The Painful Eye

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Acute angle closure glaucoma

In 90\% of cases, acute angle closure glaucoma (AACG) results from pupillary block in which pupillary dilation causes apposition of the lens and the iris, resulting in obstruction of aqueous outflow from the eye [1]. Accumulation of aqueous in the posterior chamber leads to a rapid elevation in intraocular pressure beyond the normal range of 10 to 21 mmHg, which causes pain and loss of vision [2]. Pupillary block often occurs in hyperopic (farsighted) eyes with a shallow anterior chamber angle [1]. AACG may be triggered by exposure to dim ambient lighting, topical mydriatics, anticholinergics, tricyclic antidepressants, selective serotonin reuptake inhibitors, or adrenergic agonists as a result of their dilating effect on the pupil [3]. There are case reports of intranasal phenylephrine [4], topiramate [5], and nebulized albuterol causing AACG [6]. Other etiologies of AACG may include peripheral anterior synechiae formed after uveits and previous ocular surgery. AACG is more common in Eskimo and Asian populations, women, patients with hyperopia, patients over 40 to 50 years of age, and in those with a family history of the disease [3,7]. In a British study, the overall incidence of AACG was found to be as high as 1 in 1000 people over the age of 40 [8], and the peak incidence occurs between ages 55 and 70 [1].

Patients with AACG complain of an acutely painful, red eye and blurred vision with halos around lights owing to corneal edema. Other commonly associated symptoms include frontal headache, nausea, vomiting, and abdominal pain. AACG is often misdiagnosed, particularly when systemic symptoms, such as abdominal pain, vomiting, and headache are more
prominent than ocular complaints [9,10]. Rarely, AACG may present as painless loss of vision [11]. In approximately 50% of cases, the patient will report similar past episodes. In these cases, the patient often describes evening headaches owing to pupillary constriction that are relieved with sleep [2]. Between attacks the patient is asymptomatic and the eye appears normal [8]. Most cases are unilateral, but AACG may be bilateral, particularly when medications are implicated [10].

Examination reveals circumcorneal conjunctival injection, a steamy cornea, impaired visual acuity, and a mid-dilated (4–6 mm) and fixed pupil (Fig. 1). The affected globe is tender and firm compared with the unaffected eye [2]. An intraocular pressure greater than 40 to 50 mmHg as measured by tonometry can cause rapid visual loss, and pressures greater than 70 mmHg can be seen in AACG [2]. A narrow anterior chamber angle, which predisposes to AACG, can be confirmed by the oblique flashlight test, during which a penlight is shone across the anterior chamber, parallel to the iris. The anterior chamber angle is considered wide if the entire iris is illuminated, and narrow if a shadow is cast across the nasal aspect of the iris [12]. This test, which has a specificity of 69% in AACG, can help confirm the diagnosis in the proper clinical setting [12].

AACG is an ocular emergency and prompt consultation with an ophthalmologist is imperative, as optic nerve atrophy and permanent loss of vision can occur within hours if the condition is not adequately treated [9]. Reduction of intraocular pressure and preservation of vision are the primary goals of treatment in AACG. Intraocular pressure is lowered by decreasing aqueous production with a topical beta blocker (timolol), alpha two agonist (apraclonidine), and a carbonic anhydrase inhibitor (acetazolamide) [7]. Topical timolol 0.5% can be expected to lower the intraocular pressure within 30 minutes to 1 hour. Topical beta blockers are systemically

![Fig. 1. Conjunctival injection, steamy cornea, and mid-dilated pupil caused by acute angle closure glaucoma. (From Bertolini J, Pelucio M. The red eye. Emerg Clin North Am 1995;13(3):561–79; with permission.)](image-url)
absorbed, and should be used cautiously if there is a history of reactive airway disease or cardiac conduction abnormality. Acetazolamide can be administered as an initial dose of 500 mg orally or intravenously, but is contraindicated in patients with a sulfa allergy. The intravenous osmotic agent mannitol can be used as an alternative to acetazolamide [7]. A topical corticosteroid may also be applied to reduce the inflammation associated with AACG. In addition to decreasing aqueous production with timolol and acetazolamide, aqueous outflow can be increased through pupillary constriction with pilocarpine [12,13]. Topical pilocarpine 2% can be administered every 15 minutes for the first 1 to 2 hours. The miotic effect of pilocarpine may not be observed until the intraocular pressure first has been reduced below 50 mmHg, at which point the ischemic paralysis of the iris is relieved [7]. The intraocular pressure should be repeated 1 hour after initial treatment to confirm that the pressure is dropping. Medical therapy should be continued if the intraocular pressure has not been reduced, and definitive surgical therapy with laser iridotomy or peripheral iridectomy may be necessary in refractory cases.

