Lumbar puncture (LP) is used in the diagnostic evaluation of central nervous system (CNS) processes, most commonly in cases of suspected infection and subarachnoid hemorrhage. Less commonly, the procedure is used for therapeutic purposes (eg, in cases of idiopathic intracranial hypertension).

**Gut Reaction**

Trauma to the torso is the second most frequent cause of death in children. More than 80% of these cases can be attributed to blunt abdominal trauma, which is the most common unrecognized fatal injury in pediatric patients. The prompt recognition and initial management of intraabdominal injuries, particularly following motor vehicle collisions and falls, is of utmost importance to reduce the significant risk of morbidity and mortality.

**Sight for Sore Eyes**

The majority of red eye presentations are easily managed in the acute setting; however, clinicians must be adept at distinguishing between relatively benign, self-limited processes and vision-threatening pathologies requiring emergent ophthalmological evaluation. More than 2 million patients visit US emergency departments every year for eye-related complaints; chief among these are preseptal cellulitis, orbital cellulitis, and conjunctivitis.
FROM THE EM MODEL

7.0 Head, Ear, Eye, Nose, Throat Disorders
    7.2 Eye

The majority of red eye presentations are easily managed in the emergency department; however, clinicians must be adept at distinguishing between relatively benign, self-limited processes and vision-threatening pathologies requiring emergent ophthalmological evaluation. More than 2 million patients visit US emergency departments every year for eye-related complaints, approximately 3% of whom will require hospital admission.¹
CASE PRESENTATIONS

■ CASE ONE
A 32-year-old woman presents with significant swelling of the left eyelid, which she thinks was precipitated by a spider bite. Although she doesn’t recall being bitten, she woke up three days ago with a “puffy” eyelid and recalls seeing spiders outside her home. The patient’s symptoms have worsened and her eye is now swollen shut. She reports subjective fever and chills, but denies recent rhinorrhea, cough, congestion, orocular trauma. She has no allergies and does not take any medications at home.

Her vital signs are blood pressure 132/76, heart rate 94, respiratory rate 16, temperature 38.1°C (100.6°F), and oxygen saturation 99% on room air. The left upper and lower eyelids are edematous, edematous, and mildly warm to the touch. The patient reports no pain when the clinician holds the eye open, and the extraocular motions are intact. The pupil is round and reactive and there are no signs of conjunctival injection, preauricular nodes, or tenderness over the sinuses.

■ CASE TWO
A 54-year-old man presents with right eye pain and swelling. He reports rhinorrhea, congestion, and a productive cough for the past week, but explains new symptoms developed two days ago, including eye pain, fever (38.5°C [101.3°F]), malaise, nasal pressure, and discomfort in his upper teeth with eating. He complains of progressively worse swelling and blurry vision in his right eye, but denies any trauma. The patient has a history of poorly controlled diabetes, hypertension, and hyperlipidemia.

His vital signs are blood pressure 156/94, heart rate 112, respiratory rate 18, temperature 39.1°C (102.4°F), and oxygen saturation 98% on room air. The physical examination is remarkable for tenderness to palpation over the nasal bridge. The right upper eyelid is significantly edematous, erythematosus, and warm; an eye examination reveals a conjunctival injection with chemosis. His extraocular movements are limited secondary to pain.

■ CASE THREE
An 8-year-old girl with a medical history of mild intermittent asthma and seasonal allergies presents with an irritated right eye. Her parents report the patient spent most of the previous weekend playing outside. When she woke up on Monday morning, her eye was red and irritated and she exhibited congestion, rhinorrhea, and a dry cough. Now two days later, her right eye is matted shut with “gunk.”

Her vital signs are blood pressure 110/64, heart rate 73, respiratory rate 14, and oxygen saturation 100% on room air; she is afebrile. Mild clear nasal discharge is noted; the eye examination reveals bilateral conjunctival injection and a small amount of purulent discharge in the medial corner of her right eye.

The differential diagnosis for red eye presentations is very broad and includes both extracocular and orbital infections, inflammatory conditions (eg, vasculitis), malignancies, trauma and foreign bodies, corneal problems, and even acute angle-closure glaucoma and cluster headaches, just to name a few (Table 1). Many of these pathologies are beyond the scope of this article, which will focus on the three most common causes of an acute red eye: preseptal cellulitis, orbital cellulitis, and conjunctivitis.

CRITICAL DECISION
What elements in a patient’s history can help distinguish between the various causes of red eye?

Because the differential for red eye is so broad, a thorough history and physical examination are paramount. The timeline of the patient’s symptoms often provide clues about acute, subacute, and chronic etiologies. Another important consideration is whether the redness is associated with pain. Painful conditions generally are more urgent and pose a greater risk of vision loss if not recognized and treated quickly. Symptoms that suggest infection include a purulent or watery discharge and a “scratchy” sensation.

The clinician should ask the patient to describe any changes in vision, including photophobia, blurriness, or compromised sight. Beyond the acute complaint, a complete medical history should be gathered, including details about previous ocular diseases or trauma. Systemic symptoms may be related to the red eye, as well, particularly in patients with vasculitis or autoimmune disorders. Conjunctivitis generally is heralded by diffuse, painless redness; a foreign body or “scratchy” sensation; pruritus; and watery to purulent discharge. Patients should not complain of vision changes.

Most cases of preseptal and orbital cellulitis are secondary to infection of surrounding tissues (eg, nasopharynx, paranasal sinuses, and skin), so it is important to obtain information about any recent illness. Both of these disease entities may present with periocular swelling, erythema, and warmth; however, a thorough history can help differentiate between the two.

CRITICAL DECISION
How should the physical examination be approached in a patient with red eye?

Any patient presenting with a red eye should receive a complete evaluation of the head, eyes, ears, nose and throat (HEENT). The orbit, eyelids, and all surrounding external structures should be examined (Figure 1). If a foreign...
body is suspected, the eyelids should be everted to assess for perforation of the eye. Surrounding tissue should be palpated to evaluate for preauricular lymphadenopathy, which can be a sign of infection. The orbit should be assessed for proptosis, chemosis, conjunctival injection, and corneal clouding or defects.

The pupils should be evaluated for both shape and reactivity. A topical anesthetic can help facilitate a better examination in patients with significant pain or photophobia. An ophthalmoscope also should be used to examine the retina for signs of papilledema. Extraocular movement should be assessed in all four directions and evaluated for nystagmus. These findings can help differentiate between orbital cellulitis, which often restricts extraocular movement, and preseptal cellulitis, which leaves them intact.

Visual acuity, which should be documented when managing any eye complaint, can be assessed by using a standard Snellen chart or similar smartphone application. If the patient typically wears glasses but does not have them in the emergency department, the chart can be read through a pinhole to exclude peripheral light and help correct for refraction. If unable to read the chart, patients should be asked to count the numbers of fingers at two feet away or detect hand motion directly in front of them. In cases of total vision loss, the ability to detect light should be gauged.

It is imperative to measure intraocular pressure unless an open globe is suspected, particularly in cases of suspected retrobulbar hematoma or acute angle-closure glaucoma, which can precipitate permanent vision loss if not treated early. The eye can be anesthetized topically prior to the procedure. Tonometer pressures above 20 are considered abnormal and may require an emergent ophthalmological consultation.

For further evaluation of the cornea, fluorescein dye should be administered and the eye should be examined under cobalt blue light with a slit or Wood lamp. Defects such as ulcers or abrasions will appear bright yellow (Figure 2). Certain types of keratitis, which can lead to corneal scarring and vision loss, can be confirmed by specific patterns on examination. Herpetic keratitis, for example, can be diagnosed by the presence of dendrites visualized under the blue light (Figure 3).

A quick slit lamp examination also can reveal important information about the anterior chamber of the eye, including signs of inflammation such as cell and flare (protein and white blood cells floating in the aqueous humor). The diagnostic tool also can be used to measure the angle of the cornea to assess for acute angle-closure glaucoma.
CRITICAL DECISION

What clinical findings can help differentiate between preseptal and orbital cellulitis?

The orbital septum is a fibrous membrane that extends from the orbital rim to the lid margin. Not only is it an important anatomical landmark for distinguishing between preseptal (also known as periorbital) and orbital (or postseptal) cellulitis, the septum also plays a functional role in preventing eye diseases from extending into the orbit and, consequently, the central nervous system.

Preseptal Cellulitis

Preseptal cellulitis describes an infection that erupts anterior to the periosteal extension (ie, septum). Although usually self-limited, the pathogen can spread to the orbit if not treated early and appropriately. Orbital cellulitis, on the other hand, is an ophthalmological emergency that can lead to endophthalmitis and permanent vision loss. Patients with preseptal cellulitis typically complain of acute-onset eyelid swelling and redness, but no actual pain within the orbit. Orbital involvement, however, is marked by pain, decreased vision, the inability to “look around,” and signs of systemic infection such as fever and malaise.

Preseptal cellulitis is most common in children between 18 months and 3 years of age, and typically is precipitated by a local eyelid infection, trauma with secondary infection, local spread of a dental abscess, extension of a regional skin disease (eg, impetigo), or an infected insect bite. The most common pathogens include Streptococcus pneumoniae, Staphylococcus aureus, and Haemophilus influenzae (especially in children).

These patients often present with inflammation marked by erythema, warmth, and tenderness surrounding the orbit and an edematous eyelid. Vision and pupillary reflexes will be normal, extraocular movements will be intact, and the eye itself will be white and “quiet.” No cells or flare will be noted and no injections, chemosis, or irritation to the layers of the eye will be involved. The diagnosis of this condition is based purely on the physical examination.

