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Evidence-Based Management Of Skin And Soft-Tissue Infections In Pediatric Patients In The Emergency Department

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Abstract

Skin and soft-tissue infections are among the most common conditions seen in children in the emergency department. Emergency department visits for these infections more than doubled between 1993 and 2005, and they currently account for approximately 2% of all emergency department visits in the United States. This rapid increase in patient visits can be attributed largely to the pervasiveness of community-acquired methicillin-resistant *Staphylococcus aureus.* The emergence of this disease entity has created a great deal of controversy regarding treatment regimens for skin and soft-tissue infections. This issue of *Pediatric Emergency Medicine Practice* will focus on the management of children with skin and soft-tissue infections, based on the current literature.

CME Objectives

Upon completion of this article, you should be able to:
1. Describe the pathophysiology of community-acquired methicillin-resistant *Staphylococcus aureus*.
2. Differentiate the clinical presentation of common skin and soft-tissue infections.
3. Outline the management of common skin and soft-tissue infections.

Prior to beginning this activity, see "Physician CME Information" on the back page.

Case Presentations

A 7-month-old, otherwise healthy, boy is brought to the emergency department with irritability and lethargy 3 days after undergoing elective circumcision. By history, he has been afebrile. His mother noted a faint red rash and swelling around the scrotum that extends up the abdomen. He is afebrile and normotensive on arrival, but he is tachycardic to 180 beats/min and tachypneic to 59 breaths/min, and his oxygen saturation is 91% on room air. On genitourinary examination, you note a circumcised penis with some erythema and edema near the glans. The scrotum appears normal, and both testes are palpable and nontender. The perineum appears normal. There is a faint erythematous area, approximately 10 cm in diameter that extends to the right upper leg. An ecchymotic lesion with a central bulla measuring 2 cm by 2 cm is noted in the right inguinal area. No crepitus is palpated in the involved area. You are worried that this child's lesions have progressed from a localized infection to a systemic one. The mother asks what is wrong with her baby…

A 2-year-old, otherwise healthy, girl is brought to the emergency department with a rash on her face. Her mother notes that the rash started 3 days ago after her child sustained a cut on the inside of her nose. The mother notes that the child seems to be in pain when the rash is touched, and the child frequently rubs her face. She is afebrile and has no associated symptoms other than nasal congestion. The physical examination is notable for honey-colored crusted lesions around her nose and upper face. The medical student who is rotating through the department this month asks you what this rash is and how to treat it...

A 7-week-old boy presents with 2 days of vomiting and diarrhea. According to his mother, he was born full-term with no complications. She had no infections during the pregnancy, and her group B Streptococcus swab was negative. The boy has been afebrile, and has had good urine output. He has not had a cough or congestion. On examination, the infant is afebrile with normal vital signs. His anterior fontanelle is open, soft, and flat, and the head, eyes, ears, nose, and throat examination is normal. Upon removing the child's clothes, an erythematous peeling rash is noted on the neck, axillae, inguinal folds, and genitalia. Gentle traction over the involved skin results in skin sloughing. His abdomen is noted to be soft and nontender, and his extremities are normal without any rash. The mother is unsure of how long the rash has been there and asks you if the rash is normal…

Introduction

Skin and soft-tissue infections (SSTIs) are some of the most common conditions seen in children in the emergency department (ED). These infections can range from benign lesions (such as impetigo) to severe life-threatening infections (such as necrotizing fasciitis). Emergency clinicians should be able to recognize the common SSTIs frequently encountered in the ED and be prepared to treat them appropriately. The approach to common SSTIs has been drastically altered by the emergence of community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA), leading many physicians to alter their practice accordingly.

Critical Appraisal Of The Literature

A search was performed in PubMed for articles published from 2007 to 2014 pertaining to children aged < 18 years using multiple combinations of the search terms *skin and soft-tissue infections, cellulitis, impetigo, staphylococcal scalded skin syndrome, toxic shock syndrome, MRSA, erysipelas,* and *hand infections.* The Cochrane Database of Systematic Reviews was also consulted. Articles relevant to pediatric skin and soft-tissue infections were selected and reviewed. More than 400 articles were reviewed, 137 of which were chosen for inclusion in this review, including a number of randomized controlled trials, meta-analyses, and clinical practice guidelines. The latest practice guidelines for the diagnosis and management of skin and soft-tissue infections by the Infectious Diseases Society of America are included.

Epidemiology

The exact incidence of SSTIs is difficult to determine as patients may present to their ambulatory physicians or, in cases of less severe infection, patients may not seek care at all. One study showed that ED visits for SSTIs increased from 1.2 million patients in 1993 to 3.4 million patients in 2005.[1] Due the emergence of resistance to many agents commonly used to treat SSTIs in the past, there has been a dramatic increase in the number of admissions to the hospital for SSTIs. One study notes a 29% increase in admission rates between 2000 and 2004.[2] This increased frequency of visits and admissions can be partially attributed to the emergence of CA-MRSA.

Etiology And Pathophysiology

Two specific bacteria cause the majority of SSTIs: *Staphylococcus aureus* and *Streptococcus pyogenes,* also known as group A *Streptococcus* (GAS). Both bacteria carry the ability to adapt to their environment, and both have numerous mechanisms that allow them to escape the body's natural defenses and the treatments prescribed by clinicians.

Staphylococcus aureus

Staphylococci are gram-positive cocci that can be microscopically observed as single organisms, pairs, or bunched in grapelike clusters. The term *Staphylococcus* is derived from the Greek word *staphyle,*

which means "bunch of grapes." Staphylococci are nonmotile, catalase-positive bacteria. *S aureus* colonizes the skin and mucosa of humans. Multiple body sites, including the axillae, perineum, and umbilical stump, can be colonized, but nasal colonization is the most common. Longitudinal studies have demonstrated that there are 3 nasal carriage patterns in healthy humans: noncarriage, intermittent carriage, and persistent carriage.[3-7] Persistent nasal colonization is a risk factor for the development of SSTIs,[8,9] but intermittent carriers and noncarriers have lower rates of infection.[10]

S aureus can cause disease through tissue invasion. Small breaks in the skin allow the bacterium to enter the skin. Once in the skin, *S aureus* produces enzymes like hemolysins, coagulases, hyaluronidases, and proteases, which can alter and destroy local tissue and facilitate the spread of infection.[11] Some strains of *S aureus* are capable of producing toxins that cause specific diseases or syndromes. Exfoliative toxins A and B can cause fever, erythema, and blistering. They can also cause staphylococcal scalded skin syndrome (SSSS) and bullous impetigo.[11] Staphylococcal enterotoxins are found in toxic shock syndrome (TSS). These toxins, specifically toxic shock syndrome toxin-1 (TSST-1) and enterotoxin B, act as superantigens and bind to major histocompatibility complex molecules that cause T-cell stimulation, leading to the manifestations of TSS.[11] Some strains of *S aureus* have developed resistance to antibiotics (including penicillin, methicillin, cephalosporins, vancomycin, and linezolid). Methicillin-resistant *S aureus* (MRSA) strains have acquired the *mec* gene, which confers resistance to penicillinase-resistant penicillins and cephalosporins.[12]

Until the 1990s, MRSA was predominantly found in patients who were either hospitalized or who spent considerable time in a hospital setting.[13] The emergence of MRSA has led to an increase in skin and soft-tissue infections. In the 1980s, the first reports of MRSA infections in patients with no discernible risk factors for MRSA or CA-MRSA were made.[14] Since that time, isolation of CA-MRSA from wounds has increased significantly. In the United States, the prevalence of CA-MRSA from cultured lesions is almost universally > 50% and, in some areas, is as high as 80%.[15-17]

Nosocomial MRSA and CA-MRSA are genetically different bacteria.[18] CA-MRSA isolates have a small staphylococcal chromosomal cassette *mec* (SCC*mec*) element, usually Type IV, which consists of a mobile genetic element that facilitates transfer of methicillin resistance more readily than the larger elements that code for hospital-acquired methicillin resistance.[13] Many strains of CA-MRSA contain the Panton-Valentine leucocidin genes, which can be found on the SCC*mec* gene codes for the production of cytotoxins that cause tissue necrosis and abscess

formation.[19,20] CA-MRSA isolates that contain Panton-Valentine leucocidin are associated with SSTIs.

Streptococcus pyogenes

Streptococci are the second leading cause of SSTIs in children, and they are also associated with other illnesses such as pharyngitis and nephritis.[11] Streptococci are gram-positive bacteria that form pairs or chains during growth. Of particular interest with regard to SSTIs are the GAS organisms. Most streptococci that contain the group A antigens are *S pyogenes*. GAS is normally found on human skin and mucosal surfaces, and does not survive outside the human host.[11]

M protein is the major virulence factor of *S pyogenes*.[21] It appears as hair-like projections of the streptococcal cell wall, and it functions by helping GAS avoid opsonization and phagocytosis.[11] The M protein has also been shown to play a role in GAS adherence and colonization of mucosal tissue. Specific M-types of GAS have strong correlations with certain infections, such as the association of M-types 1, 3, 12, and 28 and TSS. Interestingly, pathogenic M-types have been discovered in the throats of asymptomatic patients.