Scleritis

Scleritis, or inflammation of the sclera, is an uncommon disease, and many ophthalmologists see only a few cases per year. The emergency physician nevertheless should be familiar with this condition on account of its potential to cause visual loss and to threaten the integrity of the eye. Scleritis occurs more commonly in white females and the average age of onset is 49 years [14]. Most cases involve the anterior (visible) portion of the sclera. Posterior scleritis presents with a painless, red eye. Approximately 39% to 50% of patients with scleritis have an associated rheumatologic disease [14,15]. It is important to note that scleritis may be the first presentation of an underlying systemic disease. Infection causes scleritis in 8% of cases, with herpes zoster being the most common etiology [15]. Scleritis can be classified as diffuse, nodular, or necrotizing, and this distinction has implications for both treatment and prognosis.

Patients with scleritis complain of severe, boring pain that is worse with eye movement and often interferes with normal activity or sleep. The pain usually progresses insidiously over the course of weeks [14]. Headache may be the most prominent symptom, making the diagnosis more difficult. Tearing, blurred vision, and a red eye are also common symptoms. Examination reveals dilation of the deep episcleral vessels and thinning of the sclera, resulting in a bluish discoloration of the eye (Fig. 2). Visual acuity is impaired in 16% of patients [15] and, unlike in episcleritis, the globe is often tender to palpation. The condition is bilateral in 50% of all cases [15]. Diffuse anterior scleritis is characterized by the absence of nodules and a lack of scleral necrosis. In nodular scleritis, there are well-localized, tender areas of edema with dilation of the underlying vessels. In necrotizing
anterior scleritis, there is intense dilation of the deep vasculature and focal or generalized thinning of the sclera, exposing the underlying choroid. The eye is exquisitely tender to the touch in necrotizing scleritis, and this severe form of the disease represents a threat to the integrity of the eye. The bluish discoloration of the sclera helps differentiate scleritis from episcleritis. In addition, episcleritis tends to cause engorgement of only the more superficial vessels overlying the sclera, which are easily blanched with topical application of phenylephrine. In contrast, the deeper vessels involved in scleritis are unaffected by phenylephrine [14]. The distinction between scleritis and episcleritis has both therapeutic and prognostic implications, with the latter generally being a less malignant process, with fewer ocular complications [15]. Episcleritis is covered in more detail in an article about red eye that appears elsewhere in this issue.

Investigation of previously undiagnosed systemic disease, such as rheumatoid arthritis (RA), Wegener’s granulomatosis, relapsing polychondritis, systemic lupus erythematosus, inflammatory bowel disease, and polyarteritis nodosa, becomes important in scleritis [14]. RA, the most commonly implicated systemic disease, accounts for up to 33% of all cases of scleritis referred to ophthalmologists [16]. Necrotizing scleritis often develops in the setting of peripheral ulcerative keratitis associated with vasculitis. Infectious etiologies include herpes zoster ophthalmicus, herpes simplex, Lyme disease, and HIV. Although the history and physical examination can help to focus testing in some cases, the painful, red eye of scleritis may be the only presenting symptom of an underlying systemic disease. In such cases, a complete blood count, blood urea nitrogen, creatinine, electrolyte panel, rheumatoid factor, antinuclear antibody, anticytoplasmic antibodies, and urinalysis may help to reveal an underlying systemic disease. The erythrocyte sedimentation
rate and C-reactive protein are useful in assessing the severity of disease and evaluating response to treatment.

The treatment of scleritis is tailored based on the severity of disease and should involve consultation with an ophthalmologist. Mild cases of nodular or diffuse scleritis may respond to oral nonsteroidal anti-inflammatory drugs (NSAIDs) (oral indomethacin 50 mg 3 times/day), with symptoms generally resolving over the course of 1 month [15]. Oral corticosteroids (prednisone 1 mg/kg/day) may be required in refractory anterior scleritis and necrotizing scleritis. Other immunosuppressive drugs, such as cyclophosphamide and cyclosporine, can be added at the discretion of an ophthalmologist or rheumatologist when the condition does not respond to oral corticosteroids or with the goal of treating an underlying systemic disease [15]. Scleritis may be complicated by uveitis, keratitis, or glaucoma in up to 60% of cases [15], and these conditions require appropriate treatment when they arise. Topical corticosteroids are likely to be of little benefit in scleritis, but may be used to treat associated anterior uveitis. Patients with corneal or scleral perforation may require surgical intervention [14]. Most patients with mild scleritis will have little to no change in visual acuity. However, necrotizing scleritis is associated with a much higher incidence of visual loss and a 21% 8-year mortality [7], underscoring the importance of aggressive treatment and prompt referral for follow-up care.