Orbital Cellulitis

These features are in contrast to those of orbital cellulitis, which can be both vision- and life-threatening. The most common complication of this disease (seen in 50% of cases) is the formation a subperiosteal or orbital abscess, which should be evaluated with daily monitoring of visual acuity and pupillary reactivity. The infection can extend into the cranium, causing an epidural or subdural empyema, brain abscess, or meningitis; or track through the venous system, resulting in cavernous sinus thrombosis or dural sinus thrombosis. While uncommon, extraorbital extension of the infection is possible.

Although the clinical signs of orbital cellulitis can be similar to those of preseptal disease, the diagnosis can be distinguished by pain with movement of the eye, which can decrease visual acuity and impair extraocular movements. The disease also may be evidenced by an abnormal pupillary reflex known as the Marcus Gunn pupil (ie, relative afferent pupillary defect), which can be detected by a local eyelid infection, trauma with secondary infection, local spread of a dental abscess, extension of a regional skin disease (eg, impetigo), or an infected insect bite. The most common pathogens include Streptococcus pneumoniae, Staphylococcus aureus, and Haemophilus influenzae (especially in children).

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by swinging a bright light from eye to eye. The affected pupil will constrict less when exposed to the light; however, this reaction can be difficult to spot since both pupils may appear to dilate.\textsuperscript{1,2} The eye also will appear red and oftentimes proptotic, with chemosis and noted diplopia.\textsuperscript{4,5}

The mean age of patients presenting with orbital cellulitis is 12 years.\textsuperscript{3,7} The most common etiologies are trauma with secondary infection and extension of bacterial ethmoid sinusitis into the orbit, a pathology that accounts for 60\% to 80\% of all cases.\textsuperscript{6} Most infections can be attributed to \textit{S. pneumoniae}, Group \textit{A Streptococcus}, \textit{S. aureus}, \textit{Moraxella catarrhalis}, \textit{H. influenzae} (in patients <3 years old), or a mixed bacterial infection, including anaerobes.\textsuperscript{4,7}

\textit{Pseudomonas aeruginosa} and opportunistic fungal infections also should also be considered in immunocompromised patients, including those with HIV/AIDS.\textsuperscript{6} As this infection can result in serious systemic complications, a computed tomography (CT) scan should be performed to evaluate for the presence and extent of sinus disease. Hospitalization, intravenous antibiotics, and careful monitoring are required.\textsuperscript{4,5}

### CRITICAL DECISION

What red flags should raise suspicion for various types of conjunctivitis?

Conjunctivitis is characterized by dilation of the superficial conjunctival vessels, resulting in hyperemia and edema of the conjunctiva with associated discharge (\textit{Table 2}).\textsuperscript{4} The key to diagnosis centers on a focused eye examination and thorough history; however, the clinical signs of infection can be notoriously nonspecific. Patients typically do not complain of vision changes and have minimal photophobia or eye pain.\textsuperscript{9,10}

The type of ocular discharge can range widely; bacterial conjunctivitis often is associated with mucoid to purulent drainage, while viral infections may be accompanied by watery discharge.\textsuperscript{11} Although it has been suggested that the type of discharge observed may aid in distinguishing etiologies, this idea is not fully supported by scientific evidence.\textsuperscript{11}

#### Allergic Conjunctivitis

Allergic conjunctivitis is a hypersensitivity reaction to an environmental allergen, usually

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### TABLE 2. Comparison of Conjunctivitis Etiologies\textsuperscript{2}

<table>
<thead>
<tr>
<th>Type</th>
<th>Sign/Symptoms</th>
<th>Causes</th>
<th>Treatment</th>
<th>Additional Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allergic</td>
<td>Bilateral watery discharge, itching</td>
<td>Pollens</td>
<td>Avoid allergens, oral antihistamines.</td>
<td>Patients often will have history of seasonal allergies.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mild: Artificial tears 4x/day, cool compresses</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate: Topical antihistamines 2x/day</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(lopaptadine 0.1%, epinastine 0.05%, nedocromil 2%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\textbf{PLUS} topical ketorolac 0.5% \textit{OR} pemirolast 0.1%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\textbf{Severe:} Additional topical steroid 4x/day</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(loteprednol 0.2%, fluorometholone 0.1%)</td>
<td></td>
</tr>
<tr>
<td>Viral</td>
<td>Itching, foreign body sensation, serous discharge</td>
<td>Adenovirus (leading cause)</td>
<td>\textbf{Symptom control:} artificial tears, cool compresses, topical antihistamine for severe itching, topical steroids (in severe cases)</td>
<td>Symptoms may last 2-3 weeks.</td>
</tr>
<tr>
<td>Herpes zoster</td>
<td>Pseudodendrites, Hutchinson sign</td>
<td>Varicella zoster virus</td>
<td>\textbf{Topical antivirals} 5x/day (trifluridine 1% \textit{OR} ganciclovir 0.05%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Steroids are contraindicated.</td>
<td></td>
</tr>
<tr>
<td>Herpes simplex</td>
<td>Dendrites, herpetic rash</td>
<td>Herpes simplex virus</td>
<td>\textbf{Topical antivirals} 5x/day (trifluridine 1% \textit{OR} ganciclovir 0.05%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Steroids are contraindicated.</td>
<td></td>
</tr>
<tr>
<td>Acute bacterial</td>
<td>Bilateral mucopurulent discharge, “matting” of eyelids in morning</td>
<td>\textit{Staph} spp, \textit{Haemophilus influenzae}</td>
<td>\textbf{Topical antibiotic} (eg, trimethoprim/polymyxin B, fluoroquinolone) 4x/day for 5-7 days</td>
<td></td>
</tr>
<tr>
<td>Hyperacute bacterial</td>
<td>Copious thick purulent discharge, preauricular node</td>
<td>\textit{Neisseria gonorrhoeae}</td>
<td>\textbf{Ceftriaxone} (1 g IM x1), ciprofloxacin ointment 4x/day, and saline irrigation 4x/day, treat chlamydial coinfection with oral azithromycin (1 g x1)</td>
<td></td>
</tr>
<tr>
<td>Adult inclusion</td>
<td>Stringy mucus discharge, inferior conjunctival follicles</td>
<td>\textit{Chlamydia trachomatis}</td>
<td>\textbf{Oral azithromycin} (1 g x1) \textit{OR} oral doxycycline (100 mg 2x/day for 7 days) \textbf{PLUS} topical erythromycin ointment (2x/day for 21 days)</td>
<td></td>
</tr>
<tr>
<td>Trachoma</td>
<td>Mucopurulent discharge, chronic scarring of eyelid, conjunctiva, or cornea</td>
<td>\textit{Chlamydia trachomatis} (subtype A-C)</td>
<td>\textbf{Oral azithromycin} (20 mg/kg x1) \textit{OR} doxycycline (100 mg 2x/day for 14 days) \textbf{PLUS} topical tetracycline \textit{OR} erythromycin ointment (2x/day for 28 days)</td>
<td>More common in developing countries or areas of poor sanitation.</td>
</tr>
</tbody>
</table>
pollen or dander (Figure 4). The most common symptoms include itching and bilateral, watery mucoid discharge. This condition often is chronic and has a seasonal predilection for sensitive individuals, who typically have a history of atopic disease such as asthma, eczema, and hay fever. The examination will reveal bilateral conjunctival injection, mild watery to mucoid discharge, and possible tearing and chemosis.

**Viral Conjunctivitis**

Viral conjunctivitis (Figure 5) is the most common form of acute infection (responsible for 80% of cases). Affected patients often report exposure to another infected individual and/or a recent upper respiratory infection. Symptoms include a burning sensation, scant watery discharge, and tearing; a palpable preauricular lymph node also may be present, but this finding is rare. Highly contagious, the disease is transmitted via direct contact with contaminated hands but can be transmitted through fomite for up to 72 hours. Strict hand hygiene is imperative to prevent the spread.

The adenovirus is the most common etiology of viral conjunctivitis; other culprits include enterovirus, coxsackievirus, varicella-zoster virus, and herpes simplex virus (HSV). Much like other forms of viral conjunctivitis, signs of a herpes simplex infection include a thin, watery discharge; however, it also is important to examine the patient for any associated skin changes and/or periorcular herpetic lesions. HSV virus also can spread to the cornea and/or uvea.

Patients should be assessed using dedicated slit lamp. When used in conjunction with fluorescein staining, this diagnostic modality can reveal the presence or absence of pathognomonic dendritic lesions, which appear as thin, linear, branching epithelial ulcerations with club-shaped terminal bulbs.

Varicella-zoster virus (VZV), also known as shingles, can include ocular involvement, specifically within the first and second branch of the fifth cranial nerve. Although associated vesicular lesions in a dermatomal distribution often can be seen, ocular symptoms may precede skin findings.

Given the concomitant innervation of the cornea via the nasociliary branch of V1, skin involvement on the tip of the nose (also known as Hutchinson sign) suggests likely corneal involvement. In early disease, VZV can mimic the dendritic pattern of HSV conjunctivitis; however, the infection later manifests as a pseudodendritic pattern characterized by a raised mucus plaque without a terminal bulb.

**Bacterial Conjunctivitis**

Acute bacterial conjunctivitis, which most commonly is caused by *S. pneumoniae, S. aureus,* or *H. influenzae,* is spread through direct contact with contaminated objects (frequently finger tips). Typical symptoms include mucopurulent discharge and conjunctival hyperemia (Figure 6). Tender, inflamed conjunctiva accompanied by matting of the eyelids is highly suggestive of this diagnosis. The disease can spread to deeper ocular structures without prompt treatment; however, the inflammation should be limited to the conjunctiva in uncomplicated cases and not include any corneal or anterior chamber involvement.

