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).

Love Hurts
The classic description of syphilis as learned in medical school is an incomplete characterization of a dynamic disease with diverse presentations and a serious risk of long-term sequelae. It is essential for physicians to be well versed in the clinical manifestations of this increasingly common systemic infection, implement precautions to prevent its transmission, and understand the nuances of treatment regimens based on the unique features of each case.

Blood Moon
Both acute and chronic complications are common in children with sickle cell disease (SCD), which can manifest in any part of the body and result in significant mortality. Although many patients initially present with mild symptoms, life-threatening problems such as serious organ dysfunction can erupt with little warning. Emergency physicians must consider a wide range of presentations when managing SCD, including stroke, and understand how to control pain and administer appropriate treatment.
Love Hurts
Diagnosing and Managing Syphilis

LESSON 21

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Reviewed by Lynn R. Roppolo, MD, FACEP

OBJECTIVES
On completion of this lesson, you should be able to:
1. Recognize the symptoms related to each stage of syphilis.
2. Describe the most appropriate tests for diagnosing syphilis in the emergency department.
3. Explain how syphilis is transmitted and describe effective ways to protect clinical staff from exposure.
4. Define the recommended treatment regimens for syphilis, including adjuvant treatments and follow-up measures, and list the indications for each.
5. Explain the clinical presentations that warrant admission.

FROM THE EM MODEL
10.0 Systemic Infectious Disorders
   10.1.8 Spirochetes
      10.1.8.1 Syphilis

CRITICAL DECISIONS
- What clinical signs and symptoms should raise suspicion for a syphilitic infection?
- Which tests are most accurate for diagnosing syphilis in the emergency department?
- How should syphilis be managed, and what are the potential complications of treatment?
- What special considerations should be addressed when treating pediatric patients with syphilis?
- What follow up is appropriate, and when is admission warranted?

Although the prevalence and incidence of syphilis has undulated over the course of US history, the number of reported cases has risen dramatically in recent years, exposing a pervasive and persistent disease burden (Figure 1). For the first time in five decades, the western states surpass the South in the number of patients with syphilis.¹ These troubling statistics elucidate the importance of physician awareness, recognition, and appropriate treatment of this disease, particularly in regions where incidence is on the rise.
CASE PRESENTATIONS

■ CASE ONE
A 21-year-old man with no significant medical history presents with a “sore” on his genitals. The patient says he had unprotected sexual intercourse with a woman 4 weeks earlier and now has a painless ulcer on the glans of his penis, which erupted about 1 week ago.

The physical examination reveals a solitary, indurated, nontender ulcer that isn’t draining. Inguinal lymphadenopathy and penile discharge are absent, and the patient’s vital signs are normal. The emergency physician treats the man appropriately for primarily syphilis and counsels him to encourage his recent sexual partners to seek medical care.

The patient is discharged home, but returns within hours with complaints of fever, headache, and muscle aches. His vital signs are blood pressure 95/60, heart rate 115, respiratory rate 14, and temperature 38.5°C (101.3°F).

■ CASE TWO
A 32-year-old man presents with flulike symptoms, including 3 days of “low-grade” fever, body aches, and intermittent headaches. He does not have associated chest pain, shortness of breath, cough, or nasal congestion. The patient has a history of hypertension, which is well controlled with a single medication. He also mentions a rash that started on his chest 1 week ago and now has spread to his arms, legs, hands, and feet.

He says he is sexually active with multiple partners and admits to using condoms only intermittently. His vital signs are blood pressure 130/85, heart rate 89, respiratory rate 14, and temperature 37.8°C (100°F). A HEENT examination is normal, as are cardiac, respiratory, and abdominal evaluations.

A diffuse, erythematous, maculopapular rash covers the palms and soles of the man’s feet, and nontender cervical and inguinal lymphadenopathy is noted. The patient casually mentions the presence of a penile ulcer that developed 3 months ago but resolved without treatment.

■ CASE THREE
A 48-year-old woman with a medical history of hypertension, diabetes mellitus, and rheumatoid arthritis presents with 4 months of progressively worsening sharp, shooting pains in different areas of her body. Acetaminophen and ibuprofen have failed to relieve her symptoms; a “borrowed” bottle of hydrocodone also hasn’t helped.

The patient says her level of discomfort exceeds the arthritis-related joint pains she normally experiences and has been accompanied by a slow decrease in sensation, especially in the fingers. She also reports feeling “wobbly” when she walks, especially at night; the unsteadiness has resulted in two falls. She does not have fever, chest pain, shortness of breath, or nausea and vomiting. The patient denies ever being diagnosed with a sexually transmitted infection, but recalls having “a good time in the 90s.” The cardiac, respiratory, and abdominal examinations are normal, as are the patient’s vital signs.

A full neurologic examination shows intact extraocular movements; however, the patient’s pupils constrict to accommodation but not to light. She also has a reduced sensitivity to light touch, as well as decreased proprioception of the great toes bilaterally. She has decreased patellar reflexes bilaterally; a Romberg test is positive; and her gait is ataxic and jerky. Given the woman’s extensive neurologic symptoms and examination findings, the clinician initiates a brain CT, lumbar puncture, and blood tests.

The classic description of syphilis as learned in medical school is an incomplete characterization of a dynamic infection with diverse presentations. It is essential for the practicing clinician to be well versed in the various manifestations of the disease, understand and implement the necessary precautions to prevent transmission, and be sensitive to the nuances of treatment regimens and disposition based on the unique features of each case.

By gaining clinical knowledge and adopting appropriate diagnostic and management strategies, emergency physicians can decrease the spread of syphilis, which can result in extensive sequelae and even death.

CRITICAL DECISION
What clinical signs and symptoms should raise suspicion for a syphilitic infection?

Treponema pallidum, an exclusively human pathogen, is the causative infectious organism responsible for syphilis, yaws, and pinta diseases.1 There are four well-defined stages of syphilis: primary, secondary, latent, and tertiary.

Primary Syphilis
Primary syphilis, which represents the initial infection, is characterized by a solitary painless ulcer with indurated borders (“chancre”), typically located on the genitals. Approximately 5% of syphilitic chancres are extragenital, erupting on the oral mucosa due to unprotected orogenital contact.2 The ulcer appears after an average incubation period of 21 days and usually regresses spontaneously within 3 to 6 weeks.

Nonsuppurative regional lymphadenopathy generally develops within 30 days of the lesion’s...
appearance; however, unlike a chancre, this symptom may persist for months.\textsuperscript{1,3}

**Secondary Syphilis**

A clinically asymptomatic period (typically 3 to 6 weeks) follows regression of the primary chancre. Development of a generalized rash and lymphadenopathy define the diagnosis of secondary syphilis. The classic rash is dull red-pink and variable with papular lesions, although macules and papulosquamous eruptions also may be present (Figure 2).

The rash commonly starts on the trunk and flexor surfaces of the extremities with generalized progression to the palms and soles (Figures 3 and 4); however, papulosquamous reactions may be limited to the palms and soles.\textsuperscript{3,4} These symptoms often are accompanied by systemic, infection-induced complications such as fever, malaise, headache, and sore throat.

Condylomata lata (painless wart-like mucosal lesions) may erupt in moist areas such as the mouth, perineum, axilla, and between the toes (Figure 5).\textsuperscript{1} Like the chancres of primary syphilis, all lesions at this stage are highly infectious and saturated with spirochetes. Alopecia may be found on examination, and hepatitis may be noted on laboratory tests.\textsuperscript{5} This stage of the disease is characterized by spontaneous regression.\textsuperscript{1}

**Latent Syphilis**

A clinical latency period ranging from 3 to 20 years follows resolution of the secondary stage of the disease.\textsuperscript{3} Milder relapses of secondary syphilis may occur during this latent period. After a symptomatic hiatus, approximately one-third of cases progress to tertiary syphilis; cases that do not progress are halted by host immunologic disease clearance.\textsuperscript{1}

**Tertiary Syphilis**

Tertiary syphilis is characterized by widespread gummata (granulomatous lesions), which can affect any organ system. Rectal gummata, which can resemble fungating masses similar to neoplasms, may require surgical intervention.\textsuperscript{6} More often, however, tertiary syphilis is discovered secondary to neurologic and cardiovascular involvement.