Anterior uveitis (iritis)

The anterior uvea consists of the iris and ciliary body. Anterior uveitis refers to inflammation of one or both of these structures. The terms iritis (inflammation of the iris), cyclitis (inflammation of the ciliary body), and iridocyclitis (inflammation of both anterior uveal structures) are more specific anatomic descriptions of the involved structures in anterior uveitis. Anterior uveitis is typically associated with pain, redness, blurred vision, tearing, and photophobia. Anterior uveitis accounts for 50% to 92% of all cases of uveitis in Western countries [17]. In contrast, posterior uveitis, or inflammation of the choroid, is a less common type of uveitis and is typically painless [18]. The annual incidence of uveitis is 17 in 100,000 people [18]. Anterior uveitis occurs most commonly between the ages of 20 and 50 and rarely before the age of 10 or after the age of 70 [17].

Examination reveals conjunctival injection primarily involving the limbus. The presence of inflammatory cells and flare (protein extravasation from inflamed blood vessels) in the anterior chamber helps to confirm the diagnosis of anterior uveitis. A sterile hypopyon may develop in severe cases (Fig. 3). There may be miosis of the affected eye related to ciliary spasm. Photophobia is commonly present in the affected eye when a light is shone in either the affected or unaffected eye. The intraocular pressure should be measured as secondary glaucoma can result from blockage of the trabecular meshwork by inflammatory cells or from scarring.
HLA-B27-associated uveitis

Approximately 60% of all cases of uveitis are idiopathic [19]. Of the identifiable etiologies of anterior uveitis, HLA-B27-associated uveitis is the most common, accounting for 30% to 70% of cases. HLA-B27-associated anterior uveitis is characterized by acute (developing over hours to days), unilateral, alternating uveitis, with a high rate of recurrence [17]. The inflammation of HLA-B27-associated uveitis is often severe, but typically resolves within 2 to 4 months, leaving little to no visual impairment between episodes [7]. Only half of the HLA-B27-associated cases have an associated systemic disease, such as ankylosing spondylitis, Reiter syndrome, psoriatic arthritis, or inflammatory bowel disease [18]. The uveitis of Reiter syndrome and ankylosing spondylitis tend to be acute and unilateral, whereas those of psoriatic arthritis and inflammatory bowel disease are more insidious in onset and tend to be bilateral [7]. A small percentage of patients with HLA-B27-associated anterior uveitis develop synechiae (scarring), which can block the outflow of aqueous and result in AACG.

Other noninfectious etiologies

Other causes of anterior uveitis not typically associated with HLA-B27 include trauma, sarcoidosis, juvenile rheumatoid arthritis, Behçet’s disease, and Kawasaki’s disease. The history and physical examination can help to establish the etiology, particularly when there are signs and symptoms of systemic disease (Table 1). Uveitis associated with juvenile rheumatoid arthritis is unique in that it is often asymptomatic and can cause progressive visual loss if not detected on routine screening [18]. Other diseases may mimic anterior uveitis, including lymphoma and leukemia. These so-called
<table>
<thead>
<tr>
<th>Disease</th>
<th>HLA-B27 positive (%)</th>
<th>Incidence of uveitis (%)</th>
<th>Clinical features of uveitis</th>
<th>Clinical features of systemic disease</th>
<th>Epidemiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ankylosing spondylitis</td>
<td>90</td>
<td>20–40</td>
<td>acute, unilateral, alternating</td>
<td>sacroiliitis, morning stiffness</td>
<td>male, young adult</td>
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<tr>
<td>Reiter syndrome</td>
<td>60</td>
<td>20–40</td>
<td>acute, unilateral</td>
<td>conjunctivitis, urethritis, arthritis, recent genitourinary or enteric infection</td>
<td>male, young adult, white</td>
</tr>
<tr>
<td>Psoriatic arthritis</td>
<td>40–50</td>
<td>7</td>
<td>insidious, bilateral</td>
<td>arthritis, rash, nail changes</td>
<td>male = female, ages 30–55, white</td>
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<tr>
<td>Inflammatory bowel disease</td>
<td>35–75</td>
<td>3–11</td>
<td>insidious, bilateral</td>
<td>diarrhea</td>
<td>female, bimodal peak in younger and older adults</td>
</tr>
<tr>
<td>Behçet’s disease</td>
<td>---</td>
<td>80</td>
<td>acute, unilateral, hypopyon</td>
<td>oral and genital ulcers, skin lesions</td>
<td>male = female, ages 25–30, Asian, Mediterranean, Middle Eastern</td>
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<td>Sarcoidosis</td>
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<td>18</td>
<td>insidious, chronic, bilateral</td>
<td>respiratory symptoms, hilar adenopathy, skin lesions, fever, arthritis</td>
<td>female slightly more than male, young adult, African-American</td>
</tr>
<tr>
<td>Juvenile rheumatoid arthritis</td>
<td>---</td>
<td>5–20</td>
<td>asymptomatic, insidious, bilateral</td>
<td>fever, arthritis, rash</td>
<td>female, age younger than 16, white</td>
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*Data from Refs. [16–20].*
“masquerade syndromes,” which are typically malignancies that mimic other causes of anterior uveitis, should be suspected when patients do not respond to treatment or when uveitis is diagnosed in the elderly.