<table>
<thead>
<tr>
<th>TABLE 3. Time to Onset of Neonatal Conjunctivitis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Etiology</strong></td>
</tr>
<tr>
<td>Chemical</td>
</tr>
<tr>
<td>Gonococcal</td>
</tr>
<tr>
<td>Chlamydial</td>
</tr>
<tr>
<td>Herpes simplex virus</td>
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</table>

<table>
<thead>
<tr>
<th>TABLE 4. Medications for Allergic Conjunctivitis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class</strong></td>
</tr>
</tbody>
</table>
| Mast cell stabilizers | *Cromolyn sodium (Crolom) 1 drop 4x-6x/day*  
*Olopatadine 0.1% (Patanol) 1-2 drops each eye 2x/day*  
*Lodoxamide 0.1% (Alomide) 1-2 drops each eye 4x/day*  
*Ketotifen 0.025% (Alaway OTC, Zaditor) 1-2 drops each eye 2x/day* |
| *Less expensive and available over the counter* |
| Antihistamines | *Naphazoline (Vasocon, Naphcon): 1 drop 2x-4x/day PRN*  
*Epinastine (Elestat) 0.05% 1 drop each eye 2x/day*  
*Bepotastine (Bepreve) 1.5% 1 drop each eye 2x/day* |
| NSAIDs | *Ketorolac 0.5% (Acular) 1 drop 4x/day for 7 days*  
*Diclofenac 0.1% (Voltaren) 1 drop 4x/day* |
Copious amounts of purulent discharge in sexually active patients should raise concern for hyperacute bacterial conjunctivitis, usually caused by gonococcal infection. The discharge has been described as a “waterfall of pus” that immediately reaccumulates after being wiped away. Patients usually present early, given the acuity of onset and severity of symptoms. It is important to obtain a thorough social and sexual history when examining these patients, who also should be questioned about any history of genital lesions or discharge.

Chronic, subacute cases (>4 weeks) are associated with a variety of bacteria; these patients warrant an ophthalmological consultation. Chlamydia conjunctivitis, also referred to as inclusion conjunctivitis, can be either subacute or chronic. These patients typically present after multiple courses of antibiotics have failed. Most notably, the disease is marked by a follicular response in the inferior conjunctival fornix (small rice grain-sized pale bumps) that is considered pathognomonic.

Newborn Conjunctivitis

Diagnosed within the first 4 weeks of life, newborn conjunctivitis manifests in several forms: chemical, gonorrheal, chlamydial, and herpetic (Table 3) disease. Given the route of transmission (from mother to fetus during transit through an infected birth canal), neonates routinely receive postpartum prophylaxis with antibiotic ointment (historically silver nitrate). However, the prophylactic treatment itself is responsible for the most common form of the disease, chemical conjunctivitis. These infections typically erupt within 24 to 36 hours after the application of eye ointment. Symptoms, including mild palpebral edema and clear sterile eye discharge, are self-limited and usually resolve within 48 hours. The incidence of this condition has declined with the growing use of erythromycin ointment.

Gonorrheal conjunctivitis usually erupts within the first 2 to 4 days of life but can occur as long as 7 days after birth. Features of the infection include severe bilateral involvement lid edema, chemosis, and severe purulent exudate that quickly reaccumulates after being wiped away. Patients also are at risk for vision-threatening complications such as corneal ulceration and perforation.

Chlamydia conjunctivitis has a delayed incubation period and typically presents later than the other causes of neonatal conjunctivitis. Symptoms usually develop within 5 to 14 days of birth, but onset can be delayed for several weeks. The infection begins with mild watery discharge that eventually becomes copious and purulent with diffuse conjunctival swelling and chemosis.

Herpes simplex virus conjunctivitis usually manifests within 6 to 14 days of birth. Infants delivered to mothers with primary infections are most at risk for the most devastating complications, including corneal involvement, uveitis, and even permanent vision loss. The diagnosis is evidenced by the presence of conjunctival hyperemia and a dendritic pattern that can be visualized with fluorescein staining of the conjunctiva and/or cornea. The periocular skin should be examined for any associated vesicular lesions, and an emergent ophthalmological consultation should be requested.
Critical Decisions in Emergency Medicine

CRITICAL DECISION

What diagnostic studies can help guide the diagnosis and management of red eye?

Further diagnostic tests are rarely needed when evaluating a patient with red eye; however, certain ancillary tests can be valuable in select situations. A complete blood count (CBC) may be warranted if the patient is febrile and there is concern for systemic disease. Orbital cellulitis can cause a potential elevation in the white blood cell count, although this finding is less likely in cases of preseptal cellulitis. A measurement of the erythrocyte sedimentation rate also can help diagnose temporal arteritis, especially in the context of an elderly female with a unilateral red eye. Cultures should be obtained in any patient with a corneal ulceration or orbital cellulitis. Although routine cultures are controversial in patients with conjunctivitis, they may be indicated in patients with severe, recurrent, or recalcitrant signs of infection. A Gram stain and culture are particularly sensitive for guiding antibiotic management. A polymerase chain reaction test should be initiated if suspicion is high for chlamydia. Although herpes keratitis usually is diagnosed on clinical examination, a Giemsa stain can be used to evaluate for multinucleated cells; a viral culture also can help confirm the disease.

CRITICAL DECISION

How should red eye be managed in the acute setting?

**Cellulitis**

Preseptal cellulitis typically can be treated on an outpatient basis with 10 days of oral antibiotics (typically cephalaxin, dicloxacillin, or clindamycin) and warm compresses applied to the periorbital region for comfort. Patients with orbital cellulitis must be treated more aggressively, as the disease can result in severe complications such as meningitis, vision loss, and septic shock.

These patients require hospitalization and treatment with intravenous antibiotics, typically a 7-day course of ampicillin sodium/sulbactam sodium or a third-generation cephalosporin followed by an oral course of amoxicillin/clavulanate potassium, cefuroxime, or cefprozil. If methicillin-resistant bacteria is suspected, a 7-day intravenous course of vancomycin, linezolid, or daptomycin is recommended, followed by an oral course of clindamycin, sulfamethoxazole and trimethoprim, or doxycycline. Surgical drainage may be warranted if symptoms are significant, a large abscess can be visualized on CT, or the patient fails to improve with appropriate antibiotic treatment.

**Conjunctivitis**

The type of conjunctivitis completely dictates the course of disease management (Table 2). Viral cases typically are self-limited and resolve in 10 to 14 days with good eye hygiene and the application of cool compresses and lubricants. Although steroids usually are not required, there are two exceptions to this rule: herpes simplex and herpes zoster infections of the conjunctiva. HSV infections should be treated with antiviral eye drops (eg, trifluorothymidine); topical steroids are contraindicated as they can increase the risk of perforation. Immunosuppressed patients with VZV infections involving V1 ophthalmic nerve distribution should be treated with intravenous acyclovir to reduce the risk of progression to herpes encephalitis. Allergic conjunctivitis also is best managed with the application of cool compresses and lubricants and avoidance of allergens. When supportive care cannot sufficiently resolve symptoms, ocular mast cell stabilizers are the preferred second-line treatment and have been proven to be safe and well tolerated. Ocular antihistamines and nonsteroidal anti-inflammatory agents also can be used (Table 4). Symptoms that do not respond to topical medications can be treated with oral antihistamines of the H(1) class, which are particularly effective in controlling associated systemic complications. First-generation agents (eg, diphenhydramine) are nonselective

---

**FIGURE 6. Bacterial Conjunctivitis**

This 30-year-old woman’s symptoms are complicated by a corneal abrasion. Note the drainage and discoloration to the sclera.
for H(1) and cholinergic receptors, and therefore are associated with greater central nervous system depression. On the other hand, second- and third-generation antihistamines (eg, loratadine and cetirizine) are more selective for peripheral H(1)-receptors; these drugs are less sedating and often can be purchased over the counter.9,10

Symptoms of bacterial conjunctivitis usually resolve within two weeks with supportive care, including good eye hygiene.13 Although seldom required, a 7-day course of antibiotics may clear symptoms within 48 to 72 hours from start of treatment.9,10,13 The first-line treatment for bacterial infections is trimethoprim-polymyxin B solution (2 drops 4x/day) during the daytime, and erythromycin ointment (0.5%) nightly.9,10 More serious or refractory cases may benefit from additional medicated drops, including gentamicin 0.3% ointment or solution, ciprofloxacin 0.3% ointment or solution, ofloxacin 0.3% solution, or tobramycin 0.3% solution (the ointment is expensive and not generic).5,9,10

It is important to avoid neomycin drops, which can trigger allergic reactions and are highly sensitizing in 26% of patients after only three days of use.3 Patients with gonococcal or chlamydia conjunctivitis should be instructed to clear discharge frequently with saline solution, and mothers and partners should be treated for infection.2 Treatment depends on local susceptibilities. For penicillin-susceptible organisms, intravenous (IV) penicillin G (100,000 units/kg/day 4x/day for 7 days) is recommended.9,10 For those with penicillin-resistant strains or unknown resistance, ceftriaxone (25-50 mg/kg up to 250 mg IV, or a single intramuscular [IM] dose), or a single dose of cefotaxime (100 mg/kg IV or IM) will effectively treat the infection.10,13