While certain M-types may have an association with specific disease, GAS has other virulence factors as well. The GAS capsule confers some resistance to phagocytosis. Levels of encapsulation vary between strains of GAS, and those with greater encapsulation are more virulent. One study demonstrates that, in uncomplicated pharyngitis, only 3% of strains were encapsulated, and in more serious infection, 21% of strains were encapsulated.[23]

Streptolysin O is a protein that is capable of lysing numerous cell types.[11] It is produced by almost all GAS strains. Hence, antistreptolysin O titers can be used to determine the past presence of GAS infection. Streptolysin S is similar to streptolysin O, and it is a potent cytotoxin that plays a large role in necrotizing soft-tissue infections.[24]

GAS also secretes streptokinase which cleaves plasminogen into a fibrinolytic plasmin form. Plasmin has the ability to break down local thrombi that the body creates to contain infection.[11] This is the method by which GAS gains access to the vascular system to promote systemic infection.

Other Pathogens

While *S aureus* and GAS cause the majority of SSTIs, other pathogens can also cause SSTIs. Prior to development of the *Haemophilus influenzae* type b (Hib) vaccines, Hib was responsible for approximately one-third of facial cellulitis in children aged < 2 years, but this is now a rare cause.[25] While *Streptococcus pneumoniae* is rarely the cause of SSTIs, cellulitis from this pathogen has been reported, most commonly in young children with facial or perior-

bital cellulitis.[26]

Actinomyces israelii is an anaerobic gram-positive bacterium found in the normal oral flora.[27] *Actinomyces* SSTIs have been noted after oral trauma and after pulmonary or abdominal injury. Disease typically starts as cellulitis and develops into a suppurative mass.[28] *Nocardia* is also an anaerobic gram-positive bacterium usually found in the soil. It can cause infection if introduced into the skin. *Nocardia* SSTIs tend to occur in farmers.[29] Similarly, sporotrichosis is a fungal infection caused by traumatic inoculation through thorns or other vegetation. Infection begins with an ulcer or nodule at the point of entry, and satellite nodules form along the surrounding lymph nodes.[30]

Bite wounds become infected with unique flora that are not found in typical cellulitis. Infections from cat bites are typically due to *Pasteurella multocida*.[31] Dog bites become infected less frequently than cat bites, but dog saliva also contains *Pasteurella* species.[31] Human bite infections, on the other hand, contain a wide variety of flora, including *S aureus* and anaerobes.

Aquatic environments contain bacterial flora that are unlike those found on land. The wounds are still primarily infected with *S aureus* and GAS, but they may have other pathogens as well. *Pseudomonas aeruginosa* can thrive in hot tubs, because warmer water breaks down chlorine or other disinfectants faster than cool water.[32] *Pseudomonas* can cause a dermatitis or folliculitis, especially on the areas of skin covered by swimwear. Wounds sustained in or around salt water may become infected with *Vibrio* species.[33] *Vibrio* species are facultative anaerobic gram-negative rods. Vibrio causes aggressive, necrotizing soft-tissue infections and may require surgical debridement to control the infection.[33] *Aeromonas hydrophila* is another anaerobic gram-negative rod found in fresh water that can cause SSTI.

Differential Diagnosis

Impetigo

Impetigo, a form of pyoderma, is an acute, highly contagious superficial skin infection. It is the most common bacterial skin infection and the third most common skin disease in children.[34] Impetigo can occur at any age, but it is most commonly seen in children aged 2 to 5 years. The overall incidence is similar in males and females. It is seen most commonly in hot and humid climates. The prevalence of impetigo varies seasonally, with the peak incidence occurring in the summer and the fall.[35]

Impetigo can be either bullous or nonbullous. Nonbullous impetigo is far more common than the bullous form, comprising approximately 70% of cases.[34] Both *S aureus* and GAS cause nonbullous impetigo. *S aureus* causes approximately 80% of cases,

GAS causes 10%, and, in 10% of cases, both bacteria can be isolated.

Nonbullous impetigo starts as erythematous papules that evolve into vesicles and pustules that rupture, leaving behind a honey-colored dried crust on a erythematous base.[36] **(See Figure 1.)** It tends to affect the face or areas that have experienced minor trauma caused by irritation, such as by bites, cuts, or abrasions.

Bullous impetigo is most common in neonates and infants, and can even be present at birth if there is prolonged rupture of membranes. Bullous impetigo is caused by certain strains of *S aureus*, particularly phage type 71, which produce a toxin that causes cleavage of the dermal-epidermal junction to form fragile vesicopustules.[36] **(See Figure 2, page 5.)** This same bacterium causes SSSS. MRSA has been isolated in up to 20% of bullous impetigo cases.[37]

Bullous lesions tend to occur on intact skin in the intertriginous areas like the neck, axilla, and diaper area, but they can appear anywhere on the body. The lesions appear as thin-walled, flaccid, and transparent bullae, and are usually smaller than 3 cm. The bullae contain a clear-to-yellowish fluid that may turn cloudy.[38] The lesions rupture easily, usually within 1 to 3 days, and leave a collarette of scale around an erythematous base as well as multiple concentric rings resembling an onion slice.[36]

Folliculitis

Folliculitis is inflammation of the hair follicle. It may occur secondary to infectious etiologies as well as trauma or occlusion of the follicle. Superficial folliculitis is quite common, but often self-resolves, so

Figure 1. Impetigo

Image courtesy of Jenny Sanders, MD, and Sylvia Garcia, MD.

To view a full-color version of this issue's photos, scan the QR code with a smartphone or tablet or go to: www.ebmedicine.net/2015SSTIfigures.

patients generally do not seek care. Those who do seek care often do so because they have recurrent or deep folliculitis. The overall incidence of folliculitis is unknown.

Folliculitis typically presents with acute onset of papules and pustules that are often pruritic or uncomfortable. On physical examination, a pustule or papule on an erythematous base can be seen with a hair noted centrally. Deep folliculitis, in contrast, involves the hair follicle and adjacent dermis, is painful, and often has purulent drainage. It may present with fluctuant nodules. As the lesions of deep folliculitis heal, they can often leave behind scar tissue.

S aureus is often the bacterial etiology for folliculitis. However, gram-negative bacteria such as *Klebsiella, Enterobacter,* and *Pseudomonas* can also be the cause. Pseudomonal folliculitis is also known as hot-tub folliculitis. It can appear 8 to 14 hours after exposure to contaminated water. Lesions appear similar to other forms of superficial cellulitis, but are often concentrated in areas that were occluded by swimwear, such as a swimsuit bottom.[39] There is often associated fever, headache, and malaise. Pseudomonal folliculitis often self-resolves within 7 to 14 days.[39]

Furuncles, Carbuncles, And Abscesses

A furuncle is an infection of the hair follicle in which purulent material extends through the dermis and into the subcutaneous tissue. Furuncles progress from an episode of folliculitis and can occur anywhere on skin that is hairy. In contrast, a carbuncle is a collection of furuncles into a single inflammatory mass with purulent drainage. Patients who present with carbuncles often have systemic symptoms including fever and malaise. Skin abscesses are collections of pus found within the dermis and deeper skin tissue. Abscesses often have a previous history of trauma or irritation to the skin, or can be due to

bacteremia. Abscesses present as painful, tender, erythematous, and fluctuant nodules. Often a central pustule can be seen.

Cellulitis

Cellulitis refers to nonnecrotizing inflammation of the skin and subcutaneous tissue that is typically caused by infection. The majority of cases of cellulitis are caused by *S pyogenes* and *S aureus*, but *S pneumoniae, Vibrio spp, Pseudomonas,* and others can be implicated. Cellulitis presents with the 4 cardinal signs of inflammation, including warmth, erythema, pain, and swelling. **(See Figure 3.)** Cellulitis occurs after a break in the skin, such as a fissure, tear, cut, laceration, or bite. The breach in the skin may not be visible on gross inspection.

Facial cellulitis is often associated with odontogenic infections. Cellulitis of odontogenic origin is typically polymicrobial, including GAS, *Neisseria, Eikenella,* and anaerobes. A thorough inspection of the dentition should be part of the physical examination in any patient who presents with facial cellulitis, as chronic dental caries or dental abscesses can be the cause. A retrospective study showed that children who present with upper face infections tend to be younger and have more acute infection, while those with lower face infections tended to be older (aged > 5 years).[40]

Perianal infection dermatitis, formally known as perianal cellulitis, occurs mostly in young children, with an average age of 4.25 years,[41] although patients as young as 6 months have been seen.[42] It presents as a bright-red, well demarcated area around the anus. This infection is usually caused by GAS, but can also be caused by *S aureus, Escherichia coli, Peptostreptococcus spp,* and others.[43] Almost half of patients experience rectal pain, and a third have blood-streaked stools.[42]

Figure 2. Bullous Impetigo

Image courtesy of Jenny Sanders, MD, and Sylvia Garcia, MD.

Figure 3. Cellulitis

Image courtesy of Jenny Sanders, MD, and Sylvia Garcia, MD.