In patients with unexplained anterior uveitis, performing serologic testing for syphilis and chest radiography to screen for sarcoidosis is a reasonable diagnostic approach. Knowing the HLA-B27 status may provide some prognostic information, as patients with a positive result tend to have a more severe uveitis [7]. Idiopathic cases of anterior uveitis tend to resolve in 6 weeks and do not necessarily require an extensive diagnostic workup as the process tends not to recur [19].

Infectious etiologies

Anterior uveitis may be caused by infectious etiologies, including syphilis, herpes simplex virus (HSV), and herpes zoster virus. Infectious causes should be suspected when symptoms do not resolve with anti-inflammatory therapy. Iritis associated with syphilis is usually acute and unilateral [18]. HSV-associated iritis usually occurs in the setting of stromal keratitis [21]. Zoster iritis may be due to viral infection of the iris itself, and often occurs when skin lesions are observed on the tip of the nose [21].

Treatment of anterior uveitis

There is a paucity of randomized controlled trials to support the current treatment of anterior uveitis [19]. Treatment may require a multidisciplinary approach, including consultation with a rheumatologist and an ophthalmologist. Topical corticosteroids are used for anterior uveitis and the dosing depends on the severity of disease [18]. Topical prednisolone acetate 1% achieves a high concentration within the anterior chamber and initially may be administered hourly in severe cases. Dosing can be slowly reduced as a therapeutic result is achieved [7]. Cataracts and glaucoma are not only complications of uveitis, but of treatment with long-term topical steroids as well. Systemic corticosteroids and other immunosuppressive medications may be used in refractory cases or to treat a specific underlying systemic disease. Mydriatics relieve the pain associated with ciliary spasm and may prevent the development of adhesions between the pupil and lens.

Uveitis due to syphilis should be treated as neurosyphilis [18]. HSV-associated iritis is treated with topical antivirals. Topical corticosteroids may also be indicated for HSV-associated iritis, but should be used only after consultation with an ophthalmologist, given the potential risk of exacerbating HSV keratitis with this therapy [21]. Zoster iritis usually requires long-term therapy with topical corticosteroids, and there does not seem to be the same risk of worsening the infection as with HSV. Zoster iritis can last for months to years and often causes significant visual impairment, cataracts, and glaucoma [21].
Optic neuritis

Optic neuritis is characterized by inflammatory demyelination of the optic nerve. Although optic neuritis can be associated with many systemic or infectious diseases, including sarcoidosis, systemic lupus erythematosus, syphilis, postviral syndromes, lymphoma, and leukemia, it classically occurs in the setting of multiple sclerosis [7]. In the Optic Neuritis Treatment Trial, a landmark study of the effects of corticosteroids on optic neuritis, 38% of patients with optic neuritis ultimately developed multiple sclerosis [22]. Optic neuritis affects women more commonly than men, and the median age of onset is at approximately 30 years [23].

Patients with optic neuritis complain of unilateral visual loss in most cases, and there may be associated change in color perception or visual field defects. Symptoms develop over the course of hours to days. Up to 92% of cases will be associated with pain [24], which is often worse with eye movement. Pain often begins to resolve after the first few days, as visual loss commences [25]. A small number of cases involve both eyes simultaneously, and the disease may recur in the same or opposite eye. Examination reveals visual loss, with a median acuity of 20/60 in the affected eye [24]. A visual field defect and afferent pupillary defect are also common findings. The optic disk may appear edematous in some patients, but up to two thirds will have a normal-appearing optic disk [24]. Although the diagnosis of optic neuritis is made on a clinical basis, MRI should be routinely performed primarily for prognostic reasons: patients with one or more demyelinating lesions on MRI at the time of optic neuritis have a significantly increased risk of being diagnosed with multiple sclerosis over 10 years [22]. MRI of the orbits, which reveals characteristic enhancement of the optic nerve, may also be indicated in cases where the diagnosis is in question or when there is a lack of recovery of visual acuity [25].

