Chapter 10
Eye Infections

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Brief Introduction

Eye complaints account for approximately 1–2% of all ED visits [1, 2]. Eye emergencies can be categorized into three categories: the red eye, the painful eye, and those with associated vision loss. This chapter will focus mainly on eye infections and the most common disorders emergency department physicians need to be suspicious of, diagnose, and rapidly treat upon their presentation. This chapter will discuss the presentation, workup, treatment, and disposition for:

1. Periorbital cellulitis
2. Orbital cellulitis
3. Bacterial conjunctivitis
4. Viral conjunctivitis
5. Neonatal conjunctivitis
6. Contact lens complications (as they pertain to infectious etiology)
7. Herpes simplex virus (HSV) keratoconjunctivitis
8. Herpes zoster ophthalmicus

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9. Corneal ulcer
10. Bacterial keratitis
11. Fungal keratitis
12. Uveitis/iritis
13. Endophthalmitis

Clinical Presentation

Patients present to the ED for eye-related concerns in a variety of ways. The emergency physician must evaluate for threats to life, limb, or eyesight. Common patient eye complaints include double or blurry vision, redness, pain, fever, discharge from the eye, foreign body sensation or foreign body in the eye, vision loss, color vision changes, floaters, and a "dark curtain," as well as redness, tenderness, or swelling of the structures around the eye. This chapter will discuss several common eye infections and disorders.

1. Periorbital cellulitis: Preseptal or periorbital cellulitis is an infection of the tissues anterior to the orbital septum and often presents with lid erythema, warmth to the touch, tenderness, and swelling, as well as low-grade fever (Fig. 10.1). The orbital septum is a thin fibrous membrane that divides the orbital from the preseptal compartments of the eye [1–6]. The Chandler classification system is used to categorize periorbital infections into five groups. This includes preseptal cellulitis as group 1, orbital cellulitis as group 2, and groups 3–5 which encompass subperiosteal orbital abscess, diffuse orbital infection or abscess, and cavernous sinus thrombosis, respectively [4–6]. Common routes for inoculation of pathogens causing periorbital cellulitis include direct inoculation following recent eyelid trauma and insect bites. Inoculation secondary to spread from contiguous structures such as the paranasal (particularly the ethmoid) sinuses, chalazia/hordeolum, impetigo, herpes simplex virus (HSV), and herpes zoster skin infection. Finally, hematogenous spread often secondary to an upper respiratory or middle ear infection can also cause preseptal

FIGURE 10.1 Preseptal cellulitis. Obtained from EyeRounds.Org on 20 Aug 2017

cellulitis [1–6]. Bacteria such as gram-positive cocci, i.e., *Staphylococcus* and *Streptococcus* species, are responsible for the vast majority of infections, and the strain depends on the route of infection. *Staphylococcus aureus* and *S. epidermidis* are common after penetrating injury, whereas *Streptococcus pneumoniae* is most common secondary to sinusitis [4–7]. Although much less common than before the introduction of the *Haemophilus influenzae* type b vaccine, those children under 5 years old who are unimmunized are still at increased risk for infection secondary to those bacteria [7]. Common viruses include adenovirus, HSV, and varicella zoster.

2. Orbital cellulitis: Orbital cellulitis occurs posterior to the orbital septum and involves the soft tissues found within the bony orbit [1, 2, 6] (Fig. 10.2). Again, similar to preseptal cellulitis, this is commonly due to spread from a local infection occurring in adjacent structures (>90% from

Figure 10.2 Orbital cellulitis. Obtained from EyeRounds.Org on 20 Aug 2017

underlying sinus disease). Odontogenic origins of infection are also possible if there is orbital involvement [6]. Both preseptal and orbital cellulitis have periorbital edema and erythema; however, unlike preseptal cellulitis, orbital cellulitis will commonly have proptosis, extraocular movement (EOM) restriction secondary to pain and swelling, diplopia, ophthalmoplegia, pain with eye movement, and patient toxicity on exam [1, 4–6, 8]. There is a greater risk of morbidity and mortality associated with orbital cellulitis as compared to preseptal cellulitis [6]. Bacterial infections in children are often due to a single organism, likely *S. aureus* or *S. pneumoniae* [1, 2, 5, 6]. Infections commonly are polymicrobial in adults and adolescents. The number of bacteria involved ranges from 2 to 5, and common organisms include *Streptococcus* and *Staphylococcus*. In the event of odontogenic etiology, *Peptostreptococcus* is commonly seen. Fungal and *Pseudomonas* infections may occur in immunocompromised patients [4, 6, 8].

3. Conjunctivitis: The spectrum of conjunctivitis encompasses infectious and noninfectious etiologies. Within infectious causes, bacterial, viral, and neonatal all deserve specific discussions. Other infectious causes include parasitic and

fungal but are much more rare. Included in noninfectious are allergic, chemical or toxic, and systemic, among many other causes that do not fall under the scope of this chapter. Conjunctivitis is an inflammation or infection of the conjunctiva and commonly presents with hyperemia, erythema, matting, a gritty or foreign body sensation, as well as edema and discharge from the eye [1, 2, 9–11]. The clinical presentations of bacterial, viral, and neonatal conjunctivitis have significant overlap and are often nonspecific [12, 13]. Visual acuity should be normal, and a recent history upper respiratory infection suggests viral cause. Of the 3% of ED visits related to ocular complaints, conjunctivitis accounts for over 30% [9]. Bacterial and viral are by far the most common etiologies of conjunctivitis with viral being the more common (80%) [14–18] of the two, despite bacterial being more common in children [1, 2, 14–19]. Risk factors for infection include contact with contaminated sources such as fingers, fomites, and oculogenital contact of an infected individual [9, 10, 19–22]. Anything that causes a disruption of the epithelial layer of the eye such as trauma and immunocompromised status also increases risk.

