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Evaluation and management of suspected methicillin-resistant Staphylococcus aureus skin and soft tissue infections in children

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INTRODUCTION — Methicillin-resistant *Staphylococcus aureus* (MRSA, oxacillin minimum inhibitory concentration [MIC] ≥4 mcg/mL) has increased in prevalence worldwide as both a healthcare-associated and a community-associated pathogen. Community-associated MRSA (CA-MRSA) most frequently causes skin and soft tissue infections (SSTI) [1-3]. However, it is also associated with invasive infections, particularly pneumonia and musculoskeletal infections. (See "Epidemiology and clinical spectrum of methicillin-resistant Staphylococcus aureus infections in children".)

The substantial prevalence of CA-MRSA as a cause of SSTI [4] and the increasing prevalence of multidrug-resistant CA-MRSA calls for changes in the approach to the evaluation and management of suspected *S. aureus* SSTI in children. MRSA is the most common identifiable cause of SSTI in many communities and should be suspected (along with methicillin-susceptible *S. aureus* and group A *streptococcus*) in children with SSTI. The evaluation and management of suspected methicillin-resistant *S. aureus* SSTI will be reviewed here. The epidemiology, prevention, and control of MRSA infections in children and the treatment of invasive MRSA infections in children are discussed separately. (See "Epidemiology and clinical spectrum of methicillin-resistant Staphylococcus aureus infections in children" and "Prevention and control of methicillin-resistant Staphylococcus aureus in children" and "Treatment of invasive methicillin-resistant Staphylococcus aureus infection in children".)

General aspects of management of SSTI and the treatment of SSTI in adults also are discussed separately. (See "Cellulitis and erysipelas" and "Skin abscesses, furuncles, and carbuncles" and "Impetigo" and "Folliculitis" and "Treatment of skin and soft tissue infections due to methicillin-resistant Staphylococcus aureus in adults".)

EVALUATION

History — Important aspects of the history in a child with SSTI include risk factors for MRSA, underlying medical conditions, recent use of antibiotics, trauma to skin, including any foreign body that could be imbedded, exposure to ill contacts (eg, group A *streptococcus*), animal bites, and allergy to antibiotics.

Although it is impossible to distinguish MRSA from MSSA on clinical or epidemiologic grounds [5,6], it is important to inquire whether children with SSTI have risk factors for MRSA, particularly a previous history of boils, abscesses, infection or colonization with MRSA in the patient or close contacts, and/or

underlying medical conditions [7]. MRSA isolates in children with healthcare risk factors are more likely to be resistant to clindamycin and other commonly used drugs than isolates from children without risk factors [2,8,9]. (See "Epidemiology and clinical spectrum of methicillin-resistant Staphylococcus aureus infections in children", section on 'Epidemiology and risk factors'.)

Examination — Examination features determine the type and severity of SSTI. Important aspects of the examination include general appearance, the presence of systemic signs (eg, fever, hypotension, tachycardia), and the extent of involvement of the skin and soft tissues. Staphylococcal SSTI may be falsely attributed to spider bites by both patients and clinicians [10,11].

- Localized pustules – Localized pustules have a number of infectious causes. Two common causes in children include impetigo and folliculitis. Impetigo is a superficial bacterial infection that manifests with lesions that progress from papules to vesicles, pustules, and crusts. Folliculitis is a superficial bacterial infection of the hair follicles with purulent material in the epidermis. (See "Approach to the patient with pustular skin lesions" and "Impetigo" and "Folliculitis".)
- Furuncles and carbuncles – A furuncle (or "boil") is an infection of the hair follicle in which purulent material extends through the dermis into the subcutaneous tissue, where a small abscess forms. A carbuncle is a coalescence of several inflamed follicles into a single inflammatory mass with purulent drainage from multiple follicles in the epidermis (picture 1). (See "Folliculitis".)
- Skin abscess – Skin abscesses are collections of pus within the dermis and deeper skin tissues. (See "Skin abscesses, furuncles, and carbuncles".)
- Cellulitis – Cellulitis is an infection of the deep dermis and subcutaneous fat without an underlying suppurative focus; it manifests with erythema, edema, and warmth. (See "Cellulitis and erysipelas".)