Conjunctivitis associated with chlamydia often manifests distinguishing features. Trachoma or granular conjunctivitis caused by chlamydia trachomatis should be treated with a single dose of oral azithromycin (20 mg/kg-1g ) plus oral doxycycline (100 mg 2x/day for 21 days).10 Any patient with suspected chlamydia conjunctivitis also should be treated with 250 mg IM ceftriaxone to cover for possible concurrent gonorrhea infection. Adult inclusion conjunctivitis should be managed with oral doxycycline (100 mg 2x/day) plus oral erythromycin (250 mg 4x/day for 21 days).10 The first-line treatment for neonatal inclusion conjunctivitis is erythromycin base or erythromycin ethylsuccinate (50 mg/kg/day divided 4x/day for 14 days).10

CRITICAL DECISION

**Which patients require urgent follow up or ophthalmological evaluation?**

Most cases of red eye can be treated easily in the acute setting; however, there are several presentations that can result in severe sequelae and warrant an emergent ophthalmological consultation. Gonorrhea conjunctivitis is an aggressive infection that, if not properly treated, can result in corneal extension with ulceration, perforation, and permanent vision loss.8 Orbital cellulitis can culminate in fatal complications such as meningitis and cavernous sinus thrombosis.14 Uveitis, angle closure glaucoma, and endophthalmitis — eye diseases that are beyond the scope of this article — also necessitate specialty evaluations.2

Although emergency department clinicians are well prepared to treat most types of conjunctivitis, the American Academy of Ophthalmology recommends prompt ophthalmological evaluation in patients who develop vision loss, moderate or severe pain, severe purulent discharge, corneal involvement, or conjunctival scarring; have a history of recurrent episodes or HSV eye disease; or are otherwise immunocompromised.9 In addition, specialty consultation is warranted for those with conjunctivitis who wear contact lenses, require topical corticosteroids, or report no improvement after 7 days.8

**Summary**

It is imperative for emergency medicine clinicians to keep a broad differential diagnosis in mind when evaluating red eye presentations. Providers must determine which complaints are benign, which need treatment, and which necessitate urgent to emergent ophthalmological management. The most common causes of acute red eye are preseptal cellulitis, orbital cellulitis, and conjunctivitis. Conjunctivitis is distinguished by eye discharge, possible pruritus, or a scratchy feeling. Preseptal and orbital cellulitis often are associated with swelling, redness, and pain. When pain is associated with extraocular movements or there are changes in visual acuity, orbital cellulitis should be high on the differential until proven otherwise.

A complete eye evaluation should be performed in virtually any patient who presents with a red eye. The assessment should include a good HEENT examination, gross inspection, measurements of visual acuity and intraocular pressure, fluorescein staining, and a slit lamp examination. When diagnosed early, acute conjunctivitis and preseptal cellulitis are benign and self-limited conditions.

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**Pitfalls**

- Failing to consider systemic disease, fungal infections, and other aggressive pathologies in the immunocompromised patient.
- Failing to measure visual acuity in every patient with a red eye.
- Relying solely on a gross examination when evaluating red eye; subtle findings such as herpetic dendrites and small foreign bodies may be overlooked.
- Prescribing steroid eye drops to patients with conjunctivitis; this treatment is not needed and actually can worsen certain conditions.
Patients should be advised to follow up with an ophthalmologist or primary care provider. An urgent or emergent ophthalmological evaluation may be required in cases of orbital cellulitis, particularly in patients with severe pain or vision changes, or at high risk for vision loss or long-term disability.

REFERENCES
A 74-year-old woman with episodes of lightheadedness.

The Critical ECG

Sinus rhythm with second-degree atrioventricular (AV) block type 2 (Mobitz II), rate 47, probable reversal of leads V₂ and V₃.

Second-degree AV block is characterized by intermittent non-conducted P waves. Mobitz II conduction is diagnosed when the PR intervals in the conducted beats remain constant. The R-wave progression in the anteroseptal leads is abnormal, and is likely the result of reversed positions of leads V₂ and V₃ on the chest wall.

By Amal Mattu, MD, FACEP

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CASE

A 79-year-old man with hemophilia A (factor VIII deficiency) presents with two episodes of bright red blood per rectum in the past 12 hours. The patient has a history of atrial fibrillation and surgically resected colon cancer. Despite his hemophilia, he takes warfarin due to a previous episode of ischemic colitis, which was suspected to be a consequence of his atrial fibrillation.

His vital signs are blood pressure 139/75, heart rate 80, respiratory rate 16, temperature 36.6°C (97.9°F), and oxygen saturation 96% on room air. The patient is alert and in no acute distress. He denies fever but notes mild abdominal discomfort. His examination is normal, with a regular cardiac rhythm and no abdominal tenderness. His ECG shows a normal sinus rhythm.

Laboratory tests reveal an international normalized ratio of 2, hematocrit 37 (decreased from a recent baseline of 41), and a factor VIII level of 60 (normal range 74%-212%). The patient is orthostatic and is given a normal saline bolus, recombinant factor VIII, 4-factor prothrombin complex concentrate, and vitamin K. He experiences a third episode of blood per rectum while in the emergency department.

A CT scan of the abdomen and pelvis with IV contrast (but without enteric contrast) is performed to assess for mesenteric ischemia, diverticulitis, colon cancer recurrence, and the source of the bleeding.

A. Axial CT slice, abdominal/soft tissue window. Low-density fluid is present in the descending colon. Against this backdrop, high-density fluid representing extravasated vascular contrast is readily recognized. Had high-density enteric contrast been administered, the extravasated contrast would have been masked.
CASE RESOLUTION

The patient was admitted and underwent mesenteric angiography. The patient tested positive for *Clostridium difficile* and improved with antibiotic therapy.

**KEY POINTS**

- For the detection of gastrointestinal hemorrhage, CT angiography should be performed **without** high-density enteric (oral or rectal) contrast, as high-density contrast material in the intestinal lumen will obscure abnormal extravasation of injected vascular contrast.\(^1\)\(^3\)

- PACS tools can measure the density of fluid collections to determine the likely material. Density >90 Hounsfield units (HU) is typical in acute hemorrhage.\(^1\) CT detects lower GI bleeding in about 38% of clinical cases of hemorrhage (a rate comparable to tagged red blood cell scintigraphy), but is more accurate in localizing the bleeding source (53%, 95% CI 39%-67% for CT vs 30%, 95% CI 22%-40% for scintigraphy).\(^2\)

- Computed tomography angiography (CTA) also appears to have a prognostic value.\(^3\) In one study, 77% of patients with lower GI bleeding and a negative initial CTA did not rebleed and did not require angiographic embolization or surgical intervention.\(^4\)

- Appropriately timed intravenous contrast is essential for the detection of mesenteric ischemia; enteric contrast is not required.\(^5\)\(^6\) For diverticulitis, CT is highly sensitive and specific without enteric contrast.\(^9\)

**REFERENCES**

The Critical Procedure

WOUND CLOSURE WITH STAPLES

The simplest, fastest technique available for the closure of linear wounds in the emergency department, stapling offers several advantages over other laceration repair methods, including a lower incidence of infection with comparable cosmetic outcomes.

CONTRAINDICATIONS
- Planned radiographic imaging
- Location of wound on patient’s body

Risks and Benefits
The risks associated with wound stapling are minimal and are similar to those posed by other methods of laceration repair. Possible complications include infection; poor cosmetic outcomes; and pain during removal, which some patients find to be more pronounced than with the removal of sutures.

Surgical staples offer many advantages over traditional sutures and tissue adhesives, including a decreased rate of infection in contaminated wounds. Staples also can be placed significantly faster than sutures, while providing similar — and sometimes superior — cosmetic results. A final benefit that should not be overlooked is the reduced risk of an accidental needle-stick injury to the health care provider.

Reducing Side Effects
As with any method of skin closure, general precautions should be taken prior to performing the procedure, including thorough wound cleaning and the possible administration of anesthetic, analgesic, or anxiolytic agents. Many clinicians avoid anesthetics, however, due to the discomfort associated with the injection.

By Steven J. Warrington, MD, MEd
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itself and the increased risk of needle-stick injuries.

Staples alone are not ideal for closing wounds that are deep or nonlinear, and generally should not be used to treat lacerations on the face, neck, hands, feet, or over extensor/flexor surfaces. When the lengths of two opposite sides of a laceration are uneven, stapling can warp the adjacent skin and create a “dog ear.” This cosmetic risk can be reduced by everting the skin edges and aiming the midpoint of the staple over the laceration. The device should not be allowed to apply too much pressure on the wound during the procedure.

Patients should be informed about the possibility of worse outcomes if staples are left in place longer than recommended. A specially designed surgical staple remover is preferred over a hemostat or other non-specific tool.

**Special Considerations**

While skin stapling can be used alone for the repair of simple wounds, it also can be an effective adjunct in the multilayer closure of deep, V-shaped, or nonlinear lacerations, including those involving the scalp. In such cases, initial sutures may be used to approximate the skin at selected points and create multiple linear wounds that are amenable to staples. If a “dog ear” is inadvertently created, the laceration can be extended toward the redundant skin, which can be excised to create a longer but aesthetically improved wound.

Staples generally should remain in place for approximately the same amount of time sutures would.