Bacterial conjunctivitis is characterized by an acute onset of symptoms with minimal to no pain and matting of the eyelids in the morning. The most common pathogens in children include nontypeable *H. influenzae*, *S. pneumoniae*, and *Moraxella catarrhalis* [23]. In adults, the most common microbes are *Staphylococcus* and *Streptococcus*, followed by *H. influenzae* [23]. The course lasts approximately 7–10 days [10]. Bacterial conjunctivitis is most prevalent in the months from December to April [19]. Incubation typically ranges from 1 to 7 days, and communicability ranges from 2 to 7 days [9, 10, 19]. Any patient presenting with signs and symptoms of 4 or more weeks has chronic bacterial conjunctivitis, and these patients are most commonly infected secondary to *Staphylococcus aureus*, *Moraxella lacunata*, and enteric bacteria.

Bacterial infections of note are those associated with sexually transmitted infections occurring due to oculogenital spread. *Neisseria gonorrhoeae* should be considered in hyperacute bacterial conjunctivitis, which presents with severe copious amounts of purulent ocular discharge and decreased vision. True *N. gonorrhoeae* involvement places the patient at risk for corneal perforation [10, 24]. Chlamydial conjunctivitis is not uncommon, with a prevalence ranging from 1.8 to 5.6% of cases [17]. Presentation is typically unilateral, and a concurrent genital infection is likely (54% of men and 74% of women) [11, 25]. Patients also present with a purulent or mucopurulent discharge, conjunctival hyperemia, and typically will have mild symptoms for months before presentation. Finally, conjunctivitis secondary to trachoma will be discussed. Trachoma is caused by the subtypes A through C of *Chlamydia trachomatis* and is the leading cause of blindness in the world [25, 26]. Mucopurulent discharge and pain are the most common presenting symptoms. Blindness is a late complication and is due to corneal, eyelid, and conjunctival scarring.

4. Viral conjunctivitis is comprised of two main entities: epidemic keratoconjunctivitis (EKC) and pharyngoconjunctival fever, both of which are typically secondary to adenoviruses (65–90%) and is considered highly contagious with a risk of transmission ranging from 10 to 50% [10, 19, 27, 28]. Incubation typically ranges from 5 to 12 days, and the communicability ranges from 10 to 14 days [9, 10, 19]. Viral conjunctivitis is most commonly seen in the summer. Pharyngoconjunctival fever is characterized by pharyngitis, high fever, preauricular lymphadenopathy (typically bilaterally), as well as bilateral conjunctivitis. EKC typically has unilateral lymphadenopathy and has a more severe presentation with increased discharge and hyperemia. Patients may also have symptoms of a recent upper respiratory infection.

5. Neonatal conjunctivitis, also known as neonatorum ophthalmia, is defined as conjunctival inflammation occurring

in the first 30 days of life and can be secondary to chemical, bacterial, and viral conjunctivitis. Treatment is important due to the potential for permanent scarring and blindness if left untreated. Although chemical conjunctivitis is not covered in depth here, it is important to note that the overall prevalence of chemical causes has decreased significantly since the abandonment of silver nitrate after delivery, making infectious causes much more likely in today's population. Common causes of bacterial conjunctivitis are *Chlamydia trachomatis* (most common), *Neisseria gonorrhoeae*, *S. aureus*, *Pseudomonas aeruginosa*, and *Streptococcus* species. Risk factors include maternal infections encountered during birth, inadequate prophylaxis at birth, premature rupture of membranes, ocular trauma during delivery, poor prenatal care, and poor hygienic conditions during delivery [1, 2, 29]. Chlamydial infections in the United States complicate 4–10% of pregnancies, and those infants of untreated mothers have a 30–40% chance of developing conjunctivitis. Timing of infections with regard to birth is important in the diagnosis of neonatal conjunctivitis. Infectious causes are not expected if less than 24 h of life. *N. gonorrhoeae* infections present 3–5 days after birth, and *C. trachomatis* presents in days 5–14 [1, 2, 29]. HSV can present in the first 1–2 weeks of life, and vesicles are likely present on examination.

6. Contact lens complications: Wearing contacts causes alterations to the eye through several mechanisms including trauma, decreased corneal oxygenation, decreased wetting/lubrication, allergic and inflammatory responses, and infection [30]. Symptom-related complications are no different than those already discussed with regard to the "red eye" and can present within 24 h after onset. Bacterial keratitis accounts for >90% of the infectious causes related to contact lens wearing. *Pseudomonas aeruginosa* is the most common pathogen, followed by *Staphylococcus*, *Streptococcus*, and *Serratia*. Although rare, fungal keratitis caused by *Acanthamoeba* is closely related to contact

lens use [30–33]. A major risk factor for bacterial keratitis in contact lens patients is corneal abrasions [34]. Even without abrasions, contact lenses place the patient at an increased risk, particularly with overnight or extended wear types [35–37]. Rates of infectious keratitis increase with the length of time each contact is used. Rigid lenses pose the least risk, while extended-wear soft lenses pose a 5× increase in risk [38]. Other risk factors include lens hygiene, poor supervision by an eye care professional, smoking, male gender, low socioeconomic status, and young age [39–42].