The acute management of patients with optic neuritis should involve admission to the hospital for intravenous methylprednisolone (250 mg every 6 hours for 3 days, followed by an oral prednisone taper), which has been shown to improve short-term recovery from optic neuritis but has not been demonstrated to improve long-term visual impairment [26]. Visual loss begins to improve rapidly with intravenous corticosteroids, but will also improve over the course of weeks without treatment [7]. Most patients eventually regain their baseline visual acuity [24], but many are left with subtle visual changes that affect their quality of life [7]. Patients who develop multiple sclerosis after initial optic neuritis generally have relatively mild neurologic disability [22]. (See the article on optic neuritis elsewhere in this issue.)

Keratitis

Keratitis is defined as inflammation of the cornea. This condition may be infectious or noninfectious in etiology. Patients with keratitis complain of
photophobia, foreign body sensation, tearing, and exquisite pain due to the rich sensory innervation from the ophthalmic division of the trigeminal nerve. Herpes simplex and varicella zoster viruses, which may cause decreased corneal sensation, are often less painful than other causes of keratitis [27]. The cornea is an important refractory surface of the eye and inflammation may affect visual acuity. In both infectious and noninfectious causes, the corneal inflammation may be superficial and involve only the epithelium or deep with ulceration through the epithelium [27]. In other cases, the epithelium may remain intact while the stroma becomes inflamed. With stromal keratitis, an infiltrate is observed as a focal area of corneal opacity, which does not stain with fluorescein. Infectious and noninfectious etiologies can often be determined from a careful history and examination. Infectious keratitis may be caused by bacteria, fungi, amoeba, and viruses. Complications of keratitis include corneal ulcer and perforation, scarring with partial or complete visual loss, glaucoma, and uveitis. Examination reveals conjunctival injection, which is more pronounced at the limbus. Cells and flare in the anterior chamber may be noted on slit lamp examination, and a hypopyon may form in more severe cases. Corneal defects are seen as green-stained areas when fluorescein is applied to the affected eye. In superficial keratitis, scarring does not typically occur and vision is not permanently affected [7].

**Noninfectious keratitis**

*Superficial punctate keratitis*

Superficial punctate keratitis (SPK) is a condition characterized by pain, redness, and tiny, pinpoint areas of fluorescein uptake on examination. Noninfectious causes of SPK include Thygeson’s SPK, blepharoconjunctivitis, and UV light exposure.

Thygeson’s SPK is a bilateral keratitis of unknown etiology. It is typically insidious in onset, lasts for months to years, and affects both men and women in the second and third decades of life. Patients experience repeated exacerbations and remissions [7]. Thygeson’s SPK is unique form of keratitis in that there is no conjunctival injection. Most patients improve with topical corticosteroids without scarring or significant change in vision [7].

Chronic blepharoconjunctivitis can result in keratitis due to a hypersensitivity reaction to a *Staphylococcal* antigen associated with this condition. There are often infiltrates seen on the periphery of the cornea, and in severe cases the cornea may ulcerate. Treatment of the underlying blepharoconjunctivitis involves warm compresses and topical or systemic antibiotics [27]. Topical steroids are indicated for associated keratitis after infectious etiologies have been excluded.

Most cases of keratitis caused by UV light exposure occur in welders with inadequate eye protection [28]. UV keratitis has also been described with tanning booths, other UV lamp exposure, and sunlight reflecting off
snow. The onset of pain and photophobia occurs several hours after the UV exposure [28]. Treatment of UV keratitis includes avoidance of further light exposure and topical lubricants. In most cases, the cornea heals without consequence, but permanent corneal damage has been reported [28].

Other causes of SPK include dry eye syndrome, mechanical trauma from chronic eye rubbing, topical drug toxicity (tobramycin, neomycin, eye drop preservatives, and topical antivirals), mild chemical injury, and contact lens use [7,27]. Treatment of SPK in these cases should be directed toward the underlying cause, as well as appropriate oral analgesics, artificial tears, or other lubricants, such as erythromycin ointment. In contact lens wearers with SPK, contact use should be discontinued and a topical antibiotic with activity against *Pseudomonas* should be prescribed. Patients should be reexamined daily until the cornea has healed.

**Ulcerative keratitis**

Extensive inflammation of the corneal epithelium may result in ulceration. Although corneal ulcers often result from infectious causes, many non-infectious etiologies can cause this condition, such as neurotrophic keratitis, atopic keratoconjunctivitis, vitamin A deficiency, rosacea, and collagen vascular diseases [27]. When ulceration does occur, the cornea is at increased risk of infection and scarring.