Clinical manifestations may include meningitis, dementia, neuropathy (tabes dorsalis), and thoracic aneurysm. An intracranial guma may imitate a neoplastic cerebral mass such as a glioma or glioblastoma. Historically, intracranial gummata were thought to require years to develop, but formation in only a few months has been described.\textsuperscript{7} During the tertiary stage, the patient is not considered infectious with \textit{T. pallidum}.\textsuperscript{1}

**Neurosyphilis**

Neurosyphilis is characterized by meningovasculitis and degenerative parenchymal changes in any part of the
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Neurosyphilis begins as meningitis. Although patients often present with no physical symptoms, diagnostic findings will be present on cerebral spinal fluid (CSF) analysis. Distinct clinical variants of neurological involvement include:

- **Asymptomatic neurosyphilis**: an Argyll Robertson pupil occasionally is found on examination, even in otherwise-asymptomatic patients. In such cases, the pupil will be dilated and possibly irregular; it will not react to light, but will constrict with accommodation.

- **Meningovascular neurosyphilis**: multiple, usually small cerebrovascular infarctions; the presentation may imitate ischemic cerebral infarction.

- **Paretic neurosyphilis**: progressive dementia, dysartrhria, myoclonic jerks, action tremor, seizures, hyperreflexia, positive Babinski signs, Argyll Robertson pupils, progressive physical dissolution.

- **Tabetic neurosyphilis**: lancinating (lightning) pains, paresthesias, ataxia (secondary to sensory loss), urinary overflow incontinence, constipation/megacolon, absent knee and ankle deep tendon reflexes, impaired vibration and proprioception, positive Romberg sign, Argyll Robertson pupils, optic atrophy, Charcot joints.

**Cardiovascular Syphilis**

Classically and of most concern, cardiac syphilis involves the aorta and precipitates arteritis of the vasa vasorum; however, the disease can involve any part of the cardiovascular system. This pathology results in medial necrosis and loss of elastic fibers, a process that manifests as aortic aneurysm and root dilation. The disease ultimately may lead to subsequent aortic valve incompetence and aortic rupture.

**CRITICAL DECISION**

Which tests are most accurate for diagnosing syphilis in the emergency department?

- **T. pallidum** does not grow on laboratory media, but dark field microscopy can help detect all stages of the disease. Direct spirochete visualization using this methodology is diagnostic; however, a negative test does not rule out syphilis.

- Infection with **T. pallidum** triggers the formation of antibodies that react with cardiolipin. Nonspecific cardiolipin antibodies, which flocculate in the presence of the **T. pallidum** antibody, can be detected by venereal disease research laboratory (VDRL) and rapid plasma reagin (RPR) blood tests. These diagnostic tools, known...
Nontreponemal tests, which routinely become nonreactive after treatment, generally are limited by a positivity-latency period that occurs 1 to 4 weeks after the first chancre appears. This feature restricts their role in the diagnosis of early disease, although these tests are nearly 100% sensitive and highly specific for secondary syphilis.

False-positive results can occur secondary to measles, hepatitis, mononucleosis, lymphoma, tuberculosis, endocarditis, pregnancy, IV drug abuse, and Wharton jelly contamination (thus umbilical cord blood should not be used). Nonspecific reactions also are attributable to autoimmune disease. Due to this nonspecificity, any patient with a positive nontreponemal (RPR or VDRL) laboratory result should undergo specific antibody testing. Readily available and inexpensive, nontreponemal tests are an appropriate first-line diagnostic tool.

Specific treponemal antibody measurements, on the other hand, remain positive regardless of disease activity and treatment. The fluorescent treponemal antibody absorption (FTA-ABS) and microhemagglutination assay for antibodies to *T. pallidum* (MHA-TP) tests detect antibodies specific to the pathogen.

An FTA-ABS test becomes positive when a fluorescein-labeled antibody to immunoglobulin G (IgG) indicates a reaction to nonviable *T. pallidum*. An MHA-TP becomes positive when a patient’s serum reacts with sheep erythrocytes coated with *T. pallidum* antigens, resulting in hemagglutination. False-positive treponemal tests may result secondary to infection with other spirochetal diseases (eg, leptospirosis, Lyme disease, rat bite fever).

The FTA-ABS test generally is positive 1 to 2 weeks after the onset of primary syphilis (typically a few days prior to VDRL positivity). Cerebral spinal fluid analysis is indicated in cases of syphilis marked by neurologic symptoms, and for patients with suspected tertiary infections. HIV testing is recommended for those infected with *T. pallidum*, a serious risk factor for the disease.

**CRITICAL DECISION**

How should syphilis be managed, and what are the potential complications of treatment?

*T. pallidum* enters the host through mucous membranes, non-intact skin, or via transplacental and hematologic routes. Contact precautions must be maintained to protect health care staff, and universal protocols for preventing...
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Primary and secondary syphilis should be treated with penicillin G (2.4 million U IM). Doxycycline (100 mg 2x/day for 14 days) or tetracycline (500 mg PO 4x/day for 14 days) can be used to treat penicillin-allergic patients with early disease. Azithromycin, once regarded as a viable alternative to penicillin, appears to be ineffective due to drug resistance and is no longer recommended.

Any sexual partners within the past 90 days also should be treated with penicillin or doxycycline. Any pregnant woman with a penicillin allergy must be admitted, desensitized to, and treated with the agent.

Fever, headache, exacerbation of skin lesions, and myalgia are common within the first 24 hours and often occur within the first few hours of treatment. This acute febrile response, known as the Jarisch-Herxheimer reaction, represents a systemic reaction to spirochete lysis. Patients should be counseled to expect this apparent worsening of symptoms, which does not represent penicillin allergy. The coadministration of antipyretics may diminish symptoms but will not prevent this systemic response.

Tertiary syphilis should be treated with three doses of penicillin G (2.4 million U IM weekly for 3 weeks). These patients should be followed closely by a primary care physician or the department of public health to ensure compliance, and disease regression should be monitored via repeat serologic testing at 6 and 12 months.

Neurosyphilis requires management with aqueous crystalline penicillin G (200,000-300,000 U/kg/day in 4 to 6 divided doses IV for 10 to 14 days). Ceftriaxone (2 g IV daily for 10 to 14 days) can be used as a second-line treatment in patients with penicillin allergies.

CRITICAL DECISION

What special considerations should be addressed when treating pediatric patients with syphilis?

Children can acquire syphilis through typical “adult” routes, or as a result of transplacental infection. A fetus is susceptible to transplacental infection only after the fourth month of pregnancy, underscoring the importance of early pregnancy testing, treatment, and repeat evaluations in high-risk patients.

Although newborn syphilis often is asymptomatic, clinical manifestations such as jaundice, anemia, thrombocytopenia, reticulocytosis, hepatosplenomegaly, edema, subclinical CNS infection, or overt meningitis may be present.

Pitfalls

- Undertreating tertiary syphilis with a single dose of 2.4 million units of IM penicillin G.
- Attributing a Jarisch-Herxheimer reaction to an allergic or anaphylactic response, and failing to counsel patients regarding this complication.
- Dismissing the contagiousness of lesions caused by secondary syphilis and failing to warn patients about taking precautionary measures.
In young infants (3 to 12 weeks), clinical signs can include moist mucocutaneous lesions, pseudoparalysis of the arms or legs, shotty lymphadenopathy, hepatomegaly, splenomegaly (50%), anemia, “snuffles” (syphilitic rhinitis characterized by profuse mucopurulent discharge), and a syphilitic rash (raised, bright red maculopapular lesions commonly on the palms and soles).

Sequelae include rhagades (scarring of the mouth or nose), a saddle nose deformity marked by a depressed nasal bridge (Figure 6), a high forehead (secondary to CNS infection), Hutchinson teeth (peg-shaped upper central incisors with a central notch), and mulberry molars (lobulated mulberry appearance of the sixth-year molars). The Wimberger sign, which is nearly pathognomonic, is defined by bilateral symmetric osteomyelitis with pathologic fractures of the medial tibial metaphyses.15

Older children (ages 6 to 12 years) may present with bilateral interstitial keratitis (photophobia, lacrimation, corneal vascularization), chorioretinitis, optic atrophy, meningovascular syphilis, deafness, saber shins (thickening of the periosteum of the anterior tibias), knee joint effusions, and disseminated gumma.15 The Centers for Disease Control and Prevention recommends managing pediatric patients with penicillin G benzathine (50,000 U/kg IM) up to the suggested adult dose (2.4 million U IM).18

CRITICAL DECISIONS
What follow up is appropriate, and when is admission warranted?

