunction early
- Avoid agents that are harmful to delicate epithelium (ie BSCL and NSAID)

Medical Management

- Topical Pred Forte Q1h or Durezol Q2h x 7 d then taper & switch to
  - 1% topical medroxyprogesterone QID
  - 1% Atropine QD
  - Zymaxid / Moxeza / Besivance QID
  - Amniotic Membrane by day 3
  - Non Preserved artificial tears q1h
  - 100mg Doxycycline BID PO
  - 500 mg Diamox BID PO
  - Ultram 100mg PO q4-6h
  - Topical 10% ascorbate and 10% Citrate Q2h

Thank you

Please feel free to contact us:
Nicholas Colatrella, OD, FAAO, Dipl AAO, ABO, ABCMO
NColatrella@pineconevisioncenter.com
Jeffrey Varanelli, OD, FAAO, Dipl ABO, ABCMO
SECJRVOD@gmail.com