7. HSV keratoconjunctivitis: HSV involved conjunctivitis comprises 1.3–4.8% of acute conjunctivitis and is usually unilateral upon presentation [15–18]. It is a major cause of blindness secondary to corneal scarring worldwide, and HSV-1 accounts for most ocular infections, although HSV-2 is on the rise [43]. Ocular HSV-1 disease comprises eyelid lesions (herpetic blepharitis), conjunctivitis, keratitis (most common), retinitis, and rarely scleritis [44]. This most often seen in young adults and typically presents with a thin, watery discharge. Patients also have a foreign body sensation, possibly decreased visual acuity, tearing, and photophobia. On fluorescein exam, a dendritic pattern with terminal bulbs and/or punctate lesions can be seen. Risk factors for infection with ocular involvement include primary infections or recurrences of latent infection. Latent infections tend to involve the same eye [45, 46]. Other risk factors include immunosuppression and ultraviolet light exposure (laser treatment for corneal refractive surgery and environmental). The disease course runs over 1–2 weeks with appropriate treatment.

8. Herpes zoster ophthalmicus: Herpes zoster, the virus responsible for shingles, can also affect the eye. Reactivation of the varicella zoster virus along the trigeminal nerve (CN V) in the ophthalmic division leads to this condition and is present in 10–20% of reactivations [47]. Patients commonly present with painful palpation to the forehead and face, fever, hyperesthesia, redness, and

the typical unilateral vesicular rash. There may be vesicular lesions on the eyelid, particularly if the first and second branches of the nerve are involved. Hutchinson's sign is also seen and indicates that the nasociliary branch of the trigeminal nerve is involved. Eyelids and conjunctiva are involved in patients with shingles, 45.8% and 41.1%, respectively [10, 31]. Patients with zoster can have corneal complications (38.2%) and subsequent uveitis (19.1%) [10, 31]. The typical patient population includes adults >60 years old. Diagnosis and treatment are important to prevent acute necrotizing retinitis associated with the condition [1].

9. Corneal ulcer: Corneal ulcers are considered a type of keratitis and can be large or small, typically round, and are best visualized under slit-lamp examination where edema and a white clouding can be seen. Common causes are overuse of contact lenses. Patients typically present with pain, redness, vision changes depending on the location of the ulcer, and photophobia [1]. Infections associated with corneal ulcers can be bacterial, viral, fungal, or due to *Acanthamoeba* and are discussed further in the keratitis section of this chapter. They can have an acute and rapid presentation or a delayed presentation after a traumatic event. Thorough history usually helps delineate the cause.

10. Bacterial keratitis: Bacterial keratitis is a medical emergency and is often referred to as a "corneal ulcer" due to their strong association. Patients usually have at least one risk factor for the disease, with the predominant risk factor being contact lens wear. As discussed in contact lens complications, overnight wear, poor hygiene, infrequent lens changing, male sex, and low socioeconomic status also increase risk [39–42]. Bacterial keratitis can form in those without risk factors and is typically associated with virulent organisms such as *Neisseria*, *Diphtheria*, and *Listeria* species [48]. Patients will present with symptoms of redness, pain, photophobia, and an objective foreign body sensation, a sign of an active corneal process. Slit-lamp and fluorescein findings include a corneal infiltrate/

opacity with a focal hazy or cloudy appearance to them. Frequently, a corneal ulcer with fluorescein uptake is seen. In severe cases, a hypopyon, a layer of white blood cells in the anterior chamber, may be visible [49–51].

11. Fungal keratitis: Fungal keratitis is a common disease worldwide but is rare in the United States. The incidence varies widely based on the geographic region of the United States. It represents 2% of the keratitis cases in New York and upwards of 35% in Florida [50]. Risk factors for fungal keratitis include trauma, particularly trauma with vegetative material (tree branches, soils, and grasses), soft contact lens use, topical corticosteroid use, and immunosuppression [50]. Patients present with symptoms similar to bacterial and viral keratitis (pain, photophobia, foreign body sensation, and blurred vision) but with a more insidious onset. Patients returning to the ED for a corneal ulcer that has not responded to broad-spectrum antibiotics should raise suspicion. Examination with a slit lamp and fluorescein reveals a corneal infiltrate or ulcer. Fungal corneal infections in the Southern United States (i.e., Florida), the *Fusarium* spp., are the most common cause (45–76%), whereas in the northern states (i.e., New York, North Dakota), *Candida* and *Aspergillus* spp. are more common [50, 52]. Without prompt diagnosis and treatment, there are devastating consequences for patients.

12. Uveitis/iritis: Anterior uveitis describes inflammation of the iris and/or the ciliary body. Inflammation of the iris alone is iritis, while inflammation of the iris and ciliary body is iridocyclitis. Anterior uveitis accounts for over 90% of the patients diagnosed with uveitis and 10–15% of cases of blindness in the United States [53]. Iritis can be caused by a wide variety of inciting events/conditions. Trauma, systemic and ocular infections, autoimmune diseases (adult and juvenile rheumatoid arthritis, sarcoidosis, and ankylosing spondylitis), and immunosuppression are other causes [1]. Ocular infections include keratitis, cytomegalovirus (CMV) retinitis secondary to AIDS [1], and

systemic infections secondary to Epstein-Barr virus, influenza, and syphilis [54, 55]. Patients typically present with severe eye pain but rarely have discharge.