Laboratory evaluation — Laboratory evaluation is necessary to determine the microbiologic etiology of SSTI. Various bacterial and viral pathogens can cause skin lesions that are clinically indistinguishable from MRSA [12,13]. (See "Impetigo" and "Folliculitis" and "Skin abscesses, furuncles, and carbuncles" and "Cellulitis and erysipelas".)

Before the emergence of CA-MRSA, obtaining material for culture and susceptibility testing was not a routine part of management of SSTI in children [14]. Such infections were easily treated with beta-lactam antimicrobials (eg, antistaphylococcal penicillins, first- or second-generation cephalosporins). However, given the high prevalence of MRSA as a cause of SSTI, and the geographic and temporal variability of CA-MRSA antimicrobial susceptibility, this practice may need to be reconsidered [6,10,15-17].

Culture and susceptibility testing results guide decisions regarding antimicrobial therapy [6,10,17]. Culture results also are important in monitoring the local proportion of *S. aureus* infections caused by MRSA and the prevalence of resistance to various classes of antimicrobials [6,10,12,16].

- Wound cultures – We suggest that specimens for Gram stain, culture, and susceptibility testing be obtained from patients with abscesses or purulent skin lesions if purulent material can be obtained [11,12,18]. It is particularly important to obtain wound cultures from immunocompromised patients and those with severe local infections, systemic signs of infection, recurrent or multiple abscesses, an epidemiologic link to individuals with MRSA infection, and those who have failed initial treatment [12,19].
- Blood culture – We suggest blood cultures be obtained from patients who have signs of systemic infection (eg, prolonged fever, tachycardia, hypotension), especially those with cellulitis and underlying conditions [19,20].
- Nasal cultures – We do not suggest obtaining routine nasal cultures from patients presenting with possible MRSA infection [12]. The predictive value of screening for colonization is not known [21]. In addition, nasal and wound isolates may be discordant with respect to antimicrobial susceptibility and pulsed-field gel electrophoresis [22].

- Gram stain – Gram stain identification of gram-positive cocci in clusters provides early indication of staphylococcal infection, which can help guide empiric therapy. If *S. aureus* is isolated in bacterial culture, susceptibility testing is necessary to distinguish MRSA from MSSA [5]. In some laboratories, methicillin-resistance maybe detected rapidly using commercially available molecular tests for the mecA gene that leads to methicillin-resistance. (See "Rapid detection of methicillin-resistant Staphylococcus aureus".)
- Susceptibility testing – *S. aureus* isolates should be tested for susceptibility to beta-lactam antibiotics, rifampin, trimethoprim-sulfamethoxazole (TMP-SMX), tetracyclines, erythromycin, clindamycin, vancomycin, linezolid, and daptomycin [23]. A D test for inducible resistance to clindamycin should be performed on isolates that are resistant to erythromycin but susceptible to clindamycin if clindamycin therapy is being considered. (See "Epidemiology and clinical spectrum of methicillin-resistant Staphylococcus aureus infections in children", section on 'Microbiologic characteristics' and "Overview of antibacterial susceptibility testing", section on 'D test'.)

TREATMENT OVERVIEW — In the absence of controlled studies of the treatment of suspected MRSA SSTI in children, treatment is based upon clinical factors and local susceptibility patterns [11]. Information regarding local susceptibility patterns can be obtained from local public health officials or hospital laboratories.

The approach to treatment provided below is based upon that suggested by the American Academy of Pediatrics Committee on Infectious Diseases and the Infectious Diseases Society of America [11,18].

Drainage, adjunctive antimicrobial therapy, wound care, patient education, and reliable follow-up are the primary components of management of MRSA SSTI [11,18]. Empiric management strategies vary depending upon patient age, comorbid conditions, and the severity of the infection.