Neurotrophic keratitis results from recurrent injury to the cornea in patients with decreased corneal sensation. Neurotrophic keratitis can be caused by HSV and VZV infection, diabetes mellitus, chemical burns, stroke, and trigeminal nerve palsy [7]. Corneal perforation may result if the condition goes unrecognized. Treatment is primarily focused on maintaining eye lubrication and addressing the underlying disease process.

Atopic keratoconjunctivitis is associated with allergic conjunctivitis and is often seen in patients with a history of other allergic disease, such as atopic dermatitis. The inflamed tarsal conjunctiva initially results in SPK, but these areas often coalesce to form a corneal ulcer. Treatment depends on the severity of disease, but may include oral antihistamines, topical steroids, topical mast cell stabilizers, and topical NSAIDs [7].

Ulcerative keratitis may be seen in a wide range of collagen vascular diseases, including RA, sarcoidosis, and many of the vasculitides. Ulcerative keratitis may be the initial presentation of the underlying disease in some cases. Approximately 20% to 30% of patients with RA have keratoconjunctivitis sicca [27,29], which increases the risk of ulcerative keratitis. Corneal involvement in RA may also present as peripheral corneal ulceration from vasculitis [29]. Corneal involvement is common in systemic lupus erythematosus (SLE) and may be a result of autoimmunity or keratoconjunctivitis sicca. Ocular involvement in sarcoidosis may occur at any time during the disease. Single or multiple round opacities may be observed on the cornea, and the condition is often bilateral. The diagnosis may be difficult in the
absence of systemic evidence of sarcoidosis [27]. The vasculitides, including Wegener’s granulomatosis and polyarteritis nodosa, and Churg-Strauss, typically cause a peripheral ulcerative keratitis, sparing the avascular central cornea [29]. Such corneal ulcers are susceptible to infection and this complication must be excluded before starting corticosteroid therapy. Treatment of keratitis related to collagen vascular disease is typically directed toward the underlying disease process and is best undertaken after consultation with a rheumatologist and ophthalmologist.

**Infectious keratitis**

**Bacterial**

Bacterial keratitis is one of the leading causes of blindness in the developing world [7]. The relatively avascular cornea predisposes to infection, particularly when the epithelium is compromised. The incidence of bacterial keratitis is increasing in developed countries, and contact lens use is the most common risk factor [30], followed by ocular surface disease. In the United States, the incidence of bacterial keratitis is 10 to 30 per 100,000 in contact lens wearers [7]. A change in the pathogens implicated in bacterial keratitis can also be attributed to increased contact lens use: *Streptococcus pneumoniae* has traditionally been the most common bacterium isolated from corneal ulcers, but *Pseudomonas, Staphylococcus aureus,* and *Serratia* are now the most commonly isolated organisms in contact lens wearers [7]. Although *Neisseria gonorrhoea, Corynebacterium diphtheriae, Shigella,* and *Listeria* can invade an intact cornea [31], disruption of the cornea from underlying corneal disease, corneal trauma and foreign bodies, poor tear production, contact lens use, or corneal surgery allows for adherence and invasion of more commonly isolated bacteria. Diabetes, allergy, and topical steroid use may also increase the risk of bacterial keratitis [30]. Advanced HIV does not seem to increase the risk of bacterial keratitis, but patients may have a more aggressive course once infection occurs.

Examination often reveals a corneal infiltrate, and there may be associated conjunctival injection and chemosis. Cells and flare are found in the anterior chamber in up to 25% of cases [30], which may be severe enough to develop a sterile hypopyon. Familiarity with *Pseudomonas* keratitis has become important not only because of its increasing incidence related to contact lens use, but also owing to its virulence: if improperly treated, this infection can spread rapidly, invading the entire cornea in a matter of hours. A yellow-green discharge may be seen over the affected areas of the cornea and ulceration may progress to perforation of the cornea. Anterior chamber inflammation and hypopyon are commonly seen in *Pseudomonas* keratitis.

The vast majority of bacterial infections will respond to broad-spectrum empiric antibiotics, but culture of corneal scrapings may be prudent when less-common organisms are suspected, when the etiology is not clear from
the history, or in more severe cases. Although combination therapy with a cephalosporin, such as cefazolin and an aminoglycoside or fluoroquinolone is typically recommended, antibiotic choice should be tailored based on clinical features, suspected pathogens, and local resistance patterns. Topical antibiotics, which achieve high concentrations in infected tissue without systemic side effects, are generally preferred over systemic antibiotics. Frequent, repetitive dosing, (every 2 minutes for the first five doses) is usually used as a loading dose. Antibiotics are then instilled approximately every 30 minutes for the first 24 to 36 hours depending on the severity of the infection [31]. Antibiotic therapy should not be delayed for any reason, as site-threatening complications can occur rapidly. Many patients require admission, particularly if treatment noncompliance is a concern or if there is site-threatening infection. Large, central ulcers or extensive infiltrates can result in scarring and varying degrees of visual loss.