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**TECHNIQUE**

1. **Obtain** consent if possible, and notify staff of the procedure.
2. **Consider** whether the situation warrants an anesthetic, analgesic, or anxiolytic agent.
3. **Prepare** the room and patient for the procedure.
   a. The stapler and any other required equipment should be brought to the bedside.
   b. Clean the wound.
4. **Place** initial sutures if necessary (eg, for deep or complex lacerations).
5. **Approximate** and evert the skin edges prior to staple placement.
6. **Align** the midpoint of the stapler with where the skin edges meet.
7. **Fire** the stapler while allowing it to rest just above or on the skin. The head of the stapler should not be allowed to apply significant pressure to the patient’s skin.
8. **Repeat** this process until the wound is closed.
9. **Consider** applying antibiotic ointment and a dressing over the wound.
10. **Instruct** the patient on wound care and staple and/or suture removal.
Thoracic aortic dissection is a critical but difficult diagnosis to make due to its low incidence and variable clinical presentation. Written by the American College of Emergency Medicine (ACEP), this clinical policy addresses evidence regarding the emergency department diagnosis and initial management of suspected nontraumatic thoracic aortic dissection in nonpregnant, adult patients. It aims to answer five key clinical questions.

1. Are there clinical decision rules that can safely identify patients at low risk for thoracic aortic dissection?

   The low prevalence of this disease presents a challenge in the development of prospective decision rules. Existing clinical protocols should not be used alone to identify very low-risk patients (level C recommendation). The decision to pursue further diagnostic tests should be made at the discretion of the treating provider.

2. Is a negative D-dimer sufficient to identify patients at very low risk for thoracic aortic dissection?

   D-dimer has been studied as a potential means of excluding aortic dissection and decreasing the need for additional diagnostic testing. However, the test is insufficient and should not be used alone to exclude this deadly diagnosis (level C recommendation). False-negative values can occur in certain populations; elevations are not specific for thoracic aortic dissection.

3. Is the diagnostic accuracy of CTA at least equivalent to TEE or MRA to exclude thoracic dissection?

   In the studies reviewed, computed tomography angiography (CTA) showed a diagnostic accuracy similar to that of transesophageal echocardiography (TEE) and magnetic resonance angiography (MRA) and may be used to exclude thoracic aneurysm (level B recommendation). Additionally, CTA has the potential ability to identify alternative etiologies for the patient’s symptoms.

4. Can an abnormal bedside TTE confirm an aortic dissection diagnosis?

   Although bedside transthoracic echocardiography (TTE) is an appealing diagnostic tool, particularly in hemodynamically unstable patients, current evidence does not support the reliability of a negative test to definitively diagnose thoracic aortic dissection (level B recommendation). However, a TTE finding suggestive of aortic dissection warrants surgical consultation or transfer to a higher level of care (level C recommendation).

5. Does reducing the targeted heart rate and blood pressure help mitigate morbidity and mortality?

   The leading cause of death in these patients is a progressive dissection resulting in rupture. Animal studies suggest that this devastated complication is associated with shear force. Therefore, major specialty guidelines list the following therapeutic targets: heart rate (60 beats/min), and systolic blood pressure (<120 mm Hg).

   While any elevations should be corrected, no specific targets have demonstrated a reduction in morbidity and mortality (level C recommendation).

**KEY POINTS**

- No existing clinical decision rules can safely identify patients at very low risk for thoracic aortic dissection.
- Additionally, a negative D-dimer is not sufficient to exclude the diagnosis in this population.
- The accuracy of CTA is similar that of TEE and MRA for excluding thoracic aortic dissection.
- Bedside TTE is insufficient for diagnosing thoracic aortic dissection.
- No specific blood pressure and heart rate targets have demonstrated reduced morbidity or mortality.
OBJECTIVES

On completion of this lesson, you should be able to:

1. Apply appropriate diagnostic criteria when assessing pediatric patients with blunt abdominal trauma.
2. Describe the risk factors and clinical signs that point to intraabdominal injury (IAI).
3. Understand the benefits and drawbacks of diagnostic imaging and laboratory tests in children with suspected IAI.
4. Describe the acute management of both hemodynamically stable and unstable children with blunt abdominal injuries.
5. Identify children at low risk for IAI requiring acute intervention.

FROM THE EM MODEL

18.0 Traumatic Disorders
   18.1 Trauma
      18.1.1 Abdominal Trauma

Gut Reaction

Pediatric Blunt Abdominal Trauma

LESSON 4

By Robert P. Olympia, MD; and Annie Huyler, BA

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Reviewed by Sharon E. Mace, MD, FACEP

CRITICAL DECISIONS

- How should the initial assessment and management of pediatric blunt abdominal trauma be approached?
- How can clinical prediction tools be used to evaluate children with suspected blunt abdominal trauma?
- When is diagnostic imaging indicated?
- What role should laboratory tests play in the evaluation of pediatric trauma patients?
- When is it safe to discharge a child who has sustained blunt abdominal trauma?

Trauma to the torso is the second most frequent cause of death in children. More than 80% of these cases can be attributed to a blunt abdominal injury, the most under recognized fatal presentation in pediatric patients.1 While mortality is less than 20% in patients with isolated liver, spleen, or pancreatic trauma, it rises above 20% with involvement of the gastrointestinal tract and can be as high as 50% if major vessels are injured.2
Critical Decisions in Emergency Medicine

CASE PRESENTATIONS

CASE ONE

A 6-year-old girl presents following a rollover motor vehicle collision (MVC) in which she was a restrained, backseat passenger. Her mother’s vehicle was traveling at a moderate rate of speed (45 miles per hour) when it was “T-boned.” EMS reports that the patient remained awake at the scene of the accident.

Her vital signs are blood pressure 110/76, heart rate 110, and respiratory rate 26. She is awake and alert. Her Glasgow coma score (GCS) is 15. She remembers the event and denies head headache; neck, back, or chest pain; or shortness of breath. Although she denies belly pain, a seatbelt sign is noted just above her umbilicus. The abdominal examination reveals no tenderness to palpation or distention. She has no spinal tenderness and exhibits normal strength and sensation in her extremities. Her chest, back, and extremities have no external evidence of trauma.

The prompt recognition and initial management of children with intraabdominal injuries (IAI), particularly following motor vehicle collisions and falls, is of utmost importance to reduce the substantial risk of sequelae and death. Importantly, emergency physicians must be able to decide if and when diagnostic tests such as CT (computed tomography) scans, focused assessment sonography for trauma (FAST) examinations, and laboratory trauma panels should be implemented.

Until the 2013 publication of the Pediatric Emergency Care Applied Research Network (PECARN) clinical prediction rules for the identification of patients at very low clinical risk for IAI, clinicians relied on several small, single-center studies to guide the probability of these injuries based on the history and physical examination.1

Children are not merely small adults; there are several critical factors that make this patient population unique.

Children are more vulnerable to significant IAI as they have relatively compact torsos with a larger organ/body mass ratio than adults (ie, forces delivered to the abdomen dissipate over a smaller area, heightening the risk of injury), larger viscera that extend below the costal margin, and less overlying fat and abdominal musculature.

Pediatric trauma patients can mask significant hemorrhage with their ability to maintain normal blood pressures despite large-volume blood loss. As a result, hypovolemic shock can progress rapidly to cardiovascular collapse and cardiac arrest at the onset of hypotension.

In addition, the initial assessment of children can be further complicated by their various developmental stages and potentially limited communication skills.

CRITICAL DECISION

How should the initial assessment and management of pediatric blunt abdominal trauma be approached?

The first steps in evaluating a child with suspected blunt abdominal trauma should adhere to Advanced Trauma Life Support guidelines and remain focused on maintaining airway, breathing, and circulation. Surgical intervention is required in hemodynamically unstable patients (eg, altered mental status, tachycardia, hypotension, prolonged capillary refill, pallor, decreased urine output, weak/thready or strong/bounding pulses) and in those who are unresponsive to intravenous fluids and/or blood products. Evaluation for possible IAI should occur during the secondary survey in hemodynamically stable children.

Penetrating injuries, of course, are readily apparent; however, the

CASE TWO

A 17-year-old boy presents after being injured in a high-force tackle during a high school football game. Although the exact mechanism of injury is unknown, his initial complaint on the field was left shoulder pain. EMS reports he became less responsive during transport to the emergency department.

The patient’s vital signs are blood pressure 88/50, heart rate 130, and respiratory rate 24; his GCS is 12. He denies any chest pain or shortness of breath. Despite complaints of left shoulder pain, he has no evidence of trauma to his extremities. His abdominal examination reveals significant tenderness to the left upper quadrant and left flank ecchymosis. He is pale and has poor extremity perfusion. His mother arrives to the trauma bay and says that he has been “sick” for the past few weeks.

The first steps in evaluating a child with suspected blunt abdominal trauma should adhere to Advanced Trauma Life Support guidelines and remain focused on maintaining airway, breathing, and circulation. Surgical intervention is required in hemodynamically unstable patients (eg, altered mental status, tachycardia, hypotension, prolonged capillary refill, pallor, decreased urine output, weak/thready or strong/bounding pulses) and in those who are unresponsive to intravenous fluids and/or blood products. Evaluation for possible IAI should occur during the secondary survey in hemodynamically stable children.

Penetrating injuries, of course, are readily apparent; however, the

CASE THREE

A 12-year-old boy presents with a two-day history of epigastric pain and persistent, non-bilious and non-bloody vomiting. He has had no fever, cough, or diarrhea, but his appetite is reduced. His parents report that he was involved in a bicycle accident eight days ago, during which he was thrown forward over his handle bars. Despite several abrasions to his extremities and mild abdominal pain, his parents did not seek medical attention.