13. Endophthalmitis: Endophthalmitis is a severe infection of the anterior, posterior, and vitreous chambers found within the globe (Fig. 10.3). It is most commonly found after penetrating trauma to the eye but also occurs secondary to hematogenous spread of immunocompromised patients and after routine eye surgery or procedures (cataracts and injections) [1, 56, 57]. Patients present with acute onset painful and red eye with decreased visual acuity and approximately 85% have a hypopyon. Postsurgical and postinjection endophthalmitis commonly present within a week of the procedure, typically symptom-free until about 24 h prior to presentation. Endogenous spread is associated with endocarditis in 40% of patients and can also occur secondary to abscesses, UTI, and meningitis [56]. Common bacteria include *Staphylococcus*, *Streptococcus*, and *Bacillus* [1, 56]. Fungal and mold endophthalmitis, although rare, are typically from an endogenous and exogenous source, respectively. Risk factors for fungal infections include immunosuppression, indwelling central venous catheters, total parenteral nutrition, neutropenia,

FIGURE 10.3 Endophthalmitis. Obtained from EyeRounds.Org on 20 Aug 2017

recent gastrointestinal surgery or perforation, and recent broad-spectrum antibiotics. *Candida* is the main cause [56, 58]. Mold infections (*Aspergillus*) are most typically secondary to penetrating trauma, after eye surgery, or progressing fungal keratitis [56].

Differential Diagnosis

There is a broad differential diagnosis for eye infections, as redness, swelling, and tenderness of the eyelid encompasses a vast differential. The differential for those "red eye" complaints includes cellulitis (septal and preseptal), dacryocystitis, chalazion, hordeolum (stye), dacryoadenitis, anaphylaxis, conjunctivitis, keratitis, and endophthalmitis. Other, more specific eyelid diagnoses include cysts, carcinoma, xanthelasma, papilloma, pyogenic granuloma, retinoblastoma, amyloid deposition, and any skin condition that can be found elsewhere on the body can be found on the eyelid [8, 12, 59]. This chapter will discuss eye infections, but noninfectious etiology must also be considered such as thyroid eye disease, blunt trauma, and autoimmune inflammatory diseases.

Evaluation

A solid understanding of eye anatomy provides a solid foundation for the evaluation of any eye complaint. A thorough evaluation of optic nerve function and ocular motility can provide a vast amount of useful clinical information. The exam should include best-corrected visual acuity, color vision assessment, visual field testing, fluorescein staining with a Wood's lamp exam, papillary function (particularly evaluating for afferent papillary defect), and EOM testing, as well as intraocular pressure (IOP) in the ED [6, 8, 9]. A comprehensive review of systems should be obtained. A history of photophobia, foreign body sensation, and visual changes should be elicited. Screening for trauma, contact lens wear, and any

inflammatory or autoimmune disorders is needed. The specific evaluation and physical exam findings for the specific conditions are as follows:

1. Preseptal cellulitis: Hallmarks of physical exam include periorbital edema and erythema (Fig. 10.1). Warmth to the touch, tenderness, and swelling as well as low-grade fever are also common presenting symptoms. The absence of proptosis, pain with EOM, vision loss, and diplopia is required. Pupillary function as well as color vision should be intact [6]. If any of these are abnormal, then orbital involvement is highly likely. If patients have high fever or if fever is increasing, blood cultures should be obtained [5].

2. Orbital cellulitis: Fever, leukocytosis, afferent papillary defect, proptosis, EOM dysfunction, and vision loss should increase suspicion for orbital involvement and prompt rapid treatment (Fig. 10.2). An afferent papillary defect indicates optic nerve involvement. If orbital cellulitis is high on the differential, then a thin-slice non-contrasted orbital CT scan is the modality of choice, providing information not only on the orbit but surrounding tissue and structures of interest [1, 2, 5, 6, 8].

3. Bacterial conjunctivitis: Both viral and bacterial conjunctivitis can present with either bilateral or unilateral eye involvement. Bacterial conjunctivitis presents with red eye and mucopurulent or purulent discharge, as well as chemosis. Bilateral matting with adherence of the eyelids in the morning and lack of itching is a high predictor for bacterial over viral pathology [19]. See Chap. 6 for picture.

4. Viral conjunctivitis: Patients often report a recent URI when asked. Itching, a slower progression or appearance of symptoms, and a mucoid or watery discharge are more common with viral presentations. Preauricular lymphadenopathy may be present. See Chap. 6 for picture.

5. Neonatal conjunctivitis: Timing is critical in the neonate presenting with concerns for conjunctivitis. Prenatal care, care at delivery (silver nitrate vs. erythromycin), and maternal history (STI's) are also important when examining the

patient. Chlamydial infection can present with mild conjunctival injection and tearing coupled with a mucopurulent discharge and a pseudomembrane [30]. Neisseria infections present more acutely, with sever lid edema and a copious mucopurulent discharge and are the most feared infection in the eye. Any ill-appearing neonate should raise suspicion for systemic illness and should prompt a full sepsis workup. Chemical irritant conjunctivitis is typically seen in the first 48 h of life commonly secondary to silver nitrate as topical prophylaxis. See Chap. 6 for further discussion, as well as for picture.

6. Contact lens complications: Bacterial keratitis, the most common infection related to contact lens use, typically presents with symptoms in 24 h. Most commonly patients present with redness, decreased vision concerns, and photophobia and on exam will have corneal uptake with fluorescein. Patients with keratitis can present with a hypopyon or white blood cells in the anterior chamber. Hypopyon is found more frequently in cases secondary to fungal infection. Other exam findings can be stromal loss, stromal infiltrates, and corneal edema. Stromal infiltrates tend to be yellow in bacterial keratitis and white if fungal in nature [51, 52]. See Chap. 6 for picture.