- Syphilis must be reported to the local public health department; any sexual partners within the last 90 days must be treated; and arrangements for repeat serologic testing should be arranged.5

- Admission should be considered for pregnant women, in whom the Jarisch-Herxheimer reaction can increase the risk of preterm labor. Additionally, pregnant patients who are allergic to penicillin may require admission for penicillin desensitization therapy.

Patients being treated for neurosyphilis also require admission, as do those suspected cardiac involvement, who may require monitoring for emergent complications of the disease.19

Summary

It is incumbent upon the emergency physician to identify the diverse presentations of patients with syphilis, which is again on the rise in the US. Clinicians must take action to prevent transmission of the disease, while understanding the subtleties related to managing its different stages.

Although penicillin is the mainstay of treatment, it is important to administer the appropriate dose and understand how to employ alternative therapies for penicillin-allergic patients.

Most patients can be treated in the emergency department and discharged home; however, certain complications mandate admission, including pregnancy and neurosyphilitic infections.

REFERENCES

FIGURE 6. Saddle Nose
CASE RESOLUTIONS

■ CASE ONE

When the 21-year-old man with a painless penile ulcer returned to the emergency department with fever, tachycardia, and mild hypotension, the clinician suspected an acute reaction to spirochete lysis (ie, Jarisch-Herxheimer reaction). The patient was managed supportively with antipyretics and fluids, and began to feel better almost immediately. He was observed and then discharged home with instructions to continue antipyretic medications for the next 24 hours.

■ CASE TWO

The 32-year-old man’s flulike symptoms raised red flags for the emergency physician. Secondary syphilis jumped to the top of the differential diagnosis due to several clinical clues, including normal vital signs, body aches, headache, and progressive rash involving the palms and soles.

Based on a positive rapid plasma reagin test, the patient was treated with penicillin G (2.4 million U IM) and warned about the contagiousness of his lesions. He also was advised to follow up with his primary care physician for repeat serologic testing.

■ CASE THREE

The middle-aged woman with severe pains, decreased sensation, and ataxia underwent a head CT and basic laboratory tests, which were normal. The emergency physician, however, had high suspicion for neurosyphilis given the patient’s Argyll Robertson pupils, ataxic gait, decreased lower extremity reflexes, positive Romberg test, and loss of proprioception. Aware that nontreponemal measurements can be falsely negative in cases of neurosyphilis, the clinician ordered an FTA-ABS test, which was positive.

The diagnosis was confirmed with a lumbar puncture, which showed CSF pleocytosis, elevated protein, and a positive CSF VDRL. The patient was admitted to the hospital and treated for 14 days with penicillin G IV. Upon discharge, she was instructed to undergo repeat CSF studies within 3 to 6 months, and then every 6 months for 2 years to ensure complete resolution of all abnormalities.
The LLSA Literature Review

Critical Decisions in Emergency Medicine’s series of LLSA reviews features articles from ABEM’s Lifelong Learning and Self-Assessment Reading List (available online at acep.org/llsa and on the ABEM website). Following are key points from four of the 13 articles included on ABEM’s 2016 list. Highlights of the remaining articles will appear in subsequent issues.

Edited by J. Stephen Bohan, MS, MD, FACEP; Harvard Affiliated Emergency Medicine Residency; Brigham and Women’s Hospital, Boston, Massachusetts.

Article 9
Bacterial Meningitis Post-PCV7: Declining Incidence and Treatment
- Streptococcus pneumoniae is still the most common pathogen for bacterial meningitis in children outside the neonatal period.
- In infants younger than 1 month, start ampicillin plus either cefotaxime or an aminoglycoside, and consider acyclovir therapy for herpes simplex virus coverage.
- In children older than 1 month, start vancomycin plus a third-generation cephalosporin.

Article 10
Clinical Policy: Procedural Sedation and Analgesia in the ED
- Sedation should never be delayed based on fasting time.
- Capnography can help detect hypoventilation and apnea.
- An additional provider should be in the room to monitor any patient undergoing sedation; the minimum number of personnel needed is unspecified.
- Multiple agents have been proven safe in procedural sedation and analgesia.

Article 11
Clinical Practice: Community-Acquired Pneumonia
- The patient’s clinical picture should be assessed in combination with laboratory test results to help guide the disposition (eg, discharge home, or admit to an inpatient floor or ICU).
- Outpatient community-acquired pneumonia (CAP) treatment should include antibiotics with coverage for Streptococcus pneumoniae and atypical pathogens (eg, macrolides).
- Inpatient CAP coverage should include a respiratory fluoroquinolone or a second- or third-generation cephalosporin plus a macrolide.
- A diagnosis of health care-associated pneumonia (HCAP) identifies patients at risk for drug-resistant organisms such as Pseudomonas or MRSA; however, the protocols for managing HCAP remain controversial.

Article 12
Hyperglycemic Crisis
- Type 1 diabetes, and — consequently — diabetic ketoacidosis are increasing in young children and should be included in the differential diagnosis for a newly ill pediatric patient. A finger stick glucose, IV infusion of saline, and ECG are the first important steps in diagnosis and treatment. If severe signs of hyperkalemia are absent on ECG, insulin therapy should be withheld until the patient’s serum potassium level is known and significant deficits are corrected.
- An intravenous infusion of insulin is the standard treatment.
- Hyperosmolar hyperglycemic syndrome should be considered in any elderly patient with altered mental status.
- Institutional guidelines should be in place for the management of elevated glucose, including protocols for fluid administration, insulin therapy, and electrolyte derangement.

Article 13
Bleeding and Coagulopathies in Critical Care
- Many coagulopathies can’t be confirmed with a specific diagnostic test; clinicians must rely on a thorough history, physical examination, and laboratory results.
- Tranexamic acid (TXA) should be administered when a massive transfusion is expected, ideally within 3 hours of the injury.
- There is a lack of data to support transfusion goals in thrombocytopenia.
The Critical Procedure

TUBE THORACOSTOMY

The most frequent indications for tube thoracostomy in the emergency department are pneumothorax and hemothorax, which can be acutely life threatening. In such cases, patient comfort may come secondary to survival. It is important to still the nerves; while expediency is important, so is accuracy.

Risks and Benefits

Laceration or tearing of the neurovascular bundle running below each rib may cause significant bleeding, irritation, or potentially permanent paresthesias. Malpositioned tubes may dissect soft tissue or, when placed within the fissures of the lung, may decrease functionality. In some instances, fistulas or infections can develop. An aberrantly placed tube also can penetrate the parenchyma of the lung, mediastinum, great vessels, intra-abdominal cavity and organs, or — in rare cases — the heart itself. Finally, despite a correctly positioned tube, a number of patients will develop a recurrent pneumothorax or require additional procedures such as decortication.

Lifesaving benefits include the correction of hypoxia, dyspnea, or tension physiology, and stabilization of respiratory mechanics. Additionally, evacuation of a hemothorax via chest tube placement decreases the risk of empyema.

Alternatives

For patients with a simple spontaneous pneumothorax, a traditional tube (28 to 36 Fr) often can be replaced by a smaller percutaneous pigtail catheter, which may be better tolerated. Small pneumothoraces (<10% lung volume) sometimes can be treated with supplemental oxygen and watchful waiting. Needle decompression or finger thoracostomy may be used as temporizing techniques in a crashing patient, but are not substitutes for tube thoracostomy.
Reducing Side Effects

A thorough understanding of anatomy and proper site selection will reduce most side effects. Pain is decreased by the adequate use of local anesthesia. The pleura should be breached and confirmed digitally prior to placement of the tube. Lung parenchyma should be palpated. Risk of mediastinal and great vessel perforation may be reduced by placing the tube deep enough to bury all fenestrations within the chest cavity, but no deeper. The use of trochars is no longer recommended.