In the emergency department he is awake and alert but actively vomiting. His GCS is 15 and he appears moderately dehydrated. His vital signs are blood pressure 136/88, heart rate 124, and respiratory rate 28. Several healing abrasions are noted on his extremities and there is small area of ecchymosis in the epigastrium, which is accompanied by pain on palpation. His capillary refill is 3 to 4 seconds.

The patient’s vital signs are blood pressure 88/50, heart rate 130, and respiratory rate 24; his GCS is 12. He denies any chest pain or shortness of breath. Despite complaints of left shoulder pain, he has no evidence of trauma to his extremities. His abdominal examination reveals significant tenderness to the left upper quadrant and left flank ecchymosis. He is pale and has poor extremity perfusion. His mother arrives to the trauma bay and says that he has been “sick” for the past few weeks.

The first steps in evaluating a child with suspected blunt abdominal trauma should adhere to Advanced Trauma Life Support guidelines and remain focused on maintaining airway, breathing, and circulation. Surgical intervention is required in hemodynamically unstable patients (eg, altered mental status, tachycardia, hypotension, prolonged capillary refill, pallor, decreased urine output, weak/thready or strong/bounding pulses) and in those who are unresponsive to intravenous fluids and/or blood products. Evaluation for possible IAI should occur during the secondary survey in hemodynamically stable children.

Penetrating injuries, of course, are readily apparent; however, the
likelihood of blunt abdominal trauma must be deduced from the information gathered during the history and physical examination. The history should include details about the mechanism of injury, any restraint devices or personal protective equipment used (eg, seatbelt, car seat, athletic safety pads), and impact type (eg, handlebars to the epigastrium).

A thorough physical examination is required to evaluate for both IAI and other evidence of trauma. Signs and symptoms can include lower chest and back ecchymosis and/or tenderness, shortness of breath, abdominal abrasions and/or ecchymosis, abdominal/flank tenderness to palpation, abdominal distention, absent or diminished bowel sounds, evidence of peritoneal irritation with involuntary guarding or rebound (eg, abdominal rigidity, Kehr sign [referred pain to the left shoulder secondary to diaphragm irritation associated with a traumatic splenic injury], pelvic pain/instability, and unexplained hypotension).

Emergency physicians also should maintain a high index of suspicion for IAI in pediatric trauma patients with depressed mental status (secondary to a head injury or from hypoperfusion) or significant distracting injuries (eg, extremity trauma). If diagnostic imaging is withheld to reduce the risks associated with radiation exposure, serial abdominal examinations are crucial; subtle intraabdominal injuries can present over time and result in rapid decompensation.

A history that relies on the communication skills of the patient may be limited, particularly in children who are preverbal, crying, or otherwise reluctant to speak. Young patients may have trouble describing the event or exact mechanism of injury, and adolescents occasionally give false information to avoid consequences. The history may be further complicated if the injury was unwitnessed, or the caregiver is absent or unreliable (eg, in situations of abuse).

**Special Considerations**

Although there is some variability among institutions, the management of pediatric liver and spleen injuries (Figure 1) generally is guided by hemodynamic status rather than the grade of trauma. The nonoperative treatment of these injuries has been universally accepted — an approach that has reduced the number of required hospital days. The failure of these therapies can occur early, however, and often is indicated by shock or persistent hemorrhage, peritonitis or bowel injury, pancreatic injury, ruptured diaphragm, or need for blood products (>40 mL/kg) during the first 24 hours. Clinicians should maintain a high index of suspicion for child abuse if the presentation is delayed or the history is inconsistent. In addition, underlying medical conditions such as a bleeding disorder, organomegaly, weak or absent abdominal musculature (eg, Eagle-Barrett syndrome), or previous abdominal surgeries may affect the initial assessment, differential diagnosis, and approach to treatment.

Infectious mononucleosis, in particular, can predispose patients to serious complications of IAI. Caused by the Epstein-Barr virus (EBV), the illness classically presents as a triad of fever, tonsillar pharyngitis, and posterior cervical lymphadenopathy, often accompanied by severe fatigue and splenomegaly. It most commonly is seen in patients at the high school and collegiate level. Infectious mononucleosis can be managed with supportive care with an emphasis on adequate nutrition, hydration, and rest. Diagnostic testing for EBV should be performed in any pediatric athlete with clinical signs of the disease.

**Late Findings**

Traumatic abdominal injuries associated with a late presentation include pancreatic pseudocysts, often evidenced by epigastric pain, abdominal mass, anorexia, and hyperamylasemia. The diagnosis can be confirmed with a CT scan or ultrasound. Cysts smaller than 5 cm can be treated with bowel rest, parenteral nutrition, and broad-spectrum antibiotics; surgical drainage may be required for cysts larger than 5 cm or in cases of rupture, hemorrhage, infection, or signs of gastric outlet syndrome.

Duodenal hematoma, which typically manifests as intestinal obstruction, can be confirmed via CT scan and treated nonoperatively with gastrointestinal decompression and total parenteral nutrition. Patients with hematobilia, another late finding, often present with biliary colic, obstructive jaundice, and upper gastrointestinal bleeding, which can occur as long as 4 weeks after trauma. The diagnosis, which can be confirmed with CT angiography, requires surgical treatment.

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**FIGURE 1. Splenic Injury**

This 18-month-old sustained severe right-sided injuries from an MVC, including a grade IV spleen injury and completely devascularized left kidney with active extravasation. The patient was stable on initial evaluation at the transferring facility, but during transport became hemodynamically unstable and was sent directly to the operating room for further treatment. Laparotomy demonstrated a nonsalvageable spleen and left renal injuries. (A) External signs of significant trauma. (B) Computed tomography scan obtained during period of stability demonstrating severe spleen and left renal injury.
CRITICAL DECISION

How can clinical prediction tools be used to evaluate children with blunt abdominal trauma?

In an effort to create a prediction rule for identifying patients at very low risk for clinically important IAI following blunt abdominal trauma, the multicenter PECARN study focused only on the history and physical examination findings of 12,044 children. Patients were included if they presented to the emergency department with blunt torso (thorax and abdomen) trauma within 24 hours of the injury and any one of the following:

• Decreased level of consciousness (GCS <15) in association with blunt torso trauma (but not isolated head trauma)
• Blunt traumatic event with paralysis or multiple nonadjacent long bone fractures
• Blunt torso trauma due to any of the following mechanisms of injury:
  — MVC (high speed [>40 mph], ejection, or rollover)
  — Automobile vs pedestrian/bicycle
  — Fall >20 feet
  — Crush injury to the torso
  — Physical assault involving the abdomen
• Physician concern for abdominal trauma resulting in any of the following diagnostic or screening tests:
  — Abdominal CT or ultrasound
  — Laboratory testing to screen for intraabdominal injury
  — Chest or pelvic radiography

Clinically important intraabdominal trauma was defined as any injury associated with an acute intervention, including death, therapeutic treatment (eg, laparotomy, angiographic embolization to treat bleeding), a blood transfusion for anemia as a result of hemorrhage, or the administration of intravenous fluids for two or more nights in patients with pancreatic or gastrointestinal injury.

The derived prediction rule consisted of the following seven variables in descending order of importance: evidence of abdominal wall trauma or seatbelt sign, GCS less than 14, abdominal tenderness, evidence of thoracic wall trauma, complaints of abdominal pain, decreased breath sounds, and vomiting (Table 1). Test characteristics for the derived prediction rule include a sensitivity of 97% (95% CI: 93.7-98.9), a specificity of 42.5% (95% CI: 41.6-43.4), and a negative predictive value of 99.9% (95% CI: 99.7-100). Pediatric patients who sustain blunt abdominal trauma without any of the above variables may be discharged from the emergency department without diagnostic imaging.

Although most pediatric patients with IAI and normal mental status will complain of abdominal pain and tenderness on examination, the risk of these injuries escalates commensurate with the degree of abdominal findings. The sensitivity of abdominal pain and tenderness in children with IAI declines with the decrease in GCS (the sensitivity of abdominal pain for IAI was 79% [GCS 15], 51% [GCS 14], 32% [GCS 13]; sensitivity of abdominal tenderness for IAI was 79% [GCS 15], 57% [GCS 14], 37% [GCS 13]).

But are the PECARN prediction rules superior to clinical gestalt? In a recent prospective study, the diagnostic criteria revealed a significantly higher sensitivity (97% vs 82.8%) but lower specificity (42.5% vs 78.7%) than unstructured clinician suspicion for identifying children with IAI. Furthermore, the higher the clinical suspicion, the greater the number of patients requiring acute intervention.

### Seatbelt Injuries

A secondary analysis was performed on the initial PECARN data set to determine the accuracy of the abdominal examination and the “seatbelt sign” (Figure 2) in the identification of children with clinically important IAI. Following blunt torso trauma, IAI appears to be more common in children with seatbelt injuries (eg, continuous area of erythema, ecchymosis, or abrasion across the abdomen secondary to a seatbelt restraint) than in those without (19% vs 12%; RR = 1.6, 95% CI = 1.3-2.1). This difference may be attributed to a greater risk of gastrointestinal injuries (eg, hollow viscus or associated mesentery) in these patients (11% vs 1%; RR = 9.4, 95% CI = 5.4 – 16.4).

Furthermore, no increased risk of solid organ injury (eg, spleen, liver, or kidney) has been identified in children with seatbelt signs. Approximately 5.7% of patients with a seatbelt sign without initial abdominal pain or tenderness and a GCS of 14 or 15 were diagnosed with an IAI, and 2% required acute intervention.