7. HSV keratoconjunctivitis: This disease presents with edematous and ecchymotic eyelids, and frequently there are eyelid or bulbar conjunctival vesicles or ulcers. On slit-lamp exam, there can be punctate and dendritic lesions [1, 2, 39]. Discharge is typically serosanguinous or nonpurulent. For neonates, vesicles on the skin surrounding the eye and involvement of the corneal epithelium are important to distinguish from other forms of keratitis or conjunctivitis [39]. See Chap. 6 for picture.

8. Herpes zoster ophthalmicus: There may be vesicular lesions on the eyelid if the first and second branches of the trigeminal nerve are involved. Hutchinson's sign (vesicles on the tip of the nose) highly correlates to ocular involvement (76% of patients). Pseudodendritic lesions can be seen on exam with fluorescein [1]. See Chap. 6 for picture.

9. Corneal ulcer: Corneal infiltrates can be seen on either direct visualization or with the aid of a slit lamp and appear as a white opacity on the cornea. Ulcers tend to be round on examination with or without fluorescein. See Chap. 6 for picture.

10. Bacterial keratitis: Patients with bacterial keratitis may or may not have affected vision, but this condition typically produces objective findings of foreign body sensation (inability to keep eye open) and photophobia. The pupil may be miotic at 1–2 mm [34, 38, 39, 49]. On exam, a corneal opacity is frequently seen as well as conjunctival injection. Fulminant cases of keratitis may present with a hypopyon. See Chap. 6 for picture.

11. Fungal keratitis: Providers must have a high index of suspicion for nonbacterial keratitis. A thorough clinical history, clinical exam, and attempting to isolate the specific organism are of the utmost importance. Tropical climates coupled with trauma, no matter how benign appearing, place a patient at increased risk for a fungal infection [52]. Fungal keratitis may demonstrate a feathery edge to the ulcer, whereas a lesion secondary to yeast is more defined. Satellite lesions may also be present and should increase concerns for a fungal infection, as should the presence of a hypopyon. Diagnosis will not be made in the ED, as this requires specialized corneal scrapings/punch biopsy and cultures for confirmation [52, 58]. A corneal defect is typically seen 24–36 h after injury [58]. See Chap. 6 for picture.

12. Uveitis/iritis: On exam, there can be significant conjunctival injection, most prominent at the limbus (aka ciliary flush). There is a lack of discharge, and patients do not usually have a foreign body sensation [49]. The pupil, on exam, can be miotic (1–2 mm) and sluggish when reacting to light. Consensual photophobia is common [15, 52]. On slit-lamp exam, providers may see cell and flare, which is white blood cells and protein in the anterior chamber. See Chap. 6 for picture.

13. Endophthalmitis: Examination reveals decreased visual acuity, hazy or opaque appearance to the infected chamber,

hyperemia of the conjunctiva, and chemosis. One review finds 94.3% of patients reported blurred vision, 8.1% complained of a red eye, and 74% reported pain upon presentation [57]. Visual acuity is important when discussing the case with the ophthalmologist, and differentiating hand motion (HM) and light perception (LP) are considered the most important in the evaluation [57].

Management

1. Preseptal cellulitis: Understanding the mechanism of injury and initiating antibiotics covering the most likely pathogen are essential in the management of preseptal cellulitis. Broad-spectrum antibiotics covering gram-positive and gram-negative bacteria must be prescribed. *Staphylococcus* and *Streptococcus* species are the primary causes of preseptal cellulitis for puncture wounds, and anaerobes predominate in the cause secondary to human bites. Oral antibiotics can be used for the majority of patients with close follow-up to ensure clinical improvement. Oral antibiotic options include amoxicillin/clavulanate 875/125 mg every 12 h (children at a dose of amoxicillin 90 mg/kg/day and for clavulanate 6.4 mg/day divided in two doses), levofloxacin 500–700 mg IV or PO every 24 h, and azithromycin >6 m/o is 10 mg/kg and in adults 250–500 mg every 24 h PO [6]. For infections secondary to eyelid trauma, coverage for gram-positive (*Staphylococcus*) includes dicloxacillin (pediatric dosing is 12.5–25 mg/kg every 6 h for <40 kg weight, and for over 40 kg, the dosing is the same as adults at 125–250 mg every 6 h), flucloxacillin, and first-generation cephalosporins such as cephalexin (25–50 mg/kg/day divided every 6 h and for adults 250–1000 mg every 6 h) and cefazolin (pediatric dosing is 50 mg/kg every 8 h and for adults, 1 g every 8 h). Intravenous antibiotic choices include third-generation cephalosporins such as ceftriaxone (50–100 mg/kg/day divided in 12–24 h dosing and for adults