Periorbital And Orbital Cellulitis

Periorbital (preseptal) cellulitis is a common infection of the eyelid and periorbital soft tissues. It is caused by a bacterial infection that occurs secondary to trauma to the eyelid, external ocular infection, or adjacent spread of sinusitis. Periorbital cellulitis is most commonly caused by *S aureus, Staphylococcus epidermidis, Streptococcus spp,* and anaerobes. Periorbital cellulitis is typically caused by local trauma, insect bites, or local infections such as hordeolum or chalazion.[44] It presents with tenderness, erythema, and edema of the periorbital tissues. Periorbital cellulitis differs from orbital cellulitis in that the inflammation is confined to the soft tissues anterior to the orbital septum. Rarely, periorbital cellulitis can spread posterior to the septum and develop into orbital cellulitis or abscess.[44]

Orbital cellulitis has a higher morbidity, and it should be considered a medical emergency. Orbital cellulitis involves inflammation and infection of the soft tissues posterior to the orbital septum. Unlike periorbital cellulitis, orbital cellulitis almost always results from a complication of sinusitis, especially ethmoidal sinusitis.[45] It presents with erythema and induration of the eyelid, pain with eye movements, and fever. If disease is more progressive, patients may have limited extraocular movements, proptosis, decreased visual acuity, and papilledema.[46] **(See Figure 4.)** If not recognized and treated promptly, orbital cellulitis can lead to blindness, meningitis, subdural empyema, cavernous sinus thrombosis, and brain abscesses.[47]

Erysipelas

Erysipelas is a skin infection involving the upper dermis and surrounding lymphatics. It presents as a tender, very erythematous and indurated plaque with a well-demarcated border that differentiates it from other skin infections (such as cellulitis). **(See Figure 5.)** The skin of the affected area is often described as having a *peau d'orange,* or orange-peel appearance.[48] Erysipelas is most commonly seen on the lower extremities,[48] not the face, as historically described.

Erysipelas is typically caused by streptococci. Facial erysipelas is often due to GAS, while the lower extremity infections are caused by non–group A streptococci. This infection spreads very rapidly because it invades the local lymphatic vessels.

Ecthyma

Ecthyma is a skin infection caused by GAS and *S aureus.*[49] It involves the entire thickness of the dermis. Ecthyma is seen in children of all ages, and it is seen more frequently during warm months. Minor trauma to the skin (such as scratches and insect bites) or poor nutrition can be a predisposing factor to the development of ecthyma.[49]

Lesions begin as vesicles or pustules with an erythematous base, which then rupture and form crusts.[50] The base of the lesions tends to erode through the epidermis and into the dermis, which causes the appearance of elevated margins. **(See Figure 6, page 7.)** Lesions are usually round and are found on the lower extremities. Due to their clinical appearance, ecthyma can be confused with cigarette burns. **(See Figure 7, page 7.)** Invasive complications of ecthyma include cellulitis, erysip-

Figure 4. Orbital Cellulitis

Image courtesy of Jenny Sanders, MD, and Sylvia Garcia, MD.

Figure 5. Erysipelas

Image courtesy of Jenny Sanders, MD, and Sylvia Garcia, MD.

elas lymphangitis, pneumonia, and bacteremia.[51] Nonsuppurative complications include scarlet fever and glomerulonephritis.

Necrotizing Fasciitis

Necrotizing fasciitis is the most aggressive of the skin and soft-tissue infections and is associated with significant morbidity and mortality. Luckily, it is relatively uncommon in children. Although it can occur anywhere on the body, it tends to occur in the perineal and trunk regions,[42] and typically occurs after trauma, surgery, or *Varicella* lesions.[52-54]

There are 2 types of necrotizing fasciitis, and they are categorized by microbiology: type 1 is polymicrobial, and type 2 is monomicrobial, typically caused by GAS.[55] The infection spreads along fascial planes and may or may not have any overlying cellulitis.[56] Necrotizing fasciitis can be difficult to diagnose. Pain out of proportion to the physical examination is one of the most consistent initial clinical findings.[54] Wong et al created a clinical staging system based on the natural clinical presentation of the disease.[57] In stage 1, patients may present with erythema, tenderness, warmth, and swelling, which progresses to blistering in stage 2, and crepitus and skin necrosis in stage 3.[57] Unfortunately, necrotizing fasciitis can often be misdiagnosed as cellulitis.[52]

Staphylococcal Scalded Skin Syndrome

SSSS is a superficial skin blistering condition caused by an exfoliative toxin found in some strains of *S aureus*.[42] Two toxins, exfoliative toxin A and exfoliative toxin B, are implicated in SSSS and act as proteases that target a cell-to-cell attachment protein that is found in superficial skin.[58,59] SSSS occurs most commonly in children and neonates, but can occur in adults with chronic illness.

SSSS presents as a macular erythematous rash followed by epidermal exfoliation. A prodrome of localized *S aureus* skin infection, such as impetigo, is often present. Patients may have preceding fever, malaise, and skin tenderness. The rash often begins centrally and spreads centripetally. Gentle traction on the skin results in skin sloughing and blister formation (Nikolsky sign); however, this sign is not pathognomonic for SSSS.

Toxic Shock Syndrome

TSS is another toxin-mediated disease caused by either *S aureus* or GAS. Staphylococcal TSS is more common than streptococcal TSS. TSS toxin type-1 (TSST-1) and staphylococcal enterotoxin B are the 2 toxins most commonly implicated in staphylococcal TSS. Both TSST-1 and enterotoxin act as superantigens, which cause T-lymphocyte stimulation without normal antigen reaction. The activation of the lymphocytes results in a massive release of cytokines that contributes to the development of TSS.

The incidence of TSS in the United States is estimated at 1 to 5 cases per 100,000 menstruating women. The majority of cases occur in women who use tampons. Fortunately, the incidence of menstrual TSS is declining due to changes in tampon manufacturing. Other causes of TSS include wounds, viral infection, postpartum or postabortion vaginal complications, and nasal packing.

The clinical presentations of staphylococcal and streptococcal TSS are similar, but they have slightly different clinical criteria for diagnosis. Symptoms of staphylococcal TSS include fever, systolic blood pressure below the fifth percentile for age (or < 90 mm Hg in adults) and an erythrodermic rash with subsequent desquamation. The criteria also include involvement of 3 or more of the following: gastrointestinal tract,

Figure 6. Ecthyma

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Figure 7. Cigarette Burn

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muscles, mucous membranes, renal system, hepatic system, blood, and central nervous system.

Streptococcal TSS is caused by streptococcal strains that produce streptococcal pyrogenic exotoxin A, streptococcal pyrogenic exotoxin B, or both. Like TSST-1 and enterotoxin, streptococcal pyrogenic exotoxin A and streptococcal pyrogenic exotoxin B trigger a cascade of inflammatory cytokines that lead to TSS. Streptococcal TSS is typically found to have sequelae of skin infection, surgical wounds, pharyngitis, viral infections, and nonsteroidal anti-inflammatory drug use.

Diagnosis of streptococcal TSS requires the isolation of GAS from the body. At least 2 of the following laboratory or clinical findings are also required for diagnosis: (1) creatinine levels 2-fold higher than baseline level for age, (2) thrombocytopenia, (3) elevated liver function tests or total bilirubin > 2 times the upper reference range for age, (4) acute respiratory distress syndrome, soft-tissue necrosis, or (5) a generalized erythematous macular rash that may desquamate.

Prehospital Care

The majority of children who present to the ED with skin and soft-tissue infections are well, but for those who are critically ill and may require aid from an emergency medical services team, the initial evaluation should include a rapid assessment of airway, breathing, and circulation. For children who present in shock, aggressive fluid resuscitation should be started. Antibiotics should be started immediately, and children who are critically ill should be transported to the closest facility for stabilization.

Emergency Department Evaluation

The initial ED evaluation of any child should begin with a thorough history and physical examination.

History
A thorough history is essential to the development of an adequate differential diagnosis. Information about the patient's medical history, immune status, travel history, recent trauma or surgery, animal exposure or bites, and prior therapies should be obtained. The history should also include the duration of symptoms and the anatomic location of the area in question. The patient or parents should be asked if the lesion has changed over time: Is it getting bigger or smaller? Is it becoming more painful or pruritic? Does it look different now from when it started?

Patients should be asked if they had any previous trauma or irritation to the area in question. Small breaks in the skin can be a nidus for infection. This includes insect bites, mammalian bites, scratches, and scrapes. Patients should be asked if they have any foreign bodies (such as tampons) in place. All foreign bodies should be removed, when possible.

Immunocompromised patients may have an increased risk for more progressive disease. Any medical problem that would make a patient immunocompromised, including HIV, malignancies, diabetes mellitus, sickle cell anemia, and asplenia, should be noted.

Physical Examination
The general appearance of the patient should be noted on physical examination. Patients who are ill or toxic-appearing require immediate and aggressive care. Vital signs should be evaluated to determine whether the patient is febrile, tachycardic, or hypotensive. All patients should be undressed and placed in a gown to allow for thorough examination of the skin. Particular attention should be paid to the area of the body in question. The examiner should note the size and shape of the lesion, and, when possible, an outline of the lesion should be drawn in permanent ink so that progression of the rash can be easily noted. All lesions should be palpated to assess for tenderness, fluctuance, crepitus, or induration. It should be noted whether the area is painful when palpated, and, if pain is out of proportion to the examination, the differential should change accordingly. In many cases, history and physical examination alone can yield a diagnosis. Occasionally, however, the history and physical examination are not enough, and diagnostic studies are necessary for determining a diagnosis.