Mild superficial infections (eg, localized impetigo, pustules, or folliculitis) can usually be managed in the outpatient setting with topical antimicrobials. (See 'Topical agents' below.) Small abscesses (<5 cm in diameter) in patients without systemic signs or underlying conditions can usually be managed with incision and drainage (with or without oral antimicrobials). Deeper abscesses and/or infections in children with underlying medical problems usually require hospitalization for surgical drainage and/or parenteral antimicrobial therapy [10,11,18].

Drainage — We recommend drainage of purulent and fluctuant lesions [10-12,18,24,25].

Purulent fluid should be sent for Gram stain, culture, and susceptibility testing [11]. For patients with small furuncles that are not amenable to incision and drainage, application of moist heat may help to promote drainage [10,12,26]. (See "Technique of incision and drainage for skin abscess" and 'Laboratory evaluation' above.)

The importance of incision and drainage is illustrated by the following observations:

- In the pre-CA-MRSA era, similar outcomes were achieved in patients with cutaneous abscesses who were treated with incision and drainage alone or incision and drainage plus antibiotics [27,28]
- In a prospective review of 201 patients with staphylococcal SSTI, lack of incision and drainage was associated with clinical nonresponse [29]
- In observational and randomized studies, most patients with uncomplicated skin abscesses who underwent incision and drainage or spontaneous drainage improved despite adjunctive therapy with antibiotics to which their isolates were not susceptible [30-33]

Drainage alone may be adequate therapy for previously healthy children with uncomplicated skin lesions <5 cm in diameter and no systemic signs [25,30,33]. However, we suggest adjunctive oral antimicrobial therapy in selected circumstances, as noted below. (See 'Antimicrobial therapy' below.)

Treatment of skin abscess with drainage alone was evaluated in a randomized trial in 161 children without underlying medical conditions who presented to an emergency department with skin abscess and temperature <38.4ºC [25]. After drainage, the children were randomly assigned to receive 10 days of trimethoprim-sulfamethoxazole (TMP-SMX) or placebo. More than 90 percent of the lesions were <5 cm in diameter on ultrasonography, and approximately 80 percent of the lesions in both groups grew CA-MRSA. At the 10-day follow-up, clinical resolution was similar in the TMP-SMX and placebo groups (96 and 95 percent, respectively). New lesions were more common in the placebo group at 10 days (26 versus 3 percent), but not at 30 days (approximately 28 percent in both groups). These findings suggest that antibiotics may not be necessary for resolution of skin abscess, but may be helpful in preventing short-term recurrence.

In a randomized trial comparing an agent with high MRSA activity (clindamycin) and an agent without MRSA activity (cephalexin) for uncomplicated SSTI in 200 children, spontaneous drainage occurred or a drainage procedure was performed in 97 percent of cases [33]. Although MRSA was isolated from 69 percent of wound cultures, there was no difference in the rates of improvement at 48 to 72 hours (97 and 94 percent, respectively) or complete resolution at seven days (94 and 97 percent, respectively) between groups. These findings confirm those of an observational study in 69 children with MRSA SSTI (most with lesions <5 cm in diameter) who improved after incision and drainage even if they were treated with an antimicrobial to which their isolate was not susceptible [30]. Together, these studies suggest that drainage and close follow-up are more important than antimicrobial choice for successful treatment of MRSA SSTI [33].

Antimicrobial therapy — In addition to drainage, adjunctive antimicrobial therapy may be warranted for certain patients [11,12,18]. There is some evidence from observational studies that appropriate antimicrobial therapy is beneficial [17,34-36], particularly for children with lesions >5 cm in diameter [30]. The effect of adjunctive antimicrobial therapy on the recurrence, secondary spread, and progression of disease has not been adequately studied [10].

Factors to be considered in the decision to use adjunctive antimicrobial therapy include age, severity and progression of local symptoms, signs or symptoms of systemic infection, associated chronic illness or immunosuppression, site of infection (eg, face, hands, or perineum) response to initial treatment with incision and drainage, and potential adverse effects of antimicrobial therapy [11,12,18].