Special Considerations

Full sterile technique and analgesia are unlikely to be primary concerns in true emergencies; however, local sterility and patient comfort and safety should remain high priorities. For removal of hemothoraces, the tube tip should be directed toward fluid collection; apical placement is indicated for a pneumothorax. For patients with a massive hemothorax (>1 L of intrathoracic blood), immediate surgical intervention may be warranted.

Light sedation may be used based upon the patient’s hemodynamic profile. Some patients may benefit from a soft restraint to secure the ipsilateral arm above the head during the procedure. Pediatric patients require special consideration for tube size, depth, and anxiety level.

TECHNIQUE

1. **Obtain** consent, if possible.
2. **Select** a tube sized to fit between the patient’s ribs. It is prudent to have a second smaller size at hand.
3. **Ensure** all materials have been collected and placed at the bedside. These should include:
   a. An appropriately sized chest tube
   b. A #10 blade scalpel
   c. Two Kelly clamps
d. Scissors
e. Suturing material
f. Water seal device or Heimlich valve with associated tubing, and wall suction
g. Appropriate amount of local anesthetic
   h. A large-bore filling needle
   i. One or two 25-gauge injection needles
   j. A 20-mL or two 10-mL syringes
   k. Antiseptic solution
   l. Dressing supplies (gauze, tape, and occlusive adhesive)
m. Sterile towels or drape
   n. Sterile gown and gloves (2 sets)
o. Face and eye protection
   p. Soft wrist restraint (if indicated)
4. **Place** implements on a sterile field.
5. **Consider** prophylactic antibiotics (eg, cefazolin) and a tetanus vaccine. The role of routine antibiotics remains controversial.
6. **Provide** premedication as indicated.
7. **Position** the patient in a supine or semi-recumbent position with the arm of the affected side held above the head.
8. **Locate** and mark the site of insertion (the 4th intercostal space in the anterior axillary line); however, the incision is typically made directly over the 5th rib itself. Avoid tunneling the tube from further away than one rib space, as this increases the difficulty and complication rate.
9. **Precut** the nonfenesetrated end of the chest tube so it will fit snugly on the connecting piece of the water seal or suction device.
10. **Clamp** and occlude the cut end of the chest tube.
11. **Provide** generous local anesthesia to the periostium, intrapleural space, and surrounding rib spaces:
   a. Briefly provide a wheal at the site of injection.
   b. Insert the needle until it contacts the 5th rib, and provide generous anesthesia along the periostium. Provide negative pressure to the syringe, advance over the rib, and stop just as it perforates the pleural space and air bubbles are pulled into the syringe.
   c. Inject several mLs of lidocaine into the intrapleural space and peripleural region.
   d. Withdraw the needle while injecting a tract of lidocaine into the tissues.
   e. With remaining lidocaine, liberally inject the surrounding soft tissue to block the local perforating nerves.
12. **Make** an incision with the scalpel directly down to the periostium of the 5th rib, just large enough to allow completion of the procedure (typically <5 cm).
13. **Grasp** the free Kelly clamp and insert it into the incision, keeping a finger near the tip of the clamp to maintain direction control and prevent over penetration and parenchymal injury. Provide firm, gentle pressure over the superior surface of the rib until the pleura has been punctured.
14. **Open** the Kelly clamp and remove it from the pleural space, allowing the open end to dilate the perforation in the pleura, parallel with the ribs. This may need to be repeated several times.
15. **Enter** the chest cavity with a gloved finger to ensure lung parenchyma can be palpated, and sweep the finger around the cavity to free any adhering tissue.
16. **Affix** a Kelly clamp to the tip of the fenestrated end of the chest tube and insert it through the pleural Advance the tube so the last eye is within the thoracic cavity.
17. **Remove** the clamp and suture the positioned tube into place. It is important to provide stability without puncturing the tube.
18. **Attach** the distal end of the tube to the suction or sealing device, remove the clamp occluding that end, and create a seal by suturing any remaining lacerations created by the procedure.
19. **Place** gauze around the insertion site and securely cover the tube and incision with an occlusive dressing.
20. **Order** a post-procedure chest x-ray.
A 37-year-old man with diffuse myalgia, severe weakness, and a large rash on his torso.

The Critical ECG

SR with high-grade atrioventricular (AV) block, rate 50, left ventricular hypertrophy (LVH). The atrial rate is 88 but the ventricular rate is only 50, indicating the presence of an AV block. There does not appear to be a regular association between the P waves and QRS complexes. While some of the QRS complexes follow a relatively normal PR interval and appear to be conducted beats, other QRS complexes appear more isolated (eg, the first QRS complex) and may be escape beats. Additionally, many of the P waves are non-conducted. The rhythm does not meet the criteria for a diagnosis of second-degree or third-degree (complete) heart block, and as a result is simply referred to as “high-grade AV block.” This patient did go on to develop complete heart block but recovered in time. He was eventually diagnosed with Lyme carditis.

By Amal Mattu, MD, FACEP
Dr. Mattu is a professor, vice chair, and director of the Emergency Cardiology Fellowship in the Department of Emergency Medicine at the University of Maryland School of Medicine in Baltimore.

Clinicians must be prepared to manage the acute and chronic complications of sickle cell disease (SCD), an inherited blood disorder that can result in significant mortality if not identified and properly treated. Although many pediatric patients initially present with mild symptoms, life-threatening problems such as serious organ dysfunction can erupt with little warning.
CASE PRESENTATIONS

■ CASE ONE

An 8-year-old boy with a history of sickle cell disease presents with pain in his lower back and right hip. He has experienced discomfort in his back before, but the hip pain is new and much more intense. The symptoms are worse with movement and when bearing weight, but are severe even at rest. The patient’s mother reports that the boy has been running a “low-grade fever” for the last 2 days.

His vital signs are blood pressure 108/66, heart rate 112, respiratory rate 22, temperature 38.8°C (101.8°F), and oxygen saturation 97% on room air. On examination, the patient resists range of motion of the right lower extremity because of the pain. His skin is warm, but there is no obvious joint redness or swelling, and the spine is nontender to palpation. Radiographs of the lumbar spine and hip are unremarkable.

The patient’s pain decreases from a 10/10 to a 6/10 after intranasal fentanyl and intravenous hydromorphone are administered; however, he remains unable to walk even after receiving 3 doses of narcotics.

Sickle hemoglobin (HbSS) is the result of a single amino acid mutation in the beta-globin chain. Inheritance of two abnormal genes for HbSS leads to sickle cell disease. Carriers of the gene mutation are most frequently found in places with endemic malaria: sub-Saharan Africa, the Middle East, and Southern Asia. Although these carriers have an improved malaria survival benefit of about 60% compared to noncarriers, this increased survivability comes at a cost.

Gene, and 70,000 to 100,000 Americans suffer from SCD (Figure 1).

Although morbidity is significant, more than 90% of children with SCD survive to adulthood. Unfortunately, a host of acute and chronic complications plague these patients. Recurrent crises occur as small vessels are blocked by the sickle hemoglobin, causing tissue ischemia and pain.

Acute Cases

Vaso-occlusive crisis (VOC) is the most common complaint of patients with SCD who present to the emergency department. Other life-threatening complications related to the disease include:

• Acute chest crisis
• Stroke
• Acute renal failure
• Infection and sepsis
• Priapism
• Biliary tract disease (eg, increased secreted unconjugated bilirubin from increased hemolysis precipitates and causes gallstones)
• Acute anemia
• Splenic sequestration (a major cause of acute anemia in children 1 to 4 years of age)
• Multiorgan failure
• Ocular issues: (eg, hyphema, central retinal artery occlusion)
Chronic Cases
Chronic problems can occur as a result of organ injury related to acute or chronic insult, including:
- Chronic pain
- Leg ulcers
- Pulmonary hypertension and cor pulmonale
- Chronic kidney disease
- Vision-threatening disorders such as sickle retinopathy and vitreous hemorrhage

CRITICAL DECISION
What is the best approach to pain management in children with acute complications of sickle cell disease?