Diagnostic Studies

The need for laboratory and diagnostic studies will vary, depending on the severity of the skin infection. For example, simple cases of impetigo and cellulitis in a normal host may not require any diagnostic studies. However, in the immunocompromised patient, a more extensive workup of even a simple skin condition may be required.

Gram Stain And Culture
Routine Gram stain and culture of purulent material from abscesses and carbuncles is controversial. Some sources recommend Gram stain and culture of purulent lesions to determine regional prevalence and sensitivity of organisms, and to help guide treatment.[60-62] If a patient has previously been placed on empiric antibiotics after incision and drainage and is not improving, then the emergency clinician can consider antibiotic sensitivities and change therapy accordingly. However, other sources have found that management is often not affected by results of Gram stains and cultures.[63] It is our recommendation that Gram stain and

cultures should be obtained from surgical lesions, moderate to severe abscesses, and from purulent lesions of patients requiring admission.

Blood Cultures And Other Blood Tests

Blood cultures are not routinely recommended for the diagnosis of cellulitis in immunocompetent patients.[61] In one pediatric study, only 2% of patients with cellulitis had a positive blood culture, and 5.4% of children had contaminated blood cultures.[64] Another study demonstrated a longer length of stay for patients in whom blood cultures were obtained.[65] Fine-needle aspiration of blood or injected saline from cellulitis yields higher positive cultures than blood culture, but is only positive in up to 51.7% of patients, [66-68] and it is not routinely recommended in the evaluation of cellulitis or erysipelas.[61]

For patients who are systemically ill or immunocompromised, blood cultures and other blood tests may be useful. Laboratory findings associated with necrotizing fasciitis are nonspecific. One study suggested that a white blood cell (WBC) count $> 14 \times 10^9$ cells/L, sodium < 135 mmol/L, and serum urea nitrogen > 15 mg/dL can help distinguish nonnecrotizing skin infection from necrotizing fasciitis.[69] Another study suggested that patients with necrotizing fasciitis tend to have a significantly elevated WBC count (up to $24.5 \pm 16.0 \times 10^9$ cells/L).[69] A more recent study attempted to create a decision rule for differentiating necrotizing fasciitis from other SSTIs. A scoring system based on C-reactive protein, creatinine, hemoglobin, WBC count, sodium, and glucose levels was created. Patients who scored ≥ 6 had a positive predictive value of 92% for necrotizing fasciitis and a negative predictive value of 96%.[70] However, this scoring system has not been validated in children. Patients with TSS may also have abnormal laboratory values. No specific test is diagnostic for TSS, but leukocytosis and lymphopenia are often reported. In late or severe disease, signs of end-organ damage can be seen (such as transaminitis and elevated creatinine).[71]

Radiographic Studies

Radiographic studies may be useful in the evaluation of some SSTIs. Plain radiographs are often nonspecific, but may demonstrate soft-tissue thickening in cellulitis and necrotizing fasciitis, and, in a minority of cases, soft-tissue emphysema can be seen in necrotizing fasciitis.[72] If there is concern for a retained foreign body as a cause of chronic cellulitis, radiographs may be diagnostic if the foreign body is radio-opaque. Computed tomography (CT) is more sensitive than plain radiographs in identifying subcutaneous gas in soft tissues in necrotizing fasciitis.[73] CT is also the preferred modality in distinguishing periorbital from orbital cellulitis; however, magnetic resonance imaging may be beneficial for following disease progression over time.[74] **(See Figure 8.)**

Ultrasound

Ultrasound can be a useful noninvasive tool in the ED for the evaluation of SSTIs. The ultrasound findings in cellulitis include thickening of the skin and subcutaneous tissues that appear heterogeneous with random anechoic strands dissecting through the tissue.[75] **(See Figure 9, page 10).** When an abscess is present, there is thickening of the skin and subcutaneous tissues with a focal hypoechoic region. **(See Figure 10, page 10).** A prospective study demonstrated that the ultrasound findings described above correlate with the clinical picture of cellulitis.[76]

A pediatric study involving 387 skin lesions found that the addition of ultrasound did not improve the accuracy of diagnosis for lesions requiring draining (as evaluated in the study by independent clinical examination by 2 physicians).[77] Thus, ultrasound may be a useful adjunct when the clinical diagnosis is unclear. Ultrasound may also be useful in the evaluation of necrotizing fasciitis. Specific findings include thickened fascial planes with fluid accumulation in the fascial layers and subcutaneous edema.[72] If available, bedside ultrasound, using a linear probe transducer to evaluate the skin and soft tissues, can provide valuable information.

Treatment

Impetigo

Impetigo typically heals within 2 to 3 weeks, even without treatment. Randomized prospective clinical trials have demonstrated a 13% to 52% spontaneous clinical resolution rate.[78,79] Treatment leads to higher cure rates and decreases spread of infection to other parts of the body and to other people.[80,81] Lesions usually resolve over 7 to 10 days with treatment. Both

Figure 8. Orbital Cellulitis Computed Tomography Scan

Reprinted from *Atlas of Pediatric Emergency Medicine*, 1st edition, Shah BR, Lucchesi M, Amodio J, Silverberg M, Ophthalmology, Figure 8.3a, Copyright 2007, with permission from Elsevier.

bullous and nonbullous impetigo can be treated with either topical or oral antibiotics. Topical ointment, such as mupirocin, is the treatment of choice.[80,82] However, if the patient has numerous lesions or is immunocompromised, oral therapy should be used. Beta-lactamase–resistant antibiotics, such as cephalexin or dicloxacillin, are recommended, but if MRSA is suspected, alternative antibiotics, such as clindamycin or trimethoprim-sulfamethoxazole (TMP-SMX), should be given. Bullous and nonbullous impetigo should be treated with either mupirocin[36] or retapamulin[78] twice daily for 5 days. **(See Table 1.)**

Patients should be advised to avoid touching the lesion. Children should remain out of daycare or school until 24 hours after the initiation of therapy.[83] Patients should also be prescribed medication for relief of itching, as scratching can lead to autoinoculation, spread of lesions, and superinfection.

Figure 9. Cellulitis On Ultrasound
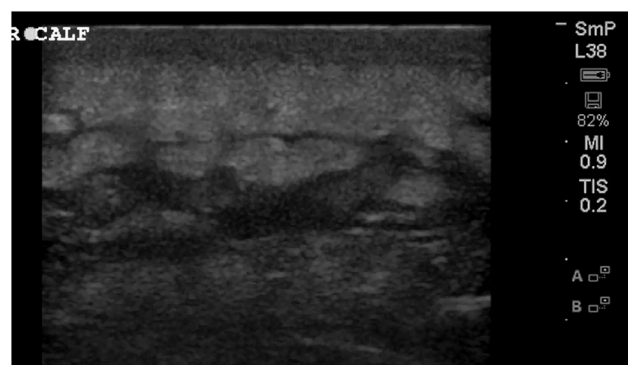
Thickening of the skin and subcutaneous tissues can be seen with random anechoic strands dissecting through the tissue creating a "cobblestone" appearance.
Image courtesy of Jenny Sanders, MD, and Sylvia Garcia, MD.

Figure 10. Cellulitis And Abscess On Ultrasound

Thickening of the skin and subcutaneous tissues with a focal hypoechoic region noted that is consistent with abscess formation.
Image courtesy of Jenny Sanders, MD, and Sylvia Garcia, MD.

Folliculitis

For patients with recurrent uncomplicated folliculitis, including hot-tub folliculitis, thorough hand washing and the use of antibacterial soaps are all that is necessary for treatment and prevention. Antihistamines should be used for relief of itching, as scratching can lead to superimposed infection or spread of the lesions. Patients with refractory or deep folliculitis may benefit from a course of topical or oral antibiotics with *S aureus* coverage (such as dicloxacillin) or cephalosporins. If there is concern for MRSA, coverage with TMP-SMX, clindamycin, or linezolid is recommended.

Furuncles, Carbuncles, And Abscesses

Incision and drainage is the therapeutic treatment for simple abscesses, furuncles, and carbuncles, although small furuncles can often be treated with warm compresses to promote drainage. A randomized trial comparing incision and drainage versus ultrasound-guided needle aspiration of abscesses demonstrated that aspiration was successful in only 25% of cases overall.[84] Therefore, needle aspiration is not recommended.