**Viral**

Common causes of viral keratitis include HSV, VZV, Epstein-Barr virus, and adenovirus. HSV is one of the most common causes of corneal blindness in the world. Initial infection with HSV, which often occurs in childhood, is asymptomatic in most cases. In symptomatic cases of primary ocular infection, periorbital cutaneous vesicles are noted and there may be associated blepharitis, conjunctivitis, malaise, fevers, and local lymphadenopathy [21]. Keratitis occurs in 33% to 50% of primary infections, and usually appears 1 to 2 weeks after the appearance of skin lesions. Recurrent disease accounts for most cases of ocular HSV, and classically presents with unilateral dendritic corneal defects (Fig. 4), but the lid and conjunctiva may be involved as well. Within 1 to 2 years, 25% of patients will have a recurrence after an initial infection [21]. Stress, trauma, surgery, and menstrual period often trigger

![Dendritic lesion of herpes simplex keratitis. (Reprinted from Auerback PS. Wilderness medicine, 5th edition. Philadelphia: Mosby; 2007. Fig. 25–8; with permission.)](image-url)
recurrent attacks, which lead to corneal scarring and visual loss. Examination with fluorescein reveals superficial punctate lesions or characteristic dendrites, which can coalesce and enlarge. Recurrent disease may also be isolated to the stroma, appearing as a white infiltrate, which tends to be a more severe and difficult to treat form of HSV keratitis [21]. Interestingly, there is decreased corneal sensation associated with HSV keratitis. The diagnosis is often made clinically, but viral culture can be performed if there is uncertainty.

Trifluridine is the drug of choice for topical treatment owing to its high degree of ocular penetration. Trifluridine is administered six to eight times per day for the first several days and then the frequency is reduced as healing occurs [21]. Up to 97% of patients with dendritic lesions will heal within 2 weeks of trifluridine therapy [21]. Oral acyclovir 400 mg five times per day is used as alternative or adjunctive treatment to topical therapy. Topical steroids are contraindicated in the epithelial stage, but may be used in stromal stages after consultation with ophthalmologist. HSV keratitis can resolve spontaneously or with treatment over 1 to 2 weeks. Most patients will have minimal change in visual acuity, but others will be left with significant visual impairment.

VZV keratitis, similar to HSV, may result in a painful, red eye with fever and malaise. The skin findings of VZV are painful vesicular lesions over the ophthalmic division of the trigeminal nerve (forehead and upper eyelid), and typically do not cross the midline. Less commonly, patients will present with isolated corneal involvement [32]. The dendritic lesions of VZV keratitis do not have well-stained terminal bulbs and ulceration is uncommon, in contrast to HSV keratitis [21]. Corneal sensation is often markedly impaired, even in mild cases [27].

VZV keratitis is treated with oral acyclovir 800 mg five times per day or oral valacyclovir 1000 mg three times per day for 7 to 10 days [32]. Therapy is most effective when started in the first 3 days, but may have some efficacy within 5 days of the onset of symptoms [21]. There is no clear evidence for the efficacy of topical antiviral medications for VZV keratitis [21].

There are at least 50 types of adenovirus, and not surprisingly the spectrum of symptoms is broad, ranging from isolated ocular involvement to ocular disease associated with pharyngitis or gastroenteritis [21]. Adenovirus is quite contagious, and ocular disease appropriately has been termed epidemic keratoconjunctivitis. In corneal involvement with adenovirus, patients complain of severe pain and often have bilateral conjunctivitis with a palpable preauricular lymph node. Diffuse punctate keratitis, which typically resolves without treatment in 7 to 10 days, is followed by subepithelial infiltrates. Topical steroids may provide pain relief and improve vision at this later stage [21].

Fungal

Fungal keratitis is commonly seen in the southern United States and tropical regions of the world. Infection with *Fusarium* and *Aspergillus* is often caused by traumatic injury from vegetable matter, and *Candida albicans*
is seen in patients with underlying eye disease [33]. Signs and symptoms are similar to that of bacterial keratitis, and fungal infections are often treated as bacterial until culture results are available. Topical therapy is used for mild keratitis and systemic antifungal therapy is added in more severe cases. Patients are usually admitted to the hospital for hourly dosing of topical antifungal therapy, which may be required for several days [33]. Topical steroids are contraindicated. Anterior uveitis is a common finding and cycloplegics are often used in these cases. Improvement usually occurs over weeks; corneal transplant is reserved for refractory cases.