Guidelines for managing the acute pain associated with SCD encourage the timely, aggressive use of analgesia. Subcutaneous or intranasal opioids should be used when the establishment of intravenous access is difficult or delayed; the first dose of medication should be given within 30 minutes of triage. Severe pain should be treated at 15- to 30-minute intervals, and the dose should be maintained or increased by 25% with subsequent doses; patients should be reassessed following each dose.

Meperidine, which can be toxic in large or repeat doses, is discouraged unless it is the only effective opiate for the patient. Nonpharmacologic adjuncts to pain relief such as heat packs can help treat vaso-occlusive crises. The use of nonsteroidal anti-inflammatory drugs (NSAIDs) is controversial and can be problematic in patients with SCD, many of whom also have renal disease. Nonetheless, NSAIDs may be appropriate in children whose pain responds to these agents and who lack contraindications for their use.

Intravenous fluids are routinely used in many centers as an adjunct to pain control for the correction of volume deficits. Severe pain can limit oral intake, and patients with SCD may lack adequate renal concentrating ability, depleting intravascular volume. However, intravenous hydration should be used cautiously to prevent fluid overload, which has been associated with acute chest syndrome (ACS) in patients with vaso-occlusive pain.

Researchers have failed to identify an ideal method of delivery, volume, or fluid type for managing this symptom in patients with SCD.

Recent studies have investigated the use of magnesium and antiplatelet agents as disease-modifying therapies for VOC. Magnesium has vasodilatory and anti-inflammatory properties, but does not appear to reduce the need for opioids or lengths of stay in pediatric patients. Although prasugrel is an antiplatelet agent postulated to mitigate intercellular adhesion and thrombosis
during the disease, it has failed to demonstrate a lower risk of VOC in children and adolescents.\(^9\)

Opioid abuse and misuse is a significant concern, and the management of many chronic pain conditions is currently trending away from the use of opioid analgesics.\(^{10,11}\) Although these agents are becoming less appropriate for treating some painful conditions, opioids remain the first-line treatment for patients with acute vaso-occlusive pain. Adequate, timely pain relief is associated with improved pain scores, increased rates of discharge from the emergency department, and reduced lengths of stay.

**CRITICAL DECISION**

**What causes of bone and joint pain are most concerning in pediatric patients with sickle cell disease?**

**Vaso-Occlusive Crisis**

The most common cause of bone and joint pain in SCD is vaso-occlusive crisis, which occurs when the abnormal hemoglobin polymerizes into triple-helix chains when deoxygenated, resulting in the blood cell's classic sickle shape (Figure 2). This manifests most frequently in smaller vessels and capillary beds with slower blood flow. As a consequence, the erythrocyte integrity is disrupted and becomes dehydrated, rendering it fragile and adherent to other structures; this results in blockage of these small vessels and endothelial damage.

Other pathologic events are triggered by vaso-occlusion, including ischemia and reperfusion injury, which can cause inflammation and pain in the affected tissues. Mild fevers are not uncommon with VOC.\(^{15}\)

Dactylitis — often the first manifestation of vaso-occlusion in young children — is marked by swollen, warm, and tender hands or feet. Mild redness of the digits and a low-grade fever also are common.

Forty percent of patients with SCD develop this complication, and just under half of children with hemoglobin SS will experience an episode of dactylitis by the time they’re 2 years old; it is rare in children over the age of 4 years. Symptoms resolve spontaneously in uncomplicated cases.

**Alternative Diagnoses**

Although avascular necrosis (AVN), osteomyelitis, and septic arthritis are less common etiologies of bony pain in sickle cell disease, they can have devastating effects if not appropriately diagnosed and treated.\(^{16}\) Symptoms of these disease processes are very similar, so differentiating among them can be a challenge.

**Avascular Necrosis**

AVN, which can accompany or precede an infectious process, can result in bone death due to loss of blood supply related to vaso-occlusion. The femoral and humeral heads are the most commonly involved joints. Although half of patients with the disease will lack symptoms, classic findings include reduced range of motion and pain in the groin or buttocks, which are worse with movement or when bearing weight.

Most patients with shoulder symptoms also will have abnormal hips. Treatment usually is conservative, with a focus on pain relief, mobility, physiotherapy, and surgery (rarely). Patients with SCD are at increased risk.
risk of complications from operative management, and most research has failed to show an improved outcome from surgery for AVN in this population.\textsuperscript{17}

**Osteomyelitis**

Osteomyelitis in patients with SCD, which frequently occurs in previously infarcted areas of bone, most commonly is caused by *Salmonella*. Fewer than 25\% of cases are associated with *Staphylococcus aureus*, the most common etiologic agent in patients without SCD. No single element of the patient’s history, radiographic study, or laboratory test, with the exception of positive bone culture, can confirm or rule out the disease.

Long bones, which are most commonly affected, may be infected at multiple sites.\textsuperscript{18} An absence of splenic function reduces resistance to the encapsulated bacteria that seed and infect long bones. Blood cultures are positive 30\% to 76\% of the time in patients with osteomyelitis.\textsuperscript{19} Signs associated with an increased risk of the disease include a longer fever duration (probability increases by 80\% for each day a child is febrile) and documented limb swelling (increases risk by 8.4 times). Osteomyelitis is 30\% less likely if there is more than one site of pain; however, each additional day of pain increases likelihood of the diagnosis by 20\%.\textsuperscript{20}

Radiographs may fail to demonstrate acute bony destruction for 7 to 10 days. Magnetic resonance imaging (MRI) has a higher sensitivity for osteomyelitis than does technetium (Tc 99) bone scanning, WBC studies, or plain radiography.\textsuperscript{21} Unenhanced T1-weighted fat-saturated magnetic resonance images, however, do not appear to be more accurate in differentiating osteomyelitis from bone infarct.\textsuperscript{22} Clinical suspicion should dictate the initiation of antibiotics and hospital admission, and hematology and infectious disease consultations should be obtained as soon as feasible.

**Septic Arthritis**

Septic arthritis is less common than osteomyelitis in SCD patients. Although joint aspiration is considered the gold standard for confirming the diagnosis, synovial fluid tests can be difficult to interpret. Low WBC counts can be present even in culture-proven cases. In the past, it was taught that a synovial fluid WBC count of more than 50,000/mm\(^3\) was associated with septic arthritis; however, in more recent publications, only 50\% to 75\% of culture-proven cases demonstrate an initial WBC this high.\textsuperscript{24}

A positive synovial fluid Gram stain is diagnostic, but an absence of bacteria does not rule out a septic joint, as the sensitivity of Gram stain is about 50\%.\textsuperscript{25} The most common infectious organism in septic arthritis is *S. aureus*.\textsuperscript{26}

Empiric antibiotic therapy is recommended for the management of both suspected osteomyelitis and septic arthritis. Although there is not enough high-quality evidence to dictate treatment, coverage should include treatment for *Salmonella* and *S. aureus*. Ceftriaxone (50-75 mg/kg, maximum 2 g/dose) is a first-line agent. In areas with higher *S. pneumoniae* resistance, a higher dose (75-100 mg/kg/dose, maximum 2 g/dose) is recommended. Clindamycin (10-15 mg/kg/dose) is recommended for cephalosporin-resistant cases. Vancomycin (15 mg/kg/dose) also is an option for septic pediatric patients or those with documented reactions to clindamycin. Treatment should be continued for 6 weeks.\textsuperscript{27,28}

**CRITICAL DECISION**

What causes of dyspnea are most concerning in a patient with sickle cell disease, and how should this complication be managed?

Pulmonary issues, both acute and chronic, are common in patients with SCD. One of the most feared complications of the disease is acute chest syndrome, which is defined as a new chest radiograph radiodensity and at least one of the following symptoms:

- Fever
- Cough
- Chest pain
- Hypoxia

ACS is most common in children between the ages of 2 and 4 years. The syndrome is less frequently seen in adults, but is associated with a higher mortality rate in patients older than 20 years.\textsuperscript{29} Because the syndrome is acutely life-threatening, early diagnosis and aggressive treatment are essential to prevent respiratory failure, multiorgan failure, and death. Long-term survivors of ACS can develop pulmonary fibrosis following an episode.\textsuperscript{30}

The precipitating event for ACS cannot be definitively established in most cases (Table 1). The presence of infection or obstruction to blood flow results in reduced oxygen tension in the small vessels of the lung — a decrease that causes local polymerization of HbSS. Blood flow then decreases further as a result of worsening vaso-occlusion, prompting a chain reaction of deoxygenation and sickling of erythrocytes. Endothelial injury increases platelet adhesion and *in situ* thrombosis results.