There is some debate regarding whether or not wound packing should be part of routine management after incision and drainage.[85-87] Theoretically, packing a wound allows for continued drainage by preventing the incision in the skin layer from closing prematurely. However, packing is painful and may lead to increased healing times.[86] A small prospective randomized trial investigated the impact of wound packing versus no wound packing on rates of treatment failure and abscess

Table 1. Treatment Of Impetigo

Antibiotic	Dosage, Adult	Dosage, Children
Dicloxacillin	250 mg po qid	N/A
Cephalexin	250 mg po qid	25-50 mg/kg/day po ÷ tid or qid
Erythromycin	250 mg po qid	40 mg/kg/day po ÷ tid or qid
Clindamycin	300-400 mg po qid	20 mg/kg/day po ÷ tid
Amoxicillin-clavu-lanate	875-125 mg po bid	N/A
Amoxicillin	875 mg po bid	25 mg/kg/day po ÷ bid
Retapamulin ointment	1 application topically bid	1 application topically bid
Mupirocin ointment	1 application topically bid	1 application topically bid

Abbreviations: bid, 2 times per day; N/A, not applicable; po, by mouth; qid, 4 times per day; tid, 3 times per day.
Stevens DL, Bisno, AI, Chambers, HF, et al. Practice Guidelines for the Diagnosis and Management of Skin and Soft-Tissue Infections: 2014 Update. *Clinical Infectious Diseases.* 2014;59(2):e10-e52. By permission of the Infectious Diseases Society of America.

recurrence, and found no difference in failure rates, pain scores, or healing times between the groups.[85] However, the study was not powered to show equivalence. Another small randomized study also found no statistical difference between patients who received abscess packing compared to those who did not.[88] Wound packing, therefore, may be an unnecessary step; however, large randomized studies need to be performed to further assess the utility of wound packing.

Another technique to drain abscesses is incision and loop drainage. This technique involves making 2 small incisions within the borders of the abscess, as wide apart as possible. Then, a sterile rubber band, vessel loop, or Penrose drain is passed into one incision, brought out through the other incision, and loosely tied.[89] This technique may allow for continuous drainage of abscesses[90] with minimal pain and improved wound healing, but more research on this technique is required.

Routine use of antibiotics after incision and drainage of simple abscesses may not be indicated.[61] A meta-analysis of 4 randomized, placebo-controlled trials involving both children and adults who received systemic antibiotics or placebo after incision and drainage of simple abscesses found that the addition of systemic antibiotics did not significantly improve outcomes.[91] However, this meta-analysis included only 4 trials with < 600 patients in total (161 of whom were children) and only 2 of these studies used an antibiotic that targets CA-MRSA (TMP-SMX). The other studies used cephalexin and cephradine. The 2 TMP-SMX studies also performed a 30-day follow-up, which demonstrated that patients who received antibiotics developed fewer recurrent abscesses within the follow-up period. A larger, more robust study assessing a longer follow-up period should be performed to determine whether antibiotics after incision and drainage decreases abscess recurrence.

If a recurrent abscess at a previous site of infection is noted, a search for an underlying cause, such as hidradenitis suppurativa,[92] retained foreign body, or pilonidal abnormality,[93] should be undertaken.

Cellulitis

Traditionally, typical cases of cellulitis without signs of systemic illness should be treated with antibiotics active against *S aureus* and GAS, such as cephalexin, for 7 to 10 days.[12] However, a 5-day treatment course is as effective as a 10-day treatment course if clinical improvement occurs within 5 days.[94] The treatment course can be extended if the infection has not improved during that time period.[94]

With the increasing prevalence of CA-MRSA, treatment regimens for cellulitis have changed to include TMP-SMX or clindamycin.[12] However, MRSA appears to be an unusual cause of cellulitis. A prospective study at a center with a high incidence of MRSA SSTI found 96% treatment success with antibiotics that do not have activity against MRSA, suggesting that cellulitis may be caused by GAS or MSSA rather than MRSA.[95] Jeng and colleagues were able to prove via highly specific serum tests for GAS that, despite a high prevalence of CA-MRSA, almost two-thirds of cellulitis is caused by GAS.[95] TMP-SMX has activity against CA-MRSA; however, it is not active against GAS. Therefore, treatment with TMP-SMX alone may result in treatment failure. Current recommendations suggest treatment with antibiotics that provide coverage against MSSA and GAS (such as cephalexin or clindamycin).[12] In patients with a history of CA-MRSA infection or a family history of CA-MRSA infection, inclusion of antibiotics to cover this organism, such as clindamycin or duel therapy with cephalexin and TMP-SMX, may be warranted.[12]

Clindamycin is a non–beta-lactam antibiotic that is active against GAS, *S aureus*, and anaerobic bacteria. Clindamycin is also active against CA-MRSA, and it has excellent tissue penetration in both oral and intravenous form.[96] It is dosed every 8 hours, but the liquid formulation has a poor taste, which may result in poor compliance.[97] Clindamycin capsules can also be opened and sprinkled on food to help improve compliance. CA-MRSA that is resistant to erythromycin may confer inducible clindamycin resistance. The reported rates of clindamycin- and erythromycin-resistant MRSA are variable,[98] and may be explained by the prevalence of different CA-MRSA clones in different parts of the country. Emergency clinicians should check local antibiograms for resistance patterns in their geographic area.

Doxycycline is a tetracycline antibiotic that is effective against CA-MRSA; however, it does not have activity against GAS, and it is contraindicated in patients aged < 8 years.[97] Rifampin is another antibiotic with activity against CA-MRSA;[97] however, it can be hepatotoxic.

Periorbital And Orbital Cellulitis

Treatment of periorbital cellulitis may vary, based on the severity of infection. Mild cases of periorbital cellulitis can be treated with oral antibiotics, such as amoxicillin-clavulanate. If the cause of the cellulitis is secondary to trauma, the patient should be treated with antibiotics (such as cephalexin) directed against gram-positive organisms.[99] If the patient is systemically ill, the patient should be admitted, a CT scan of the orbits should be considered, and intravenous antibiotics with coverage against both GAS and *S pneumoniae*, such as ampicillin-sulbactam or clindamycin, should be provided.

Orbital cellulitis, on the other hand, should be treated with broad-spectrum intravenous antibiotics, such as vancomycin plus ceftriaxone, piperacillin-tazobactam, or ampicillin-sulbactam.[99] Consultation

Clinical Pathway For Emergency Department Management Of Skin And Soft-Tissue Infections

Patient presents with signs and symptoms of skin or soft-tissue infection

→

Is the patient systemically unwell, aged < 3 mo, or immunocompromised?

YES →

Is pain out of proportion to examination?

NO ↓

Start empiric parenteral antibiotics **(Class II)**

YES ↓

Consider necrotizing fasciitis
- Arrange emergent surgical consultation **(Class I)**
- Start empiric parenteral antibiotics **(Class II)**

NO ↓ (from systemically unwell)

Periorbital erythema or edema ↓

Presence of pain with eye movements or proptosis?

NO ↓   **YES** ↓

YES:
- Order CT orbits to evaluate for orbital cellulitis **(Class I)**
- Start empiric parenteral antibiotics **(Class II)**

NO: Consider preseptal cellulitis
- Treat with amoxicillin-clavulanate **(Class II)**

Areas of erythema, warmth, tenderness ↓

Obviously purulent lesion and fluctuance?

NO ↓   **YES** ↓

YES: Consider abscess, furuncle, or carbuncle
- Perform incision and drainage **(Class I)**

NO: Well demarcated?

YES ↓   **NO** ↓

YES: Consider erysipelas
- Treat with amoxicillin **(Class I)**

NO: Consider cellulitis
- Treat with cephalexin **(Class II)**
- If patient has a history of CA-MSRA, administer clindamycin or cephalexin and TMP-SMX

Crusted lesions ↓

Eroded base with heaped-up margins?

YES ↓   **NO** ↓

NO: Consider impetigo
- Treat with mupirocin **(Class I)**
- If the patient has numerous lesions or is immunocompromised, start oral therapy

YES: Consider ecthyma
- Treat with mupirocin **(Class I)**

Abbreviations: CA-MRSA, community-associated methicillin-resistant *Staphylococcus aureus;* CT, computed tomography; TMP-SMX, trimethoprim-sulfamethoxazole.

Class Of Evidence Definitions

Each action in the clinical pathways section of *Pediatric Emergency Medicine Practice* receives a score based on the following definitions.

Class I
- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

Level of Evidence:
- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

Class II
- Safe, acceptable
- Probably useful

Level of Evidence:
- Generally higher levels of evidence
- Nonrandomized or retrospective studies: historic, cohort, or case control studies
- Less robust randomized controlled trials
- Results consistently positive

Class III
- May be acceptable
- Possibly useful
- Considered optional or alternative treatments

Level of Evidence:
- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

Indeterminate
- Continuing area of research
- No recommendations until further research

Level of Evidence:
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

with an ophthalmologist should be considered to determine whether surgical intervention is required.

Erysipelas

Amoxicillin remains the first-line treatment for patients with erysipelas.[50] In an effort to reduce swelling, the affected limb should be elevated, if possible. Pain medications to reduce patient discomfort are an important part of the management plan.