### CT Scans

Despite the ability to rule out serious injury with other diagnostic tools, clinicians continue to obtain CT scans of the abdomen and pelvis in pediatric victims of blunt torso trauma. Unfortunately, this gold standard modality is associated with radiation-induced malignancy, especially in children, and has limited sensitivity (60%-80%) for the diagnosis of pancreatic or bowel injury.

Although CT with IV contrast is the gold standard in such cases for its ability to detect solid organ and vascular injuries, many clinicians continue to rely on oral contrast. Oral agents, however,
are associated with several important complications, including potential aspiration and diagnostic delays. The accuracy of CT with oral contrast (sensitivity 99.2%, specificity 84.7%) and without (sensitivity 97.7%, specificity 80.8%) appears to be similar for the detection of gastrointestinal, splenic, liver, and pancreatic injuries.11

**FAST Examination**

FAST appears to have a high sensitivity and specificity for detecting hemoperitoneum in adults, as well as the ability to help pinpoint patients requiring immediate operative interventions or additional radiological evaluations. FAST has not been universally accepted, however, for the assessment of pediatric patients. The tool’s popularity has been dampened by its low sensitivity and the fact that 33% of children with abdominal injuries will have no free fluid in the abdomen despite evidence of solid organ injury on CT.12-14

Although a negative FAST examination often does not affect decisionmaking, evidence suggests that its reliability may improve when used in conjunction with PECARN prediction rules, particularly in the evaluation of suspected hemoperitoneum (Figure 3).

**Ultrasound**

In a 2007 meta-analysis examining the performance of abdominal ultrasound in the identification of children with IAI, the test diagnosed hemoperitoneum with a sensitivity of 80% (95% CI 76%-84%) and specificity of 96% (95% CI 95%-97%); the positive likelihood ratio was 22.9 (95% CI 17.2-30.5) and negative likelihood ratio was 0.2 (95% CI 0.16-0.25).15 Although abdominal ultrasonography has a modest sensitivity for the detection of pediatric hemoperitoneum, a negative result is questionable as the sole method of ruling out an IAI.

Although contrast-enhanced ultrasound using a second-generation intravenous agent has demonstrated improved sensitivity for identifying organ injury and hemoperitoneum in adult patients with blunt torso trauma, this modality has not been studied in pediatric trauma patients.16,17

**CRITICAL DECISION**

What role should laboratory tests play in the evaluation of pediatric trauma patients?

Studies have shown that serum and urine diagnostic tests (ie, trauma panels) have limited utility in the diagnosis of IAI in pediatric trauma patients. In addition, no prediction rules — including PECARN — have incorporated these measurements into their risk stratification models. There are some diagnostic tests, however, that can be useful in the initial management of the pediatric trauma patient.

Hemoglobin and hematocrit measurements should be ordered to establish a baseline, especially in hospitalized children, whose levels can be trended over time. Pediatric patients are allowed lower hemoglobin levels (7.0 g/dL) prior to transfusion, and scheduled hemoglobin rechecks may be discontinued once stability has been established.

A blood type and crossmatch should be ordered any time a blood transfusion is considered.

**Ultrasound**

In a 2007 meta-analysis examining the performance of abdominal ultrasound in the identification of children with IAI, the test diagnosed hemoperitoneum with a sensitivity of 80% (95% CI 76%-84%) and specificity of 96% (95% CI 95%-97%); the positive likelihood ratio was 22.9 (95% CI 17.2-30.5) and negative likelihood ratio was 0.2 (95% CI 0.16-0.25).15 Although abdominal ultrasonography has a modest sensitivity for the detection of pediatric hemoperitoneum, a negative result is questionable as the sole method of ruling out an IAI.

Although contrast-enhanced ultrasound using a second-generation intravenous agent has demonstrated improved sensitivity for identifying organ injury and hemoperitoneum in adult patients with blunt torso trauma, this modality has not been studied in pediatric trauma patients.16,17

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Hemodynamically stable children who sustain blunt abdominal trauma may be discharged home if their abdominal CT scan is normal. The test has a negative predictive value of 99.8% in such cases.

### Epstein-Barr Virus

The diagnostic evaluation of suspected cases of Epstein-Barr virus should include the monospot test, which detects heterophile antibodies that appear within one week of the onset of clinical symptoms and may persist at low levels for up to one year. EBV-specific antibodies also can be detected and are commonly used to determine the acuity of illness in athletes, whose strenuous physical activity increases the risk of splenic rupture (seen in 1-2 patients per 1,000, commonly 4-21 days after the onset of symptoms).

Return-to-play guidelines for athletes with infectious mononucleosis have been heavily disputed. A gradual return may be started after three weeks; however, contact and vigorous exercise typically is prohibited for the first four weeks after the onset of symptoms. Prior to the resumption of physical activity, it also is important to ensure the athlete is afebrile and without pharyngitis, the liver enzymes are at baseline, and the spleen is not enlarged or painful.

### Critical Decision

**When is it safe to discharge a child who has sustained blunt abdominal trauma?**

Intensive care units are appropriate for children with recent or ongoing bleeding, patients who were previously unstable, and those with concomitant injuries requiring critical care. It can be safe to discharge a stable child home after a negative abdominal CT, as long as criteria for return to the emergency department is delineated (eg, signs of hypoperfusion/shock, severe or worsening abdominal pain, abdominal distention). While a small percentage of children (0.19%) may have negative CT scans following blunt abdominal trauma, the estimated negative predictive value of abdominal imaging is a reliable 99.8%.

### Summary

The initial management of pediatric blunt abdominal trauma should adhere to advanced trauma life support guidelines. Hemodynamically unstable children should undergo immediate surgical intervention. A thorough history and physical examination...
CASE RESOLUTIONS

**CASE ONE**

The 6-year-old girl was considered hemodynamically stable after an initial assessment of airway, breathing, and circulation. A FAST examination showed no evidence of free fluid in the abdomen. Despite denying abdominal pain and tenderness, the patient did not meet the criteria of low risk for a clinically important IAI (presence of a seatbelt injury) based on the PECARN prediction rules.1 (Remember that nearly 6% of children with a seatbelt sign have an IAI, regardless of pain or tenderness on examination.) A CT scan of the abdomen (with IV contrast, not PO contrast) was ordered, which revealed a grade III liver laceration. The girl was admitted to the inpatient floor, where her vital signs could be monitored every 2 to 4 hours and serial blood counts could be taken. She remained hemodynamically stable overnight; after 18 hours on the inpatient floor, she was placed on a regular diet and the ambulation restrictions were removed. Her hemoglobin remained stable (>7.0 g/dL) and she was discharged home after 48 hours in the hospital.

**REFERENCES**


**CASE TWO**

The clinician quickly recognized hemodynamic instability in the teenage athlete and consulted the trauma surgery team. His heart rate and blood pressure failed to respond to two boluses (20 mL/kg) of lactated Ringer solution, so type-specific blood products (20 mL/kg) were administered.

The diagnostic puzzle pieces began to fit together: left upper quadrant tenderness + left flank ecchymosis + Kehr sign + sick for a few weeks = ruptured spleen secondary to splenomegaly and blunt abdominal trauma. A FAST examination revealed free fluid within the abdominal cavity, indicative of hemoperitoneum; the hemoglobin was 7.6 g/dL. The patient was transported to the operating suite for an emergent splenectomy.

**REFERENCES**


**CASE THREE**

The 12-year-old boy showed signs of mild to moderate dehydration; a normal saline bolus (20 mL/kg) was administered, which helped improve his tachycardia and perfusion. Although viral gastroenteritis was high on the clinician’s differential diagnosis, the abdominal trauma the boy sustained 8 days ago was concerning. His electrolytes and liver function tests were normal; however, the pancreatic enzymes were elevated (amylase 431 U/L and lipase 367 U/L). A CT scan of the abdomen demonstrated a small pancreatic pseudocyst (4 cm), most likely secondary to the handlebar injury he sustained a week earlier.

He was admitted to the inpatient floor and was treated with bowel rest, parenteral nutrition, and broad-spectrum antibiotics. The size of the pseudocyst was monitored by serial ultrasounds and resolved spontaneously without external or internal surgical drainage. The patient was discharged home 4 weeks after his emergency department visit.
1. A 35-year-old woman with a history of allergic rhinitis presents with two months of bilateral eye itching, redness, and watering. She says these symptoms erupt every spring. What is the most appropriate treatment?
   A. Initiate a CT scan with contrast and IV antibiotics
   B. Order cultures of the watery discharge and await sensitivities for treatment
   C. Prescribe topical and oral antihistamines
   D. Prescribe trimethoprim-polymyxin B eye drops

2. A 26-year-old methamphetamine user presents with right eyelid swelling for two days. He has been told he needs several tooth extractions. He has normal visual acuity and no pain with extraocular movements. What is the most appropriate next step?
   A. Consult ophthalmology emergently
   B. Discharge patient with clindamycin and instructions for dental clinic follow up
   C. Discharge patient home with trimethoprim-polymyxin B eye drops
   D. Obtain a CBC and metabolic panel

3. What finding is most consistent with orbital cellulitis but not preseptal cellulitis?
   A. Conjunctival injection
   B. Fever
   C. Intraocular pressure of 35
   D. Pain with extraocular movements or decreased visual acuity

4. A 64-year-old woman with diabetes and hypertension presents with left eye pain and redness for two days. Dendrites are seen with fluorescein staining. What treatment does this patient require?
   A. Clindamycin (450 mg 3x/day for 10 days)
   B. CT of the orbit with IV contrast
   C. Topical antiviral drops with urgent ophthalmology follow up
   D. Topical steroid drops