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**TABLE 1. Acute Chest Syndrome in Sickle Cell Disease**

<table>
<thead>
<tr>
<th></th>
<th>Children</th>
<th>Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Etiology</strong></td>
<td>Most common infectious cause (&lt;10 years): viruses</td>
<td>Necrotic bone marrow embolism</td>
</tr>
<tr>
<td></td>
<td>Mycoplasma pneumoniae most common bacterial cause</td>
<td>Fat embolism</td>
</tr>
<tr>
<td></td>
<td>Younger at presentation with coexisting asthma</td>
<td>Lung infarction due to thrombosis</td>
</tr>
<tr>
<td><strong>Severity</strong></td>
<td>Less severe; death rate: 3%</td>
<td>Death rate: 12%</td>
</tr>
<tr>
<td></td>
<td>Respiratory failure most common cause of death in ACS</td>
<td></td>
</tr>
<tr>
<td><strong>Fever</strong></td>
<td>&gt;80% of children have fever with ACS</td>
<td>Many adults are afebrile</td>
</tr>
</tbody>
</table>
Patient Management

The emergency department evaluation of any patient with sickle cell disease who presents with a chest complaint should include a chest radiograph. Although patients with ACS may not present with abnormal examination findings, x-rays may reveal small pleural effusions or minor infiltrates. A complete blood count, reticulocyte count, arterial blood gas measurements (hemoglobinopathy renders pulse oximetry less reliable), and blood cultures are recommended.

Studies to evaluate for influenza and respiratory viruses may be appropriate, depending on the season. The most concerning findings include a multifocal infiltrate on chest radiograph, doubling of baseline WBC, or a drop in hemoglobin levels greater than 1 g/dL. Thrombocytopenia of more than 200,000/mm³ is an independent predictor of mortality.

Although a patient may appear minimally ill, any child who presents with suspected ACS should be admitted due to the rapid onset of symptoms and high rate of critical illness among this population. Oxygen should be administered to maintain a peripheral arterial blood (PaO₂), or partial pressure of oxygen in capillary oxygen saturation (SpO₂) above 90% or partial pressure of oxygen in arterial blood (PaO₂) above 60 mm Hg, and antibiotics (cephalosporin and macrolide IV) should be administered to cover atypical pathogens.

Fluid management should be individualized according to the patient’s cardiopulmonary status (1 to 1.5x maintenance, adjusted for output). Respiratory therapy, including incentive spirometry, should be administered; bronchodilators may be required for patients with a positive response or known asthma.

Transfusion is warranted in children with severe disease (eg, tachyplea, hypoxia, increased work of breathing) or significantly worsened anemia compared with baseline. The treatment also may be of value in patients with multifocal infiltrates, severe respiratory distress, or requirements for ICU admission.

A previous history of cardiac disease also appears to be associated with an increased risk of respiratory failure. Children with an alveolar-arterial oxygen gradient above 30 (indicative of a defect in gas diffusion or V/Q mismatch) are at an increased risk of this complication and are more likely to require a transfusion. The procedure increases the body’s oxygen-carrying capacity and “dilutes” abnormal hemoglobin, thereby reducing vaso-occlusion. Both exchange and simple transfusions improve oxygenation and alleviate symptoms.

The major risks associated with blood transfusion are:
- Infection (eg, hepatitis B, 1 in 205,000; hepatitis C or HIV: 1 in 1- to 2 million)
- Hyperviscosity syndrome (eg, CNS effects, including cerebral venous thrombosis or infarcts)

- Acute transfusion reactions (eg, low risk due to use of leukoreduced packed red blood cells in this population)
- Fever, urticaria, shock
- Delayed hemolytic reaction (ie, 3 to 14 days following transfusion), including rapid drop in hemoglobin level, jaundice, hemoglobinuria, and increased percentage of reticulocytes
- Volume overload
- Transfusion-related acute lung injury (eg, acute noncardiogenic pulmonary edema usually presenting with dyspnea, tachypnea, and hypotension within 6 hours of transfusion). There is a high morbidity rate with most patients requiring ventilatory support.

Differential Diagnoses

Other diagnoses in the differential of dyspnea in patients with SCD include pulmonary embolism (PE), pneumonia, acute coronary syndrome, symptomatic anemia, and asthma exacerbation. Pulmonary embolism should be considered in patients with dyspnea and normal chest radiography, and in those with recent surgery or immobility. The presence of an indwelling vascular device increases the risk of this complication. D-dimer tests are of limited value in screening for PE in patients with SCD.

Pneumonia is clinically impossible to differentiate from dyspnea during a brief emergency department evaluation. The treatment is similar to that of ACS.

The exact incidence of ACS and myocardial infarction (MI) is unknown in this population, and there is little data about managing such events. Autopsy evidence suggests that MI in these cases is related to microvascular dysfunction rather than epicardial coronary disease.

Severely reduced hemoglobin compared with baseline can cause dyspnea. Splenic sequestration should be considered in any young child who has an unexplained drop in hemoglobin.

Reactive airway disease and asthma are common in children with SCD, and patients with asthma are at increased risk of ACS.

Pearls

- Pain should be addressed quickly after triage and frequently reassessed to achieve adequate pain control in patients with SCD.
- Consider the possibility of acute chest syndrome in patients presenting with SCD and chest pain or fever.
- Bony pain may have a more worrisome etiology than a patient’s “usual” sickle pain. Consider the possibility of osteomyelitis, septic arthritis, or avascular necrosis as alternative diagnoses.
- SCD patients with cough and a new infiltrate on chest radiograph may be at risk of ACS, even if they are relatively well-appearing in the emergency department. Admission should be strongly considered.
What risk factors and findings should raise suspicion for stroke in a child with SCD, and how should these cases be managed?

Eleven percent of patients with sickle cell disease will suffer a stroke before the age of 20 years, and the risk increases to 24% by age 45. Children are at highest risk between the ages of 2 and 5 years. Ischemic stroke is most common in children and adolescents; hemorrhagic stroke, by contrast, peaks between the ages of 20 and 30 years.

Silent cerebral infarct (SCI), which affects about 25% of patients with SCD by the time they are 6 years old, can result in cognitive deficits and learning problems. Regular transfusions of blood appear to greatly reduce the risk of silent stroke in children with evidence of SCI on imaging and normal physical examinations. Headaches are 10 times more likely to be associated with serious neurologic events in pediatric patients with SCD than in those without. Children with a history of transient ischemic attacks or stroke are at an increased risk of abnormal findings.

In children who have been receiving prophylactic transfusions, other risk factors include prior transient ischemic attacks, chronically low steady-state hemoglobin levels, recent ACS, hypertension, abnormally elevated mean cerebral arterial flow velocities on transcranial Doppler ultrasound, and a family history of stroke.

Stroke symptoms in patients with sickle cell disease are similar to those in patients without the disorder; however, it can be more challenging to make the diagnosis in children, who infrequently present with such complaints. Symptoms include speech difficulties, focal weaknesses, ataxia/gait abnormalities, and vision changes.

The evaluation of neurologic abnormalities in children with SCD should include early identification, rapid diagnostic imaging, and appropriate supportive care. Oxygen saturation should be maintained at levels above 95% to correct for hypoxia, and intravenous fluids should be given to maintain euvoema. Patients should receive a rapid assessment of electrolytes to prevent and treat hypoglycemia and hyponatremia; and a complete blood count, reticulocyte count, and type and screen should be obtained in preparation for a possible transfusion.

A computed tomography (CT) scan of the brain is the most rapid test for evaluating neurologic complaints in the emergency department. MRI with diffusion-weighted imaging is more specific and sensitive for stroke and can better differentiate between old and new infarcts to help determine the most appropriate treatment.