Ecthyma

The medical treatment for ecthyma depends on the extent of the lesions. Localized erythema can be treated with topical mupirocin alone.[50] The lesion should be washed with antimicrobial soap to facilitate the removal of any crusting that has formed. More-severe lesions or lesions that are unresponsive to topical therapy can be treated with oral penicillinase-resistant beta-lactam drugs, such as dicloxacillin, or first- or second-generation cephalosporins.[100]

Necrotizing Fasciitis

Necrotizing fasciitis (or suspicion of necrotizing fasciitis) requires prompt surgical evaluation. The tissue necrosis that results from this infection constitutes a barrier to the penetration of antibiotics, so surgical debridement is crucial.[101] Most patients require a return to the operating room within 24 to 36 hours for further debridement.[61] Empiric broad-spectrum antibiotics, such as vancomycin plus piperacillin-tazobactam,[61] initiated, as necrotizing fasciitis can be polymicrobial. If isolates from necrotizing fasciitis reveal a monomicrobial infection with GAS, coverage can be changed to penicillin plus clindamycin. Antimicrobial therapy should continue until debridement is no longer necessary, the patient has been afebrile for at least 48 hours, and the patient has improved clinically.[61]

Staphylococcal Scalded Skin Syndrome

Early diagnosis and prompt treatment with anti-staphylococcal antibiotics, such as a penicillinase-resistant penicillin, are critical for the management of SSSS.[102] The use of corticosteroids is associated with worsening disease and is contraindicated.[103] Fresh-frozen plasma may be used in children in an attempt to neutralize exotoxin antibodies.[104,105]

Adequate pain control is an important step in the management of these patients, as the condition is very painful. Patients with severe disease should be treated similarly to a patient who has extensive burns, by providing intravenous fluids to compensate for fluid losses. Areas of denuded skin should be covered with wound dressings and saline-soaked gauze. Betadine and silver sulfadiazine should be avoided due to the risk of systemic absorption of iodine and silver, leading to toxicity.

Toxic Shock Syndrome

Treatment for staphylococcal and streptococcal TSS includes aggressive fluid management and vasopressor support, as needed. Any foreign body should be removed, including tampons, nasal packing, etc. Antimicrobial therapy should include penicillin in conjunction with clindamycin. Clindamycin can suppress toxin production and cytokine production. Intravenous immunoglobulin may be beneficial in decreasing mortality rates in patients with TSS.[106,107] However, a multicenter retrospective cohort study found no difference in outcomes among patients treated with antibiotics alone versus antibiotics plus intravenous immunoglobulin.[108]

See **Table 2, page 14** for a summary of treatment recommendations.

Special Circumstances

Bites

Bite wounds account for approximately 1% of all ED visits, and more than 50% occur in children.[109] Dog bites are the most common animal bite seen in the ED each year. Recent reports suggest that there are upwards of 4.5 million dog bites per year in America.[110] Dogs tend to cause crush injuries due to the strength of their jaws, which can result in damage to the skin and deeper tissues, such as bones, vessels, muscles, and tendons. Cat bites, though less common than dog bites, can be more difficult to treat, as the sharp, pointed teeth of cats cause puncture wounds that can inoculate deep tissues with bacteria. Common pathogens isolated from infected dog and cat bites include *Pasteurella, Streptococcus, Staphylococcus, Fusobacterium*, and bacteriodes.[111]

When evaluating patients who present with bite wounds, it is important to note the time of the event, the type of animal, the circumstances surrounding the bite (whether or not the animal was provoked), and the vaccination history of the animal. The patient's medical history and tetanus vaccination status should also be obtained and updated if needed.

Infected bite-related wounds should be treated with antibiotics that are active against both aerobic and anaerobic bacteria, such as amoxicillin-clavulanate. Patients who are ill-appearing or febrile should be admitted for intravenous antibiotics.

Immunocompromised Patients

Immunocompromised patients present unique challenges in the diagnosis and management of SSTIs, because their SSTIs can be caused by unusual organisms.[112] Adult patients with diabetes are at an increased risk for SSTIs when compared to nondiabetic adults.[113] Poor microcirculation, peripheral vascular disease, neuropathy, and decreased immune response may make adult diabetics more susceptible to infection.[114] There is no clear evidence that the

same holds true for children. Children with well-controlled diabetes mellitus can likely be treated the same as nondiabetic children.

Children with neoplasms are at higher risk for skin infections due to their immunocompromised state. The differential for infectious skin lesions in the immunocompromised patient should include fungal and parasitic infections as well as a secondary malignancy.[61] These patients may require biopsy of the lesion in question in order to direct antimicrobial therapy.

Immunocompromised children who present with SSTIs, particularly children who are neutropenic, febrile, or systemically ill, should be treated with vancomycin plus a broad-spectrum antibiotic with antipseudomonal coverage (such as cefepime), a meropenem, or piperacillin-tazobactam).[61] Blood cultures should be obtained prior to the start of antibiotics, if possible.

Neonatal Infections

SSTIs in neonates (aged < 1 month) are common, and the prevalence of infections is increasing as rates of CA-MRSA infections have increased.[115] Neonates may be exposed to skin trauma during delivery, either by mechanical forces or instrumentation (ie, forceps, vacuum, scalp electrodes). Infants who require vascular access or those undergoing elective procedures (such as circumcision) are also at risk for infection. Trauma to the fragile skin of neonates can easily create a portal of entry for infection. Organisms known to cause SSTIs in neonates include group B *Streptococcus*, GAS, and *S aureus*, as well as herpes simplex virus. A report from Texas noted that 86.5% of SSTIs in neonates were secondary to MRSA.[115]

S aureus has been a cause of omphalitis (umbilical infection) since the 1920s.[116] Other causative pathogens include *S epidermidis*, GAS, group B *Streptococcus*, *E coli*, *Pseudomonas*, *Clostridium difficile*, and *Klebsiella*. Major risk factors for omphalitis include

Table 2. Treatment Recommendations And Dosing For Methicillin-Sensitive *Staphylococcus aureus*, Methicillin-Resistant *Staphylococcus aureus*, And Streptococcal Skin Infections

Disease	Antibiotics	Dosage, Adult	Dosage, Children
MSSA	Nafcillin or oxacillin	1-2 g IV q4h	100-150 mg/kg/day IV ÷ q6h
	Cefazolin	1 g IV q8h	50 mg/kg/day IV ÷ q8h
	Clindamycin	600 mg IV q8h **or** 300-450 mg po qid	25-40 mg/kg/day IV ÷ q8h **or** 25-30 mg/kg/day po ÷ tid
	Dicloxacillin	500 mg po qid	25-50 mg/kg/day po ÷ qid
	Cephalexin	500 mg po qid	25-50 mg/kg/day po ÷ qid
	Doxycycline	100 mg po bid	Not recommended < 8 y
	TMP-SMX	1-2 DS tablets po bid	8-12 mg/kg/day (TMP) IV ÷ q6h **or** 8-12 mg/kg/day (TMP) po ÷ bid
MRSA	Vancomycin	30 mg/kg/day IV q12h	40 mg/kg/day IV ÷ q6h
	Linezolid	600 mg IV q12h **or** 600 mg PO bid	10 mg/kg IV q12h **or** 10 mg/kg po bid for < 12 y
	Clindamycin	600 mg IV q8h **or** 300-450 mg po qid	25-40 mg/kg/day IV q8h **or** 30-40 mg/kg/day po tid
	Daptomycin	4 mg/kg IV q24h	N/A
	Ceftaroline	600 mg IV q12h	N/A
	Doxycycline	100 mg po bid	Not recommended for ages < 8 y
	TMP-SMX	1-2 DS tablets po bid	8-12 mg/kg/day (TMP) IV ÷ q6h **or** 8-12 mg/kg/day (TMP) po ÷ bid
Streptococcal skin infection	Penicillin	2-4 million units IV q4-6h	100,000-150,000 units/kg/dose q6h
	Clindamycin	600-900 mg IV q8h	10-13 mg/kg/dose IV q8h
	Nafcillin	1-2 g IV q4-6h	50 mg/kg IV q6h
	Cefazolin	1 g IV q8h	33 mg/kg IV q8h
	Penicillin VK	250-500 mg po q6h	25-50 mg/kg/day po tid
	Cephalexin	500 mg po q6h	25-50 mg/kg/day po ÷ qid

Abbreviations: bid, 2 times per day; DS, double strength; IV, intravenous; MSSA, methicillin-sensitive *Staphylococcus aureus*; MRSA, methicillin-resistant *Staphylococcus aureus*; N/A, not applicable; po, by mouth; q4h, every 4 hours; q8h, every 8 hours; q12h, every 12 hours; q24h, every 24 hours; qid, 4 times per day; tid, 3 times per day; TMP, trimethoprim; TMP-SMX, trimethoprim-sulfamethoxazole; VK, V potassium.

Stevens DL, Bisno, Al, Chambers, HF, et al. Practice Guidelines for the Diagnosis and Management of Skin and Soft-Tissue Infections: 2014 Update. *Clinical Infectious Diseases.* 2014;59(2):e10-e52. By permission of the Infectious Diseases Society of America.

poor stump care and low birth weight. Omphalitis can present with redness around the umbilicus, purulent discharge, and extension into the fascia. Due to the presence of umbilical cord vessels, systemic spread of infection is a concern. One study demonstrated a marked decrease in neonatal staphylococcal colonization and infection with the use of total body bathing with 3% hexachlorophene compared with Ivory™ soap baths.[117]

Necrotizing fasciitis can be noted in neonates as well. The most common site of infection in neonates is the abdominal wall, but infection can also start on the scalp, back, and thorax.[116] Many of the infections are polymicrobial, but the predominant bacteria include *S aureus*, *E coli*, enterococci, *Clostridium*, and bacteroides.[116]

In all but the most simple of infections, neonates should receive a comprehensive sepsis evaluation and aggressive antibiotic therapy. In an evaluation of 3 studies involving afebrile neonates with isolated pustulosis, cellulitis, or abscesses, none of the patients were found to have culture-positive meningitis,[118] suggesting that a lumbar puncture may be avoided in otherwise healthy neonates. However, in neonates with simple infections with any signs of systemic illness, a full sepsis evaluation should be performed and antibiotics should be administered. Broad-spectrum therapy includes vancomycin for empiric gram-positive coverage and cefotaxime or ceftazidime for empiric gram-negative coverage.