1–2 g every 24 h), cefotaxime (pediatrics 150–200 mg/kg/day every 6–8 h with a max dose of 12 g/day and for adults 1–2 g every 4–6 h), and ceftazidime (1 m/o to 12 y/o 90–150 mg/kg/day divided every 8 h and for adults 1 g every 8–12 h) [6]. Ampicillin/sulbactam (pediatrics 50 mg/kg, and for adults 1.5–3 g as well every 6 h IV) is also an option. Community-associated methicillin-resistant *S. aureus* (MRSA) can typically be adequately treated with oral regimens of trimethoprim-sulfamethoxazole (for pediatrics sulfamethoxazole at 40 mg/kg/day divided every 12 h and for trimethoprim 8 mg/kg/day divided every 12 h; adults are dosed 160 mg oral or 2.5 mg/kg IV every 12 h) or clindamycin (pediatric dosing 8–16 mg/kg/day divided every 6–8 h and for adults 300–450,450 mg PO every 6 h or 600–900 mg IV every 8 h) [6]. Hospital-associated MRSA should be covered with intravenous vancomycin (for 1 m/o to 12 y/o 10 to 15 mg/kg/day and for patients >70 kg, 1 g IV) or oral linezolid (<12 y/o at 10 mg/kg and for adults 600 mg every 12 h). Trauma resulting in a penetrating injury with organic material or a human bite should have treatment that includes coverage for anaerobic organisms. Metronidazole (500 mg IV every 8 h) and clindamycin (same dose as above) or levofloxacin (750 mg IV every 24 h) should be adequate [1, 2, 6]. If an abscess is present, incision and drainage by ophthalmology for adequate treatment is recommended. Ensure tetanus is up to date. If patients present to the ED on outpatient oral antibiotic therapy and there is no improvement in the past 48 h or if there is evidence of extension of the infection, intravenous antibiotics should be started and CT scan obtained [6].

2. Orbital cellulitis: Prompt treatment is vital to successful treatment of orbital cellulitis. Broad-spectrum antibiotic coverage for the most likely organisms is the standard. For patients with suspected MRSA, the coverage includes vancomycin (15–20 mg/kg every 6 h for adults and 10–15 mg/kg every 6 h with a max dose of 4 g/day in children) or clindamycin (8–16 mg/kg/day divided every 6–8 h

in children and for adults, 300–450 mg PO every 6 h or 600–900 mg IV every 8 h) [6]. Once cultures are resulted and if the organism is MSSA, vancomycin should be stopped, and the regimen should be changed to nafcillin or oxacillin (both can be dosed at 2 g IV every 4 h for adults, and for children, dosing is 50–200 mg/kg/day every 4–6 h with a max dose of 12 g/day) [5]. Other antibiotic choices include ampicillin-sulbactam, ticarcillin-clavulanate (3 g IV every 4 h in adults and 200–300 mg/kg of ticarcillin every 4–6 h for pediatrics with a max dose if 18 g), piperacillin-tazobactam (4.5 g every 6 h for adults and 240 mg/kg/day every 8 h for pediatrics), ceftriaxone, and cefotaxime [5, 6]. Combination therapy with a broad-spectrum cephalosporin along with metronidazole or clindamycin for anaerobic coverage is typical. If fungal cellulitis is a clinical concern, amphotericin B (1 mg/kg IV q24h) or voriconazole (6 mg/kg IV q12h for two doses, then 4 mg/kg IV q12h) are first-line choices. Patients with orbital cellulitis secondary to sinusitis may be candidates for surgical drainage, but this would be best managed in consultation with subspecialists as needed.

3. Bacterial conjunctivitis: While most cases are self-limiting, cases secondary to highly virulent bacteria such as *S. pneumoniae*, *N. gonorrhoeae*, and *H. influenzae* benefit from treatment [60]. There are no major advantages to the available broad-spectrum antibiotics available, but resistance patterns differ in specific regions of the United States. A newer antibiotic besifloxacin (1 gtt every 8 h) shows promise for increased rates of clinical resolution and can be used with suspected bacterial conjunctivitis [61]. Common antibiotic drops include polymyxin combination drugs, aminoglycosides, or fluoroquinolones (ciprofloxacin (1–2 gtt every 6 h or ointment every 8 h, ofloxacin (1–2 gtt every 6 h), levofloxacin (1–2 gtt every 6 h), moxifloxacin (every 8 h), or gatifloxacin (every 8 h)) [19]. Other drugs include bacitracin or ciprofloxacin ointment. Dosing for each of the antibiotics in four times a day over 5–7 days. Topical steroids should be avoided.

If *N. gonorrhoeae* is of concern, 1 g of ceftriaxone should be provided. Patients should be treated for concurrent chlamydial infection with either azithromycin 1 g orally or doxycycline 100 mg twice daily for 7 days [60]. *Chlamydia trachomatis* subtypes A and C should be treated with a single dose of oral azithromycin 20 mg/kg. Antibiotic regimens of tetracycline or erythromycin for 6 weeks topically or orally for 3 weeks can be used [19].

4. Viral conjunctivitis: Treatment is mainly supportive. Patients should receive teaching about cold compresses and be provided decongestants, artificial tears, and strict return precautions. Antihistamines can also be of use for symptom relief. A key point is prevention of coinfection of the other eye.

5. Neonatal conjunctivitis: Patients with concerns for *N. gonorrhoeae* infections require eye irrigation, intravenous penicillin G 100 Ku/kg/day in four divided doses, penicillin G benzathine 50 ku/kg/day, or ceftriaxone 50 mg/kg IM as a single dose for 7 days. They should also receive bacitracin or erythromycin ointment every 2–4 h [39]. For chlamydial infections, erythromycin eye drops four times a day plus erythromycin liquid 50 mg/kg/day in four divided doses for 2–3 weeks is recommended.

6. Contact lens complications: Conjunctivitis and keratitis (fungal and bacterial) are the most common infectious complications of wear. See those sections for specific treatment. Of note, a pathogen that is closely related to contact lens use is *Acanthamoeba*, and upwards of 90% of patients with this infection wear contacts. Specific treatment for *Acanthamoeba* keratitis is polyhexamethylene biguanide, propamidine isethionate, and neomycin [39, 62].