**Amoebic**

The first case of *Acanthamoeba* keratitis was described in 1973 [34]. Infection with this amoeba, which is abundant in the environment, usually occurs in young, healthy adults and the majority of cases are contact lens related. Symptoms are similar to bacterial keratitis, although the pain seems to be more severe and the infection progresses more slowly in the case of *Acanthamoeba* keratitis [34]. Slit lamp examination may reveal dendritiform lesions that can be confused with HSV keratitis. *Acanthamoeba* keratitis should be suspected in any contact lens wearer with dendriform keratitis, and cultures of the corneal epithelium and contact lenses should be sent in such cases. Treatment typically involves combination therapy with topical amoebicidal agents after consultation with an ophthalmologist.

**Corneal abrasion**

Patients with corneal abrasions are commonly seen in the emergency department. A corneal abrasion is a traumatic defect in the corneal epithelium, which may result from direct mechanical trauma, contact lens related injury, foreign bodies, or motor vehicle accidents with airbag deployment [35]. Patients complain of pain, sensitivity to light, and excessive tearing following trauma to the eye. The patient may recollect injury from a fingernail, makeup applicator, or excessive rubbing of the eyes. In other cases the trauma may be so minor that it is not remembered by the patient at all. Trauma to the eye of a machine worker or as a result of metal striking metal should raise suspicion for penetrating globe injury. In contact lens wearers, specific history about poorly fitting lenses and prolonged wearing should be elicited.

Application of a short-acting topical anesthetic, such as proparacaine, will facilitate examination of the painful eye. Visual acuity is typically normal unless the abrasion involves the visual axis or there is significant corneal edema. There may be blepharospasm of the affected eye as a result of photophobia. Ciliary spasm may cause miosis. The cornea can appear hazy if there is edema. Conjunctival injection is classically present and is most pronounced at the limbus. The diagnosis is confirmed by green fluorescence in
damaged areas of the cornea seen under Wood’s lamp or cobalt blue light on slit lamp examination after the application of fluorescein (Fig. 5). Contact lens-related abrasions may be punctate or coalesce to form a larger, round central abrasion. Multiple vertical abrasions suggest a foreign body and should prompt the examiner to flip the upper eye lid for careful examination. Siedel’s sign or the presence of a hyphema on slit lamp examination suggests penetrating trauma to the globe.

Current treatment for corneal abrasions is largely based on theoretical benefit and general consensus rather than on rigorous study. Primary goals of therapy are pain control, prevention of infection, and rapid healing of the corneal epithelium. In a systematic review of five randomized controlled trials, topical NSAIDs, such as ketorolac, diclofenac, and indomethacin, resulted in a modest decrease in pain without a delay in wound healing or an increased risk of infection [36]. Patients who use topical NSAIDs may also return to work earlier and require fewer oral analgesics, including narcotics. Topical NSAIDs are, however, relatively expensive. Cycloplegics should theoretically relieve pain and photophobia related to ciliary spasm, but a systematic review showed no clear evidence to support their use in corneal abrasion [37]. Patching of the eye following a corneal abrasion has been shown to be of no benefit in pain relief or rate of healing, and is no longer recommended [38]. Concerns over the safety of patching have also been raised, as this treatment leaves the patient effectively monocular, thus impairing ambulation and driving. Contact lens-related abrasions in particular are at increased risk of infection when patched, and the eye should not be covered in these cases. Patients with contact lens-related abrasions should be instructed to discontinue contact lens use until the defect heals and symptoms resolve. Oral analgesics, such as acetaminophen, ibuprofen, or opioids,
are typically prescribed for pain control. The decision to use oral NSAIDs or opioids should be made on an individual patient basis. In cases where oral analgesics are contraindicated, topical NSAIDs may be of benefit. A topical antibiotic, such as erythromycin, is commonly prescribed four times per day for 3 to 5 days to prevent infection, although there is no strong evidence to support this practice. Because of their lubricating effect, antibiotic ointments are generally preferred over drops. Patients with contact lens abrasions should be treated with prophylactic topical antibiotics to cover *Pseudomonas*, such as gentamycin or ciprofloxacin. There is no convincing evidence in the literature to support tetanus prophylaxis in patients with nonpenetrating corneal abrasions [39].

Most abrasions heal within 1 to 3 days, although defects involving greater than half of the surface of cornea may require 4 to 5 days to fully heal [40]. Patients with small corneal abrasions will heal quickly and generally require only a single 24-hour follow-up examination to ensure healing. Patients with contact lens-related corneal abrasions should be reexamined daily to ensure prompt healing and to exclude infection. Referral to an ophthalmologist is indicated for large abrasions, defects over the visual axis, abrasions that become larger or more symptomatic the next day, or for patients who develop a corneal infiltrate or ulcer.

References