We recommend adjunctive systemic antimicrobial therapy for children with SSTI >5 cm in diameter; those with systemic signs of illness; infections of the face, hands, and perineum; those under 12 months of age; those with underlying medical conditions (other than asthma or eczema); and those who have failed treatment with incision and drainage alone [11,12,18].

Initial options for oral therapy in children with SSTI include trimethoprim-sulfamethoxazole, clindamycin, or tetracyclines; linezolid is a second-line agent (table 1). Each of these agents has advantages and disadvantages, described below. (See 'Systemic agents' below.)

Education — Patient education regarding methods to limit spread of infection is an essential component of management of MRSA SSTI [12]. (See "Prevention and control of methicillin-resistant Staphylococcus aureus in children", section on 'In the community'.)

APPROACH FOR CHILDREN >30 DAYS OF AGE

Empiric therapy — Empiric treatment strategies for children >30 days of age with SSTI depend upon severity.

Mild SSTI — SSTI that occur in children who are afebrile and previously healthy are classified as mild [11]. Incision and drainage (if the lesions are fluctuant) alone may be adequate for mild SSTI. (See 'Drainage' above.)

Folliculitis and localized pustules can usually be treated topically [18]. Empiric oral therapy depends upon local susceptibility patterns, the likelihood of *Streptococcus pyogenes* (group A *streptococcus*), and the age of the child. (See 'Topical agents' below and 'Systemic agents' below.)

When MRSA is a consideration in children with mild SSTI, if systemic antibiotic therapy is warranted, we suggest oral empiric therapy with a non-beta-lactam antibiotic [23]. Options for oral therapy include (table 1) [11,18,23,37]:

- Clindamycin (if the prevalence of clindamycin-resistant MSSA and MRSA in the community is low (ie, <10 percent))
- TMP-SMX (if *S. pyogenes* is unlikely)
- Doxycycline (if the child is ≥8 years of age and *S. pyogenes* is unlikely)

In a retrospective cohort of 41,094 children with SSTI who were treated with clindamycin, TMP-SMX, or a beta-lactam antibiotic without drainage, the rates of treatment failure and recurrence were 6 and 18 percent, respectively [36]. The risk of treatment failure and recurrence were increased in children treated with TMP-SMX compared with clindamycin (adjusted odds ratio 1.67 [95% CI 1.44-1.95] for treatment failure and adjusted hazard ratio 1.3 [95% CI 1.18-1.44] for recurrence) [36]. Pending additional data from randomized trials, we do not have a preference for clindamycin or TMP-SMX for patients who have undergone drainage. For patients that have not undergone drainage, clindamycin may have some advantage. However, increased use of clindamycin may result in increased clindamycin resistance. Other advantages and disadvantages of these agents are discussed below. (See 'Systemic agents' below.)

In communities with a low prevalence of MRSA (ie, <10 percent), empiric therapy with a beta-lactam agent is an alternative for infants and children without underlying conditions, and for infections not involving the face, hands, or perineum (eg, a first- or second-generation cephalosporin, cloxacillin, dicloxacillin).

The provision of empiric MRSA coverage does not necessarily result in improved outcomes for children with mild SSTI. A retrospective case-control study assessed treatment failure among 2096 children from an area with a high prevalence of MRSA who were treated with a single oral antimicrobial agent for SSTI that, in the opinion of the treating provider, did not require drainage or culture [38]. Treatment failure occurred in 5 percent. Compared with beta-lactam therapy, clindamycin provided no benefit (OR for treatment failure 1.4, 95% CI 0.76-2.59), whereas TMP-SMX was associated with an increased risk of treatment failure (OR 2.35, 95% CI 1.28-4.34). These findings suggest that *S. pyogenes* may be a more common cause, and MRSA a less common cause, of mild SSTI (even in MRSA-endemic areas) and that empiric coverage for MRSA may not be necessary for skin infections that are not drained, especially impetigo. However, the findings must be validated in prospective studies.