7. HSV keratoconjunctivitis: This is usually a self-limiting process, but patients should be referred and evaluated within several days by an ophthalmologist for confirmation of diagnosis and monitoring [49]. A review of over 100 trials found four antiviral agents including trifluridine, acyclovir, ganciclovir, and brivudine to be equally

effective, resulting in over 90% cure rate in 2 weeks [63]. Treatment options include acyclovir intravenous at 45 mg/kg/day plus vidarabine 3% ointment five times a day for 14–21 days depending on the presence or absence of any central nervous system involvement [19]. Acyclovir can also be administered as a topical or oral agent. There is a 3% ointment in 200, 400, or 800 mg formulations. Treatment includes five times a day dosing for 10 days. Oral suspension includes a 200 mg/5 mL suspension and is dosed 400 mg five times a day for 10 days [19, 51, 60, 64]. There is also a dermatologic ointment, 5% applied six times a day for 7 days. Ganciclovir is available at a 0.15% ophthalmic gel applied five times a day until the epithelium heals and then three times a day for 7 days [19, 65]. Trifluridine 1% is given one drop every 2 h or eight to nine times a day for the first week and is typically tapered [51, 66]. Valacyclovir, oral at 500 mg three times a day for 7–10 days, is an option [60]. Topical corticosteroids are not recommended due to the potential for harm [19].

8. Zoster ophthalmicus: Patients can be treated with oral antivirals including acyclovir 800 mg five times a day for 7–10 days or famciclovir 500 mg three times a day for 7–10 days. Valacyclovir 1 g oral three times a day can also be used [19, 51].

9. Corneal ulcer: Specific treatments for suppurative corneal ulcer infections are discussed in the keratitis sections, both fungal and bacterial. In one institution, 71.9% of cultures of corneal ulcers were culture positive for bacterial, fungal, and parasitic [62]. These infections need to be treated.

10. Bacterial keratitis: If patients have not already done so, they need to remove contact lenses as soon as possible, as overnight wear of lenses is the single greatest risk factor [1, 34, 38, 39]. Patients should have topical antibiotics started immediately, though preferentially after cultures are obtained [49]. All patients should have an emergent ophthalmologic consultation for scrapings and culture of infection [2]. If ophthalmology is not readily available,

broad-spectrum topical antibiotics should be started. Options include a fluoroquinolone (ofloxacin, moxifloxacin, gatifloxacin, or ciprofloxacin) or combination therapy with cephalosporin and aminoglycoside [2, 48]. Approximately 95% of infections will respond to appropriately chosen initial antibiotics; therefore, culture results are often unnecessary [48]. Cycloplegics can offer symptom relief, as this decreases pain secondary to ciliary spasms. If an ulcer with epithelial defects is found, ophthalmic fluoroquinolones every hour around the clock are recommended [51]. Ulcers that are large and vision-threatening should be treated with fortified tobramycin or gentamicin (15 mg/mL) every hour around the clock alternating with fortified vancomycin (25 mg/mL).

11. Fungal keratitis: Treatment options are limited, and medical treatment fails in approximately 15–20% of cases [67, 68]. Surgical intervention is required in 15–40% of cases [68, 69]. The emergency physician will not definitively diagnose or treat this disease, but it is important to consider the disease when risk factors or physical findings consistent with the disease are present. Emergent referral to an ophthalmologist may lead to earlier diagnosis and treatment and decrease rates of medical failure [50]. Natamycin 5% is the only FDA-approved topical ocular antibiotic. Amphotericin B is also an option in a 0.15% dilution. Miconazole (topical suspension 1%, topical cream 2%, subconjunctival 5–10 mg), ketoconazole (topical 5%, oral 300 mg/day), clotrimazole (topical 1%), fluconazole (topical 0.2%, oral 200 mg/day), itraconazole (topical 1%, oral 100–200 mg twice daily), and voriconazole (topical 1%, oral, 200 mg twice a day) are recommended drugs with variable activity. Voriconazole has the broadest coverage of the azole medication family [52].

12. Uveitis/iritis: The mainstay of treatment is long-acting cycloplegic medications such as homatropine to aid in pain control by blocking papillary constriction [54].

13. Endophthalmitis: This is a true ophthalmologic emergency, and patients require ophthalmologist evaluation

as soon as possible. Intravitreal antibiotics are the definitive treatment and commonly require a second dose 24–48 h after the first treatment. Intravitreal vancomycin 1 g and ceftazidime 2.25 mg are the empirical antibiotics most commonly use in the United States. Amikacin 0.4 mg is used in the event of a cephalosporin allergy. Gatifloxacin and moxifloxacin are also used in a concentration of 400 mcg/0.1 mL, and if concerned for fungal etiology, amphotericin B, 5–10 mcg/0.1 mL, is recommended [56, 58]. Itraconazole, voriconazole, and fluconazole are treatment options for fungal causes, with treatment lasting for months. Patients may require operative treatment for a vitrectomy, which is a debridement of the vitreous, leading to improved visual outcomes [56, 57]. Systemic antibiotics are of little help, as they penetrate the aqueous too slowly to reach adequate concentrations. The only exception to that is moxifloxacin which reaches adequate intraocular levels [56]. Corticosteroids are controversial, and their use should be in conjunction with ophthalmology.

Disposition

1. Periorbital cellulitis: Disposition depends on several factors including age, clinical appearance, reliability of patients and parents for children, and ability to obtain follow-up. Children under 1 year of age and those more severe cases should receive intravenous antibiotics and hospital observation [5]. The recommended duration of therapy is 7–10 days, and if there are any signs of local cellulitis, oral antibiotics should be continued until all erythema has resolved [5].