Hand Infections

Acute hand infections can result in significant morbidity and mortality if not promptly diagnosed and treated. The location of infection and host factors are important considerations that can help guide initial treatment. Most hand infections will improve with appropriate antibiotics, splinting, and elevation. Any abscesses should be drained.

Paronychia

A paronychia is an infection of the eponychium, or the epidermis bordering the nail. It causes swelling, redness, and tenderness at the base of the nail. **(See Figure 11.)** Acute paronychiae are usually caused by local trauma to the skin surrounding the nail plate, such as biting the nails or sucking the thumb. This infection is usually caused by *S aureus* or GAS. If there is no abscess formation, conservative treatment with warm soaks and pain control is often all that is necessary. If an abscess has formed, it should be evacuated. Unless the infection is severe or the patient is immunocompromised, systemic antibiotics are not necessary.

Felon

A felon is an abscess of the distal pulp of the fingertip. It can result from penetrating trauma, such as a splinter or puncture wound, or from an untreated paronychia.[119] If diagnosed in the early stages of infection, felons can be treated with antibiotics and warm soaks, but if abscess formation has occurred, incision and drainage is necessary.[119] There are several options for incision, but the longitudinal incision is preferred. After administering a digital block, a longitudinal incision 3 to 5 mm from the distal interphalangeal joint is made with a scalpel through the dermis over the area of maximal tenderness. The incision is carefully enlarged with a hemostat to allow drainage once the abscess is located. The area is irrigated, and a wick is then placed to keep the wound edges separated and allow further drainage. A bulky dressing and forearm splint should be placed, with close follow-up arranged within 24 to 48 hours with a primary care physician, hand specialist, or return ED visit for re-evaluation.

Herpetic Whitlow

Herpetic whitlow is a viral infection of the hand caused by human herpes simplex virus type 1 or type 2. It presents with acute onset of edema, erythema, and tenderness. Small vesicles present initially and then coalesce and become cloudy, which can make it clinically difficult to distinguish this from a paronychia. Incision and drainage of herpetic whitlow should be avoided as it may cause increased duration of infection.[120] Herpetic whitlow usually self-resolves over a few weeks, but patients should be instructed to keep the area covered to prevent inadvertent transmission to others. Data regarding the use of topical or oral antiviral medications for herpetic whitlow are not robust, but in patients with severe disease, treatment may be beneficial.[121]

Other Hand Infections

More concerning hand infections include tenosyno-

Figure 11. Paronychia

Image courtesy of Jenny Sanders, MD, and Sylvia Garcia, MD.

vitis and deep space infections. Tenosynovitis is an infection of the flexor tendon sheath, which is usually caused by direct inoculation of bacteria from penetrating trauma (such as an animal bite). There are 4 criteria (known as Kanavel signs) that are used to diagnose tenosynovitis. These include: (1) finger held in slight flexion; (2) fusiform swelling; (3) tenderness along the flexor tendon sheath; and (4) pain with passive extension of the digit.[20] Diagnosis is primarily clinical. Radiographs should be obtained to rule out fracture or retained foreign bodies. Management includes prompt administration of intravenous antibiotics and hand surgery consultation.

Surgical Site Infections

Wound infections, or surgical site infections, are some of the most common adverse events in hospitalized surgical patients.[122] Superficial incisional surgical site infections tend to occur within 30 days of the surgery, while deep incisional infection occurs anywhere from 30 days to 1 year after the surgery if there is a prosthesis present. These infections present with pain, swelling, erythema, and purulent drainage. In patients in whom surgical site infection is a concern, sutures should be removed, and the area should be incised and drained either by the surgical specialist or after discussion with the surgical team. Cultures should be taken of exudate, if present. Systemic antibiotic therapy is not routinely indicated,[123] but may be used as an adjunct to incision and drainage in patients who have a significant systemic response including erythema extending > 5 cm from the wound margin, fever, tachycardia, and a WBC count > 12,000 cells/dL.[61] If MSSA is suspected, a first-generation cephalosporin or antistaphylococcal penicillin is recommended.[61] Vancomycin or linezolid is recommended in cases of suspected MRSA infection.[61]

Controversies/Cutting Edge

Methicillin-Resistant *Staphylococcus aureus* Decolonization

Nasal carriage of MRSA is a known risk factor for the development of SSTI.[8,9,124] Decolonization measures are often attempted to eliminate this reservoir for infection. In one randomized trial, the use of nasal mupirocin in patients who were MRSA carriers did not decrease the frequency of infections.[125] The use of chlorhexidine body scrubs was also determined to be ineffective.[126] A 5-day course of intranasal mupirocin 2 times per day and daily chlorhexidine scrubs could be trialed, but the data in efficacy are not robust.[126] A recent pediatric study found that employing preventative measures in the household members, as well as in the child, resulted in fewer recurrences of infection than with treatment of the child alone.[127] In that study, a 5-day decolonization regimen using twice-daily application of 2%

mupirocin ointment to the nares and daily use of 4% chlorhexidine gluconate with bathing was used.

New Treatments For Methicillin-Resistant *Staphylococcus aureus*

The treatment of MRSA infections has been a hot topic for many years. The rising rate of antimicrobial resistance to existing therapies has sparked considerable research and development of new therapies. The newest medications approved for SSTIs are telavancin (Vibativ®), ceftaroline (Teflaro®), and tigecycline (Tygacil®).[128] Of particular interest are dalbavancin, oritavancin, and telavancin, which are semisynthetic lipoglycopeptides. These drugs contain a heptapeptide core that enables them to inhibit cell wall synthesis.[129] These drugs have the potential to make a large impact on the treatment of MRSA given their unique pharmacologic properties.[128] There are 6 other drugs that are being researched for the treatment of SSTIs, but have yet to be approved.[128]

Vaccines

The prevalence and pervasiveness of CA-MRSA has resulted in great interest in the development of a vaccine against bacteria that cause SSTIs. Highly effective vaccines against many bacteria including *H influenzae, S pneumoniae,* and *Neisseria* have been created, but no effective vaccine has been produced for *S aureus* or GAS to date. Numerous attempts at creating an *S aureus* vaccine have gone to trial,[130-135] but none have been successful. No vaccine for GAS has been approved GAS at this time either.[136,137] However, efforts to create a vaccine are still underway for both *S aureus* and GAS.

Disposition

The disposition of a patient with an SSTI is multifactorial. Special consideration should be given to patients with signs of systemic infection and medical conditions that cause poor healing, as well as the location of the infection and the reliability of the family to provide care and follow-up.

Patients at particular risk for severe and overwhelming infection, such as immunocompromised patients, neonates, and neutropenic patients, may require admission for intravenous antibiotics and monitoring for resolution of infection. Emergency clinicians may also encounter patients who have worsening infection despite appropriate oral antimicrobials. Those patients may require admission for more aggressive therapies.

Patients who show signs of systemic disease, including cardiovascular compromise, mental status changes, and vital sign instability, should be admitted to the intensive care unit for continued workup and monitoring.

The nature of the skin infection may alter the decision to admit or discharge a patient as well. Patients who present with facial, hand, or groin cellulitis may require closer observation due to the potential of these infections to progress and result in a poor prognosis. Patients with large areas of cellulitis may also benefit from intravenous antibiotics until the infection is controlled, at which time the patient may be transitioned to oral antibiotics and discharged.

Summary

Skin and soft-tissue infections are extremely common. Children may present with benign, self-limited infections, such as folliculitis, or with life-threatening infections, such as toxic shock syndrome. The constant evolution of the bacteria that tend to cause these infections, especially CA-MRSA, has made determining the appropriate therapy for these infections quite difficult. Included in this review is a table which summarizes the most common SSTIs and the most appropriate treatment. **(See Table 3.)**

Abbreviations

CA-MRSA: Community-acquired methicillin-resistant *Staphylococcus aureus*
GAS: Group A streptococci
MSSA: Methicillin-sensitive *Staphylococcus aureus*
MRSA: Methicillin-resistant *Staphylococcus aureus*
SSSS: Staphylococcal scalded skin syndrome
SSTI: Skin and soft-tissue infection
TMP-SMX: Trimethoprim-sulfamethoxazole
TSS: Toxic shock syndrome
TSST-1: Toxic shock syndrome toxin-1

Case Conclusions

Laboratory tests were drawn on the 7-month-old boy and were notable for pancytopenia, mild coagulopathy (INR 1.5), and grossly elevated C-reactive protein (686 mg/L). Due to clinical concern for necrotizing fasciitis, the patient was taken emergently to the operating room for exploration of the affected area. Operative findings were significant for necrotized subcutaneous tissue over the entire lower abdomen, but sparing the scrotum. He