Differential Diagnoses

Other potential diagnoses also should be considered when evaluating a child with SCD for a focal neurologic deficit. Seizures are 10 times more common in children with SCD than in the general population. Postictal (Todd) paralysis can cause transient focal weakness in patients with and without the disease. Abnormal vasculature and focal hypoperfusion are thought to be major factors in the development of seizures in this group.

Alternative diagnoses also should include:

- Hemiplegic migraine — Evidence of infarcts on CT or MRI excludes this diagnosis, which usually presents as repeated hemiplegia and headache. Family history plays a significant role, as the disorder can be inherited in an autosomal dominant manner.

- Posterior reversible encephalopathy syndrome (PRES) — These patients present with headache, seizure, vision changes, and altered mental status — symptoms that are triggered by vasogenic edema of the parietal and occipital lobes of the brain. PRES is associated with severe acute chest syndrome in children.

- Central sinus venous thrombosis (CSVT) — Although this disorder is less common than strokes in patients with SCD, symptoms can mimic stroke (eg, seizures, vomiting, headaches, cranial nerve palsies, headaches, and coma). If this diagnosis is being considered, magnetic resonance venography must be added to the MRI order. Patients with CSVT require long-term anticoagulation therapy.

CRITICAL DECISION

Which patients can be managed with thrombolysis or transfusion?

Adult patients with ischemic stroke may be candidates for thrombolysis, but tissue-type plasminogen activator (tPA) is not approved for use in children. Research about the use of tPA in pediatric patients with SCD is limited to case reports. Adults with stroke and SCD who meet inclusion criteria may be managed with tPA.
Case Resolutions

**Case One**

An MRI of the 8-year-old boy’s painful hip showed diffuse bone marrow hypointensity without an acute focal lesion. Laboratory tests revealed a mildly elevated WBC, which was consistent with prior studies; blood cultures were positive for *Salmonella*. Due to concerns about osteomyelitis, ceftriaxone was initiated and he was admitted to the hospital, where his pain became manageable with patient-controlled analgesia. He was discharged home 6 days later with a prescription for oral antibiotics.

**Case Two**

The chest x-ray of the teenage girl showed new bilateral, patchy infiltrates. Laboratory tests revealed a WBC of 20,000, hemoglobin level of 6.4 (baseline of 8.9), and platelet count of 145,000; partial pressure of oxygen on arterial blood gas was 65. Azithromycin, ceftriaxone, supplemental oxygen, and intravenous fluids were initiated. The patient was admitted to the ICU, where she received a simple transfusion of leukocyte-reduced packed red blood cells. Her hypoxia quickly improved, and she was discharged home after 9 days.

**Case Three**

The young boy with a sudden-onset headache and difficulty speaking received a head CT, which showed a dense middle cerebral artery; the neurology, critical care, and hematology teams were notified. A brain MRI with diffusion-weighted imaging was ordered, and the patient was admitted to the pediatric ICU. He was treated with supportive care; the medical team considered performing an exchange transfusion but ultimately decided against it, given the patient’s improving symptoms and prior reaction to PRBCs. The parents were counseled on the importance of consistent hydroxyurea treatment, and warned about the boy’s high risk of a recurrent neurologic event.

### Summary

Pediatric patients with sickle cell disease frequently experience complications, which can manifest acutely in any part of the body. Although children initially may present with mild symptoms, they are at risk of potentially serious organ dysfunction. Emergency clinicians should maintain a high level of suspicion for complications related to SCD, particularly infections and organ injury as a consequence of vaso-occlusion.

### References


45. Kassim AA.
**CASE**

A 65-year-old woman presents after a high-speed motor vehicle collision in which she was the driver. She was restrained with a lap and shoulder belt; her vehicle, which was not equipped with airbags, suffered significant intrusion on the driver’s side. The patient complains of posterior thoracic pain, dyspnea, and left upper quadrant pain.

Her vital signs are blood pressure 108/65 mmHg, pulse rate 122, temperature 36.2 °C (97.2 °F), respiratory rate 24, and oxygen saturation 90% on room air. The patient has decreased breath sounds on the left with left upper abdominal tenderness; and the posterior thorax is tender to palpation.

A chest x-ray is performed, followed by CT of the chest, abdomen, and pelvis.

**A. AP chest radiograph.**

The left fifth, sixth, and seventh ribs are fractured posteriorly. The left cardiac border is obscured by the left hemidiaphragm, which is elevated above its normal position and above the level of the right diaphragm. Recall that the right diaphragm is usually higher than the left, as a consequence of the larger size of the liver compared with the spleen. Elevation of the left diaphragm following blunt trauma suggests diaphragmatic rupture.

**B. CT with intravenous contrast, axial image, soft tissue window.** The spleen is mottled in appearance, with areas of hypodensity representing injury; compare with the normal appearance of liver parenchyma. A bright region of active contrast extravasation indicates ongoing hemorrhage at the moment of CT.
CASE RESOLUTION

The patient was admitted and underwent surgical repair of her diaphragm injury and angiographic embolization of her spleen.

KEY POINTS

- Diaphragmatic injury from blunt trauma is a rare but important complication, occurring in 0.8% to 8% of blunt trauma cases. Abdominal organs herniated into the chest can cause immediate respiratory distress, and the substantial force required for diaphragm injury frequently results in other injuries (44% to 100% of cases) such as splenic rupture. Delayed herniation of organs through the diaphragm defect also can occur, and complications such as bowel strangulation have been reported. All diaphragm injuries require surgical repair. Left diaphragm rupture is three times more common than right, possibly due to congenital weakness of the left diaphragm and because the right diaphragm is protected by the mass of the liver.

- The plain radiographic appearance commonly includes elevation of the affected diaphragm; in the case of left diaphragm rupture, this reverses the normal relationship of the right and left diaphragms. The right diaphragm usually is more cephalad because of the larger size of the liver compared with the spleen. Herniated organs may be seen on plain radiograph; if a gastric tube has been placed prior to x-ray, the presence of the tube in the left thorax is an overt clue to gastric herniation through a diaphragm defect. A thoracic gastric bubble may be confused with pneumothorax; this, paired with decreased breath sounds and respiratory distress, can lead to unnecessary thoracostomy tube placement and iatrogenic injuries. Diaphragm injuries are missed on approximately half of initial plain radiographs, despite abnormal diaphragm contours in 75% of cases.

- In the past, single detector non-helical CT was insensitive for diaphragm injuries, but modern CT scanners with helical multidetector volume acquisitions are less likely to miss this injury. Although the reported sensitivity is as high as 90% with specificity as high as 100%, research focused on the most modern generation of scanners is lacking. At least 19 different CT signs have been described. Most can be summarized as direct evidence of diaphragm injury (eg, a visible segmental disruption of the diaphragm), indirect signs related to herniated organs (eg, the presence of abdominal organs within the thorax), or indirect signs related to the loss of the expected border between the thorax and abdomen.

REFERENCE

CME QUESTIONS

1 An otherwise-healthy 23-year-old woman who is 16 weeks pregnant presents with a confirmed case of syphilis. She is allergic to penicillin. What is the most appropriate disposition for this patient?
   A. Administer penicillin G, observe for 4 hours, and discharge home
   B. Admit for inpatient penicillin desensitization therapy
   C. Admit for inpatient treatment with doxycycline
   D. Discharge home with a prescription for doxycycline

2 What medication is an appropriate alternative to penicillin therapy for managing primary and secondary syphilis?
   A. Azithromycin
   B. Ciprofloxacin
   C. Doxycycline
   D. Vancomycin

3 Which of the following should be considered when treating a Jarisch-Herxheimer reaction?
   A. It can be prevented by administering both thorazine and penicillin G simultaneously
   B. It can be prevented by dividing the penicillin treatment into two doses
   C. It is an acute allergic response to penicillin
   D. Pretreatment with antipyretics often can diminish symptoms, but the reaction cannot be prevented

4 A 14-year-old boy presents with classic symptoms of primary syphilis. Aside from the usual treatments, what additional intervention is warranted?
   A. Contact child protective services
   B. Evaluation for sexual abuse and an assessment of the patient’s social situation to ensure a safe home for discharge
   C. Human papillomavirus vaccination
   D. Urine screen for drugs of abuse