Moderate SSTI — SSTI that occur in children who are febrile and/or ill appearing, but previously healthy, are classified as moderate [11]. We recommend that moderate SSTI be treated with incision and drainage (if the lesions are fluctuant) and adjunctive antimicrobial therapy [11,18].

Decisions regarding oral versus parenteral therapy depend upon the presence of systemic signs; age of the child; size and location of the lesions; and concerns regarding adherence to therapy and follow-up plans. We suggest initial parenteral therapy for children with systemic signs of illness. We also suggest initial parenteral therapy (one to two doses) for children (of any age) with multiple sites of infection; and for preschool children with abscesses on the face or perineum, or lesions larger than 5 cm. Initial parenteral therapy for children may be administered in an emergency department observation or “short-stay” unit if one is available.

When MRSA is a consideration in children with moderate SSTI, options for oral therapy include (table 1) [11,18,23,37]:

- Clindamycin (if the prevalence of clindamycin-resistant MSSA and MRSA in the community is low (ie, <10 percent))
- TMP-SMX (if *S. pyogenes* is unlikely)
- Doxycycline (if the child is ≥8 years of age and *S. pyogenes* is unlikely)

In a retrospective cohort of 6407 children with SSTI who were treated with a drainage procedure and clindamycin, TMP-SMX or a beta-lactam antibiotic, the rates of treatment failure and recurrence were 9 and 23 percent, respectively [36]. The risk of treatment failure and recurrence were increased in children treated with TMP-SMX compared with clindamycin (adjusted odds ratio 1.92 [95% CI 1.49-2.47] for treatment failure and adjusted hazard ratio 1.26 [95% CI 1.06-1.49] for recurrence) [36]. Pending additional data from randomized trials, we do not have a preference for clindamycin or TMP-SMX for children who have undergone drainage and are treated as outpatients; increased use of clindamycin may result in increased clindamycin resistance.

Options for parenteral therapy include vancomycin or clindamycin (if the prevalence of clindamycin-resistant MRSA is less than 10 percent in the community), pending results of culture and susceptibility testing [11,18,23]. The advantages and disadvantages of these agents are discussed below. (See 'Systemic agents' below.)

Severe SSTI — SSTI that are limb-threatening or occur in children who are toxic appearing are classified as severe [11]. In addition, immunocompromised children or those with chronic conditions other than asthma or eczema should generally be managed in the same manner as children with severe SSTI, even if the SSTI does not appear to be limb- or life-threatening.

We recommend that children with severe SSTI be treated with incision and drainage (if the lesions are fluctuant) and hospitalized for parenteral antimicrobial therapy [11,18]. Options for parenteral therapy include vancomycin or clindamycin (if the prevalence of clindamycin-resistant MRSA is less than 10 percent in the community), pending results of culture and susceptibility testing [11,18,23]. Linezolid (600 mg twice daily intravenously [IV] for children ≥12 years of age; 10 mg/kg per dose [maximum dose 600 mg] every 8 hours IV for children <12 years) is another alternative for parenteral therapy in hospitalized children [18].

Treatment of invasive MRSA infection (ie, infection that has spread beyond the skin and soft tissues) is discussed separately. (See "Treatment of invasive methicillin-resistant Staphylococcus aureus infection in children", section on 'Treatment approach'.)

Critically ill patient — We recommend that critically ill patients (eg, those with hemodynamic compromise) be hospitalized for incision and drainage (if the lesions are fluctuant) and parenteral antimicrobial therapy. We suggest an empiric regimen of vancomycin plus nafcillin for critically ill patients with suspected MRSA SSTI. The combination of vancomycin and nafcillin is necessary to maximize coverage for both MRSA and methicillin-susceptible MSSA. Given that there is little to no evidence that adding gentamicin for potential synergy is beneficial in adults, we do not suggest the addition of gentamicin; even at low doses, gentamicin is associated with increased nephrotoxicity in adults [39].

Treatment of invasive MRSA infection (ie, infection that has spread beyond the skin and soft tissues) is discussed separately. (See "Treatment of invasive methicillin-resistant Staphylococcus aureus infection in children", section on 'For critically ill'.)