Table 3. Summary Of Common Skin And Soft-Tissue Infections

Infection Type	Distinguishing Features	Treatment
Nonbullous impetigo	Papules and vesicles evolving into honey-colored dried crust on an erythematous base	Mupirocin
Bullous impetigo	Fragile thin-walled bullae filled with clear-to-yellowish fluid	Mupirocin or retapamulin
Folliculitis	Pruritic papules or pustules with a centrally located hair follicle	Supportive care
Furuncle	Purulent material surrounding a hair follicle	Incision and drainage
Cellulitis	Erythematous, tender, indurated skin	Cephalexin **or** If the patient has a history of CA-MRSA, clindamycin **or** cephalexin and TMP-SMX
Periorbital cellulitis	Tenderness, erythema, and edema of the periorbital tissues	Amoxicillin-clavulanate
Orbital cellulitis	Erythema and induration of the eyelid, pain with eye movements, and fever; advanced disease may result in limited eye movements, proptosis, and decreased visual acuity	Vancomycin **plus** ceftriaxone **or** Piperacillin-tazobactam **or** Ampicillin-sulbactam
Erysipelas	Tender, erythematous, and indurated plaque with a well-demarcated border, may have an orange-peel appearance to the skin	Amoxicillin
Ecthyma	Vesicles or pustules with an erythematous base that ruptures and crusts; the base of the lesions often erodes through the epidermis and may appear like a cigarette burn	Mupirocin
Necrotizing fasciitis	Stage 1: erythema, tenderness, warmth, and swelling Stage 2: blistering Stage 3: skin necrosis, crepitus	Surgery consult Vancomycin **plus** Piperacillin-tazobactam
Staphylococcal scalded skin syndrome	Macular erythematous rash followed by exfoliation, positive Nikolsky sign	Nafcillin
Toxic shock syndrome	Erythematous rash with subsequent desquamation plus signs of systemic involvement	Penicillin **plus** Clindamycin

Abbreviation: CA-MRSA, community-acquired methicillin-resistant *Staphylococcus aureus;* TMP-SMX, trimethoprim-sulfamethoxazole.

was placed on empiric broad-spectrum antibiotics. He was returned to the operating room 4 more times for debridement and wash-outs. Skin grafts were successfully performed, and he was discharged home approximately 1 month after initial presentation.

Based on the physical examination, you determined that the 2-year-old girl had impetigo. You explained to the medical student that impetigo is a clinical diagnosis, and it typically heals within 2 to 3 weeks even without treatment. You told the student that treatment leads to higher cure rates, and the treatment of choice is topical mupirocin. This patient was started on mupirocin, and her lesions resolved within 10 days.

Due to the presence of the hyperemic skin as well as the skin sloughing in the 7-week-old boy, you were concerned for staphylococcal scalded skin syndrome. You explained to the mother that her child may have a skin-blistering condition, and that the red peeling skin may worsen. You consulted dermatology, and punch biopsy confirmed the diagnosis. The child was admitted to the hospital and received intravenous hydration, intravenous nafcillin, pain control, and local wound care. He ultimately did well and was discharged home.

Time- And Cost-Effective Strategies

- **Do not routinely obtain blood cultures on immunocompetent patients with cellulitis.** In one pediatric study, only 2% of patients with cellulitis had a positive blood culture, and 5.4% of children had a contaminated blood culture.[64] Contaminated cultures lead to repeat visits, repeat blood cultures, and, often, hospital admission for further workup. Another study demonstrated a longer length of stay for patients in whom blood cultures were obtained,[65] which also adds to overall cost.

- **After incision and drainage, do not provide antibiotics to patients with abscesses with no surrounding cellulitis.** Routine use of antibiotics after incision and drainage of simple abscesses may not be indicated.[61] A meta-analysis of 4 randomized, placebo-controlled trials involving both children and adults who received systemic antibiotics or placebo after incision and drainage of simple abscesses found that the addition of systemic antibiotics did not significantly improve outcomes.[91] However, there were flaws in the study, and more research is needed to determine if recurrence rates are improved with the use of antibiotics after incision and drainage.

References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study will be included in bold type following the references cited in this paper, as determined by the author, will be noted by an asterisk (*) next to the number of the reference.

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Risk Management Pitfalls In Skin And Soft-Tissue Infections

1. **"The area in question was not fluctuant, so I did not think there was an abscess to drain."**
   Clinical examination alone can be sufficient to diagnose an abscess that requires drainage. However, when an abscess is not clinically evident, the use of ultrasound may improve the accuracy of the diagnosis.[77]

2. **"The patient had facial swelling, but I did not evaluate his teeth."**
   Facial cellulitis is often associated with odontogenic infections. All patients with facial swelling should receive a careful oral examination, and they may require follow-up with a dentist for tooth extraction.

3. **"The patient only complained of a rash on the arm, so I didn't look elsewhere."**
   All patients with skin and soft-tissue infections should be examined in a hospital gown so as not to miss other signs of infection. Staphylococcal scalded skin syndrome, for example, tends to start centrally and spread centripetally. If the patient is not fully examined, the central erythroderma may be missed, and the patient may be inappropriately treated.

4. **"The neonate looked well, and the rash was small, so I did not perform a complete sepsis evaluation."**
   In all but the simplest of infections, neonates should undergo a complete sepsis evaluation and immediate and aggressive antibiotic therapy.

5. **"I tightly packed the abscess cavity to encourage continued drainage."**
   Theoretically, packing a wound prevents the incision in the skin layer from closing prematurely to allow for continued drainage. However, packing is painful and may lead to increased healing times.[86] Studies have shown no difference in failure rates, pain scores, or healing times between abscesses that are packed versus not packed.[85] Additionally, patients who received no packing reported less pain.[86] Wound packing, therefore, may be an unnecessary step, but more research needs to be performed to determine whether or not wound packing should be used.

6. **"I didn't drain the paronychia, because it would be too painful for the patient."**
   If there is abscess formation present, it should be evacuated. Untreated paronychia can develop into a felon, which require more extensive incision and drainage.

7. **"I wasn't sure if the patient had periorbital or orbital cellulitis, so I treated with oral antibiotics for a periorbital infection."**
   Orbital cellulitis can be clinically distinguished from periorbital cellulitis by the presence of pain with eye movements, proptosis, limited eye movements, or decreased visual acuity. If there is any question of the presence of orbital cellulitis being present, the patient should undergo a CT scan.

8. **"I treated the infected cat bite wound with clindamycin to cover CA-MRSA."**
   Infected bite-related wounds usually have a polymicrobial etiology, and should be treated with antibiotics that are active against both aerobic and anaerobic bacteria, as well as gram-negative bacteria (eg, *Pasteurella multocida*), such as amoxicillin-clavulanate.

9. **"I performed an incision and drainage on the abscess, but did not obtain culture of the purulent material, and now my patient has returned with a worsening infection."**
   When possible, a culture should be obtained from purulent lesions. The results of wound cultures can help guide antimicrobial therapy in the event of treatment failure, and may spare the patient from receiving costly broad-spectrum antibiotics.

10. **"I thought my patient may have necrotizing fasciitis, so I started broad-spectrum antibiotics and admitted him to the hospital."**
    In patients suspected of having necrotizing fasciitis, emergent surgical consult is imperative. Antibiotics have little effect on the infection prior to surgery due to the poor vascular supply of the necrotic tissue. Delays in proper treatment can increase patient morbidity and mortality.

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1. **What is the bacterial etiology of hot tub folliculitis?**
   a. *Pseudomonas aeruginosa*
   b. *Staphylococcus aureus*
   c. Group A beta-hemolytic streptococci
   d. *Pasteurella multocida*

2. **All of the following are concerning for orbital cellulitis EXCEPT:**
   a. Proptosis
   b. Discharge from the eye
   c. Pain with eye movements
   d. Fever

3. **What is the causative organism in erysipelas?**
   a. *Staphylococcus aureus*
   b. Streptococcal species
   c. *Haemophilus influenzae*
   d. *Vibrio* species

4. **What is the most consistent physical examination finding in necrotizing fasciitis?**
   a. Erythroderma
   b. Pain out of proportion to examination
   c. The presence of bullae
   d. Soft-tissue crepitus

5. **What toxin is implicated in staphylococcal scalded skin syndrome?**
   a. Enterotoxin
   b. Exfoliative toxins A and B
   c. Panton-Valentine leucocidin
   d. Streptolysin O

6. **Which of the following blood test results are necessary for the diagnosis of cellulitis?**
   a. Elevated WBC count
   b. Elevated C-reactive protein
   c. Positive blood culture
   d. None of the above

7. **Nonbullous impetigo should be treated with which medication?**
   a. Clindamycin
   b. Amoxicillin
   c. Mupirocin
   d. Bacitracin

8. **What can be used to neutralize exotoxin in staphylococcal scalded skin syndrome?**
   a. Intravenous immunoglobulin
   b. Clindamycin
   c. Fresh-frozen plasma
   d. Corticosteroids

9. **Clindamycin is used in the treatment of TSS to:**
   a. Treat the infection
   b. Provide synergy
   c. Suppress toxin production
   d. Decrease mortality rates

10. **Infections from cat bites are typically caused by:**
   a. *Streptococcus viridans*
   b. *Staphylococcus aureus*
   c. *Pasteurella multocida*
   d. *Pseudomonas aeruginosa*