5. Which patient requires an emergent ophthalmology consultation?
   A. 6-year-old with left eye redness and pruritus for two days
   B. 17-year-old with one day of right eye redness, moderate purulent discharge, and normal visual acuity
   C. 46-year-old with right eye swelling, redness, painful extraocular movement, and decreased visual acuity
   D. 51-year-old with three months of bilateral watery eyes when outside in his garden

6. A 10-day-old boy presents with two days of bilateral eye discharge. He was born at home and has not yet been seen by a physician. The mother received scant prenatal care. What is the likeliest cause of the neonate’s symptoms?
   A. Adenovirus conjunctivitis
   B. Allergic conjunctivitis
   C. Chlamydial conjunctivitis
   D. Gonococcal conjunctivitis

7. Which laboratory test(s) can help diagnose herpes keratitis?
   A. Coagulation studies
   B. Giemsa stain and viral culture
   C. Gram stain
   D. Polymerase chain reaction test

8. A 23-year-old woman presents with two days of copious purulent discharge from her left eye. The pus reaccumulates almost immediately after being wiped away. She admits to having recent unprotected sex with a new partner. What is the most appropriate treatment?
   A. Ceftriaxone and a single dose of oral azithromycin
   B. IV ampicillin-sulbactam
   C. Ketorolac 0.5% eye drops
   D. Trimethoprim-polymyxin B eye drops

9. Which organism(s) most commonly are responsible for preseptal cellulitis?
   A. Enterococcus
   B. Neisseria gonorrhoeae
   C. Klebsiella, E.coli
   D. Staphylococcus, Streptococcus
10. A 46-year-old man presents with a red, “scratchy” right eye; he denies pain or blurry vision. What examinations are warranted?
   A. HEENT examination; and gross examination, including an evaluation of the pupils, extraocular movements, and visual acuity
   B. HEENT examination; gross examination, including an evaluation of the pupils, extraocular movements, visual acuity, and intraocular pressure; fluorescein staining; and slit lamp examination
   C. Gross examination followed by an emergent ophthalmological consultation
   D. Intraocular pressure measurement, fluorescein staining, and slit lamp examination

11. A 5-year-old arrives after being hit by a car. His vital signs are blood pressure 70/30, heart rate 140, and respiratory rate 40; his GCS is 8. The examination reveals ecchymosis and abrasions to the skin and abdominal distention. What should be the first step in his management?
   A. Consult the pediatric trauma service
   B. Order an abdominal CT scan with IV contrast
   C. Perform a FAST examination of the abdomen
   D. Protect the airway

12. Which term describes referred pain to the left shoulder secondary to diaphragm irritation associated with a traumatic splenic injury?
   A. Chance sign
   B. Kehr sign
   C. PECARN sign
   D. Seatbelt sign

13. Which finding is associated with children at low risk for intraabdominal injuries obviating CT?
   A. Absence of bowel sounds
   B. No abdominal distention
   C. No pelvic instability
   D. No seatbelt sign

14. What is the sensitivity of the PECARN prediction rules for identifying children at very low risk for clinically important intraabdominal injuries?
   A. 67%
   B. 77%
   C. 87%
   D. 97%

15. What is the gold standard diagnostic test for children with blunt torso trauma?
   A. CT scan of the abdomen and pelvis with IV contrast
   B. CT scan of the abdomen and pelvis with oral contrast
   C. Focused assessment sonography for trauma (FAST)
   D. Plain abdominal radiograph

16. Which of the following accurately describes a characteristic of intraabdominal injury?
   A. Most children with normal mental status will complain of abdominal pain but exhibit no tenderness on palpation
   B. The risk of injury increases commensurate with the degree of abdominal findings
   C. The sensitivity of abdominal pain and tenderness in children increases as the GCS decreases
   D. There is an increased risk of solid organ injury in children with a seatbelt sign

17. A 10-year-old boy presents after falling and hitting his stomach against a cement divider; he complains of mild abdominal pain. A CT scan with IV contrast reveals no acute injury, and he remains hemodynamically stable. What should be the next step?
   A. Admit him to the inpatient floor for observation
   B. Consult pediatric trauma surgery
   C. Discharge the child home with clear instructions to return if new symptoms develop
   D. Repeat the CT scan in 6 hours

18. Which of the following should be considered when managing children with liver and spleen injuries?
   A. Blood transfusions should be performed in any child with a hemoglobin level <10 g/dL
   B. The grade of injury, rather than hemodynamic status, should guide inpatient care
   C. Nonoperative management is universally accepted and can reduce the number of in-hospital days
   D. These patients should be admitted to the intensive care unit, regardless of hemodynamic status

19. Which of the following should be considered when managing a high school athlete with blunt abdominal trauma and clinical signs of mononucleosis?
   A. Antiviral medications can decrease the risk of splenomegaly and splenic rupture
   B. Testing for Epstein-Barr virus should be initiated
   C. Splenic rupture associated with infectious mononucleosis is rare; concerns about this pathology should not play a major role in acute management
   D. The patient may be cleared for return-to-play once abdominal pain subsides

20. Which of the following can be a late presentation in children with traumatic abdominal injuries?
   A. Eagle-Barrett syndrome
   B. Ecchymosis
   C. Hematobilia
   D. Kehr sign
CEFTAZIDIME/AVIBACTAM

By Zachary Morrison, University of Arizona College of Medicine; and Frank LoVecchio, DO, Maricopa Medical Center, Phoenix, Arizona

Ceftazidime/avibactam is a fixed-dose combination agent used for the treatment of Gram-negative, multidrug-resistant complicated intraabdominal and urinary tract infections, often when no other option is available. It is indicated for the treatment of Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumoniae and oxytoca, Enterobacter cloacae and aerogenes, Citrobacter freundii and koseri, and Proteus mirabilis.

Mechanism of Action
Ceftazidime is a third-generation beta-lactam cephalosporin; avibactam is a non-beta-lactam beta-lactamase inhibitor. Beta-lactams are suicide inhibitors for transpeptidase, the enzyme responsible for the final crosslinking step in the synthesis of the peptidoglycan mesh on the bacterial cell wall. These agents ultimately lead to lysis and death of the bacterial cell. Over time, bacteria have developed resistance to such mechanisms by producing beta-lactamases, enzymes that directly inactivate beta-lactams. However, the co-administration of a beta-lactamase inhibitor and a beta-lactam can restore the effectiveness of this agent.

Dosing
Adults: 62.5 g IV every 8 hours. Each dose contains 2 g of ceftazidime and 0.5 g of avibactam; IV infusion should be given over 2 hours.

Intraabdominal infections: 5-14 days (in combination with metronidazole)
Urinary tract infections: 7-14 days

Pharmacological Properties
Half-life: ceftazidime (2.76 hours); avibactam (2.71 hours)
Excretion in urine: ceftazidime (80-90% unchanged); avibactam (100% unchanged)

Side Effects
Common complications include constipation, anxiety, nausea, vomiting, abdominal pain, dizziness. Patients also may develop Clostridium difficile-associated diarrhea, although this is likelier with prolonged use.

Precautions
Contraindications: Previous hypersensitivity to ceftazidime, avibactam, or other cephalosporins or beta-lactams
Considerations: Dose adjustments are required in renal failure.

Pregnancy: Animal studies report adverse effects with the use of avibactam. Ceftazidime is excreted in breastmilk; excretion of avibactam is unknown.

PHOSPHINE TOXICITY

By Richard A. Koch, MD, FACEP, University of California, San Diego

Countless people worldwide are sickened or killed each year by phosphine gas (PH₃) exposure in their homes or workplaces.

Mechanism
PH₃ is liberated when pellets of metal phosphides (eg, aluminum) contact water (H₂O). Phosphines inhibit multiple enzymes, leading to lipid peroxidation and protein denaturation of cell membranes. PH₃ also is directly toxic to alveolar capillary membranes.

Toxic Dose (dependent on route, form, and duration of exposure)

Oral: Aluminum phosphate 500 mg or zinc phosphate 4 g can be lethal.

Inhaled: 50 ppm is dangerous; 400-600 ppm can be lethal in <30 min.

Presentation
Suspect poisoning after exposure to fumigation or grain storage in patients with cardiac dysrhythmia, acute lung injury (ALI), GI symptoms, or an odor of garlic or decaying fish.

Toxicity after inhalation or ingestion includes:

- Airway irritation, shortness of breath, chest tightness
- Nausea, vomiting, diarrhea
- Headache, ataxia, numbness, paresthesias, tremor, muscle weakness
- Significant exposure can cause acute respiratory distress, cardiac failure, dysrhythmias, convulsions, coma, shock, hypotension, and delayed hepato- and/or nephrotoxicity.

Evaluation
- Chemical analysis for PH₃ is not clinically available or helpful.
- ABG can help evaluate for metabolic acidosis and/or respiratory alkalosis.
- ECG abnormalities are common but highly variable.
- Echocardiography findings: LV dysfunction, dilation, hypokinesia.
- Chest x-ray may show infiltrates.

Treatment
Decontamination
- Inhalation: Remove from area of exposure
- Ingestion: 1 gm/kg activated charcoal

Supportive Care
- Intubation for respiratory failure/ALI
- IV hydration and vasopressors for hypotension

Experimental Treatments
- N-acetylcysteine (140 mg/kg IV loading)
- Gastric lavage with potassium permanganate (1:10,000) or sodium bicarbonate

Disposition
- Asymptomatic: May be discharged after a few hours’ observation
- Symptomatic inhalational exposures/ingestions: 24 hours’ observation due to delayed cardiac effects