5 A patient who was treated for primary syphilis with penicillin G returns 24 hours after discharge with flulike symptoms. What is the most likely diagnosis?
   A. Influenza
   B. Jarisch-Herxheimer reaction
   C. Penicillin allergy
   D. Viral upper respiratory infection

6 A 58-year-old man with a history of hypertension, HIV, and an unknown STD “in the past” presents with a 2-cm ulcer with a necrotic center and surrounding erythema on his nose. The emergency physician astutely diagnoses tertiary syphilis. What treatment should be prescribed?
   A. Admission with administration of penicillin G IV for 14 days
   B. Penicillin G (2.4 million U IM weekly for 3 weeks) with close primary care follow up
   C. Single-dose penicillin G (2.4 million U IM); follow up is unnecessary
   D. Tetracycline (500 mg 4x/day for 7 days)

7 An 18-year-old patient is concerned that he has contracted syphilis from a recent partner with known untreated disease. He was sexually active with this person for the first time 4 days ago and is asymptomatic. What is the next best step in management?
   A. Order a rapid plasma reagin test, and advise the patient to return in 1 to 2 weeks when the results will be more sensitive; administer treatment then if warranted
   B. Order a rapid plasma reagin test; discharge home if negative
   C. Order a treponemal test and admit while awaiting results; treat only if results are positive
   D. Treat the patient empirically, order a treponemal test, and discharge home

8 A 71-year-old woman is diagnosed with neurosyphilis. She is allergic to penicillin. What treatment should be initiated prior to admission?
   A. Aqueous crystalline penicillin G (200,000-300,000 units/kg IV); this is the only accepted treatment for tertiary syphilis
   B. Ceftriaxone (2 g IV)
   C. Doxycycline (100 mg PO)
   D. Tetracycline (500 mg PO)
An elderly man who reports having untreated syphilis “many years ago” presents with chest pain. The examination reveals a murmur in the second intercostal space, which isn’t noted in his earlier chart. What potential diagnosis is of most concern?

A. Aneurysm of the ascending thoracic aorta and aortic valve regurgitation
B. Aneurysm of the descending thoracic aorta and mitral valve regurgitation
C. Aortic dissection
D. ST-elevation myocardial infarction

What is an Argyll-Robertson pupil?

A. A normally reactive pupil that is unequal in size compared to the corresponding pupil
B. A pupil that reacts to accommodation but not light
C. A pupil that reacts to light but not accommodation
D. A pupil that reacts to neither light nor accommodation

What is the most common etiologic agent of osteomyelitis in patients with sickle cell disease (SCD)?

A. Haemophilus influenzae
B. Salmonella
C. Staphylococcus aureus
D. Streptococcus pneumoniae

Within what time frame following triage should a patient with an acute vaso-occlusive crisis receive pain medication?

A. 30 minutes
B. 60 minutes
C. 75 minutes
D. Guidelines do not specify a time frame

What is the most common location of avascular necrosis in children with SCD?

A. Ankle and elbow
B. Lumbar vertebrae
C. Femoral and humeral heads
D. Femoral shaft

In which age group is acute chest syndrome most commonly diagnosed?

A. 2 to 4 years
B. 6 to 8 years
C. 14 to 16 years
D. >20 years

What is the most common cause of bone and joint pain in patients with SCD?

A. Osteomyelitis
B. Septic arthritis
C. Vaso-occlusive crisis
D. Undiagnosed injury

What differential diagnosis should be considered when evaluating a child for dyspnea?

A. Central sinus venous thrombosis
B. Panic disorder
C. Pulmonary embolism
D. Silent cerebral infarct

Hyperviscosity syndrome is a complication associated with which of the following treatments?

A. Blood transfusion
B. Empiric antibiotic therapy
C. Meperidine
D. Tissue-type plasminogen activator

Which age group is most at risk of SCD-related stroke?

A. 2 to 5 years
B. 6 to 9 years
C. 13 to 16 years
D. 20 to 30 years

Which of the following is associated with an increased risk of stroke in patients with SCD who have been receiving prophylactic blood transfusions?

A. Acutely elevated hemoglobin levels
B. Chronic red blood cell transfusion therapy
C. Recent acute chest syndrome
D. Recent vaso-occlusive crisis with typical bony pain

What is the most appropriate first-line intervention for a child with stroke symptoms?

A. Aspirin therapy
B. Correction of hypoxia with oxygen
C. Simple transfusion
D. Thrombolysis with tissue-type plasminogen activator
**Drug Box**

**PERAMIVIR**

By Vijay Kannan, MD; and Frank Lovecchio, DO, Maricopa and Banner University Medical Centers, Phoenix, Arizona

Peramivir is a cyclopentane analogue indicated for the treatment of acute, uncomplicated influenza in adults who have been symptomatic ≤2 days. It is administered intravenously, and is particularly useful in patients who have developed resistance to other, nonparenteral forms of treatment.

**Mechanism of Action**
Neuraminidase inhibitors prevent viral release from host cells.

**Indications**
The CDC recommends treating all influenza patients who are hospitalized or have severe, complicated, or progressive illness. Factors that place a patient at increased risk include:
- Age ≥65 years old
- COPD or cardiovascular, renal, hepatic, hematological, or metabolic disorders, including diabetes mellitus
- Neurologic dysfunction
- Morbid obesity (BMI ≥40)
- Immunosuppression
- Pregnancy (or ≤2 weeks postpartum)
- American Indians/Alaskan natives
- Residents of nursing homes or other chronic care facilities

**Dosing**
600 mg IV as a single dose; only indicated in patients ≥18 years of age who have symptoms for ≤2 days

**Side Effects**
The most common adverse event is diarrhea. Patients also may develop anaphylaxis, serious skin reactions, or transient neuropsychiatric events such as self-injurious behavior or delirium.

**Precautions**
**Contraindications:** Previous hypersensitivity or anaphylaxis to any component of the formulation.

**Considerations:** Use with caution in patients with renal impairment; dosage adjustment is necessary.

**Pregnancy:** Indicated for the treatment of pregnant patients (category C); untreated influenza is associated with higher maternofetal morbidity and mortality.

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**Tox Box**

**SALICYLATE (ASPIRIN) TOXICITY**

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The ubiquitous usage of aspirin makes it the most common and deadliest salicylate encountered. Poisoned patients (acute ingestions >150 mg/dL) require swift recognition and aggressive treatment.

**Presentation**
- **Acute poisoning:** vomiting, hyperpnea, tinnitus, hyperthermia, lethargy
- **Severe toxicity (end-organ damage):** coma, seizures, hypoglycemia, pulmonary/cerebral edema
- **Chronic poisoning:** may be nonspecific and mimic sepsis

**Laboratory Evaluation**
- **Salicylate level:** therapeutic range (20-30 mg/dL)
- **Blood gas:** may reveal respiratory alkalosis (except in children) and metabolic acidosis
- **Electrolytes:** commonly have anion gap metabolic acidosis

**Treatment**
- Rehydrate for GI losses, but avoid fluid overload.
- **Alkalization:**
  - Administer 150 mEq Na bicarbonate in 1000 mL D5W (100-150 cc/hr IV) to “trap” non-ionized form in serum, increase renal elimination, and prevent CNS entry.
  - In serious cases, consider initial bolus of Na bicarbonate (1-2 mEq/kg IV).
- Replete glucose and potassium (urine alkalization is difficult in cases of hypokalemia). Monitor pH and aspirin levels frequently (every 2 hrs) to assess efficacy of interventions. Avoid intubation unless patient is hypoventilating.

**Decontamination/Elimination**
- Treat with activated charcoal even if >1 hr post ingestion due to bezoar formation and extended release formulations.
  - 1 gm/kg (up to 50 gm)
  - May repeat 25 gm every 2 hrs if levels rise

**Criteria for hemodialysis:**
- Fluid overload (pulmonary edema)
- Persistent altered mental status
- Persistent/severe acidemia (pH <7.2)
- Renal injury
- Salicylate concentrations >90 mg/dL (80 mg/dL with renal dysfunction) in acute cases and >60 mg/dL in chronic cases

**Disposition**
Observe until the patient is asymptomatic and serial levels have decreased with final salicylate <30 mg/dL.