2. Orbital cellulitis: Delayed treatment and management of the infection can lead to a significant morbidity for the patient, including blindness, orbital apex syndrome (comprised of ophthalmoplegia, blepharoptosis, decreased corneal sensation, and vision loss), cavernous sinus

thrombosis, cranial nerve palsies, meningitis, intracranial abscesses, and even death [5, 6]. All children and the majority of adults with orbital cellulitis should be admitted to the hospital. Intravenous antibiotic treatment should continue for a minimum of 3 days (clinical improvement should be evident), and then oral antibiotic therapy should continue for a total treatment course of 10–21 days [5]. Candidates for surgical intervention include those who are not responding to treatment or are worsening despite treatment, decreased visual acuity, patients who develop an APD, and finally those who have an abscess. Conveying this information to the Ophthalmologist will help with disposition.

3. Bacterial conjunctivitis: Patients can be discharged home with medical and supportive therapies and recommendations to follow up with their primary doctor in 2–3 days to confirm resolution of symptoms. Artificial tears can aid with overall discomfort. Cold, moist compresses can decrease swelling. Decongestants have vasoconstrictive effects and can control pruritus for some patients. Saline irrigation of the affected eye can help with discomfort as well. Major teaching points for all forms of conjunctivitis include handwashing frequently, avoiding contact with either eye to prevent cross contamination, and avoiding sharing of cosmetics or towels [18, 60]. Neisserial infections should be viewed as an ocular finding of a systemic disease, and ophthalmologic consultation is essential [18]. Admission to a hospital for intravenous antibiotics should be considered based on clinical appearance.

4. Viral conjunctivitis: Patients can be discharged home with medical and supportive therapies and recommendations to follow up with their primary doctor in 7–10 days to confirm resolution of symptoms. Artificial tears can aid with overall discomfort. Cold, moist compresses can decrease swelling. Decongestants have vasoconstrictive effects and can control pruritus for some patients. Major teaching points for all forms of conjunctivitis include

handwashing frequently, avoiding contact with either eye to prevent cross contamination, and avoiding sharing of cosmetics or towels.

5. Neonatal conjunctivitis: Infants with evidence of or concern for chlamydial conjunctivitis require systemic antibiotics due to a prevalence of over 50% of patient can have concurrent genital tract, lung, and nasopharyngeal involvement. Hospitalization is recommended for both chlamydial and gonococcal infections [1, 2, 39].

6. Contact lens complications: Close evaluation and follow-up with ophthalmology is warranted as the clinical course should be followed for at least 48 h to ensure improvement once treatment is started [39].

7. Herpes simplex virus (HSV) keratoconjunctivitis: Patients should be started on topical and oral antivirals to help shorten the course of the disease [1, 2, 39, 60]. Close follow-up with ophthalmology is warranted.

8. Zoster ophthalmicus: Hutchinson's sign (vesicles on the tip of the nose) highly correlates to involvement of the cornea and warrants a referral to ophthalmology with close follow-up and reevaluation.

9. Corneal ulcer: Most ulcers need to be seen by ophthalmology within 24 h. If infection is involved, they can rapidly lead to opacification and vision loss [1].

10. Bacterial keratitis: Concern for this diagnosis warrants a same day evaluation by an ophthalmologist, particularly if a hypopyon is present, as this finding is often associated with infectious keratitis or endophthalmitis [49]. The eye should not be patched, as this facilitates spread of infection. Further follow-up and surgical vs. medical management will be further determined by the specialist. Daily follow-up with evaluation should be instituted until a response is noted to the treatment regimen.

11. Fungal keratitis: Clinical suspicion for this diagnosis or a hypopyon on exam warrants a same day evaluation by an ophthalmologist, as it is often associated with infectious keratitis or endophthalmitis [49]. Further follow-up and surgical vs. medical management will be further determined by the specialist.

12. Uveitis/iritis: Isolated iritis without an apparent cause and no clear autoimmune condition should be evaluated by an ophthalmologist in 24–48 h [2].
13. Endophthalmitis: A hypopyon on exam warrants a same day evaluation by an ophthalmologist, as it is often associated with infectious keratitis or endophthalmitis [49]. Ophthalmology will drive the ultimate disposition, but patients will need close follow-up as reinjection of intravitreal antibiotics is frequently needed, as is surgery [56, 57]. Patient outcomes such as visual acuity long-term are difficult to predict.

Pearls/Pitfalls

An incomplete physical examination, particularly a visual acuity with the addition of a slit-lamp examination, is a major pitfall with treatment of the above conditions. Other pitfalls are not adequately covering for the likely bacteria responsible for each condition and inadequate or untimely ophthalmology referral and evaluation.

Patients with foul smelling discharge with preseptal cellulitis are more likely to have an anaerobic infection [70].

In diabetics, alcoholics, and immunocompromised patients, mucormycosis must be considered, which requires extensive debridement. A black eschar may also be seen on the roof of the mouth or in the nose [70].

An infected eye should never be patched.

Dendrites on slit-lamp examination can be seen in cytomegalovirus and adenovirus, not just with herpes simplex or herpes zoster infections [70].

Many of the bacteria that can cause conjunctivitis in an infant can lead to sepsis and death in that age group, and a full workup should be considered.

Failure to recognize a patient with both genital and ocular symptoms as a potential gonococcal infection can have disastrous implications for a patient, as within 48 h untreated *N. gonorrhoeae* can penetrate the cornea.

Postoperative endophthalmitis can occur weeks to years after surgery.

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