Definitive therapy — When the etiologic agent and susceptibility are known, antimicrobial therapy can be narrowed as indicated. MSSA infections can be treated orally with a beta-lactam agent (eg, dicloxacillin, cephalexin) or intravenously with a semisynthetic penicillin (eg, nafcillin, oxacillin) or cefazolin [11]. MRSA can be treated orally or intravenously with agents to which they are susceptible (table 1).

Avoiding the use of vancomycin, clindamycin, and linezolid when the isolate is susceptible to other drugs may help to minimize promotion of resistance to these drugs (which are crucial to the treatment of invasive infections) [16]. (See "Treatment of invasive methicillin-resistant Staphylococcus aureus infection in children", section on 'Treatment approach'.)

Duration — The total duration of therapy for staphylococcal SSTI depends upon clinical response; a total of 7 to 14 days is usually adequate if there are no complications.

APPROACH FOR CHILDREN ≤30 DAYS OF AGE — The Infectious Diseases Society of America provides guidance for the management of invasive methicillin-resistant *S. aureus* (MRSA) infections in infants (≤30 days of age) [18]. The guidelines are based upon observations from a single-institution review of 126 cases treated between 2001 and 2006 [40]. The safety and efficacy of topical, oral, and parenteral therapy for CA-MRSA infections have not been well evaluated in this age group [13].

We suggest that local pustulosis in full-term neonates without other signs or symptoms of infection be treated with topical antibiotic therapy (eg, mupirocin) in the outpatient setting [13,18]; close follow-up of such patients is imperative [40]. Blood culture and lumbar puncture are not necessary in such infants unless they have signs of sepsis. We recommend that local pustulosis in premature or very low-birth weight infants be treated parenterally at least until bacteremia is excluded [18].

We recommend hospital admission for infants ≤30 days with more severe SSTI (eg, cellulitis, abscess, mastitis, pustulosis involving multiple sites) and for those who undergo evaluation for serious bacterial infection (eg, bacteremia, urinary tract infection, meningitis, arthritis, osteomyelitis). We suggest that all neonates with infections that are more severe than localized pustulosis and those with systemic symptoms or fever undergo evaluation with blood and urine cultures; cerebrospinal fluid cultures should be obtained as clinically indicated [40]. Significant cerebrospinal (CSF) pleocytosis with sterile CSF culture may be seen in association with CA-MRSA infection in neonates [40]. The pathogenesis of the pleocytosis is unclear. (See "Evaluation and management of fever in the neonate and young infant (less than three months of age)" and "Mastitis and breast abscess in infants, children, and adolescents", section on 'In neonates'.)

Empiric parenteral antibiotics for SSTI in neonates should be based upon the local susceptibility pattern of community-associated *S. aureus* isolates [13]. We suggest vancomycin, clindamycin, or linezolid for neonates with staphylococcal infection limited to the skin and soft tissues [13,18,40]. Gentamicin may be added to broaden coverage for other neonatal pathogens. (See "Clinical features and diagnosis of sepsis in term and late preterm infants", section on 'Etiologic agents'.)

The treatment of infants ≤30 days with MRSA infections that have extended beyond the skin and skin structures is discussed separately. (See "Treatment of invasive methicillin-resistant Staphylococcus aureus infection in children", section on 'Treatment of neonates'.)

The total duration of therapy for staphylococcal SSTI in neonates depends upon clinical response; a total of 7 to 14 days is usually adequate if there are no complications [40]. Parenteral therapy for infants with noninvasive infection should continue until all of the following criteria are met:

- Resolution of systemic symptoms and fever
- Improvement in other clinical findings
- Antibiotic susceptibility results are available
- Systemic bacterial cultures (urine, blood, CSF) isolate no pathogens during at least 48 hours of incubation

Results of antibiotic susceptibility testing should be used to make decisions about which oral antibiotic to use for continuation of systemic therapy. Appropriate oral agents for neonates with noninvasive infection include amoxicillin-clavulanate, cephalexin, and clindamycin, depending upon the susceptibilities of the *S. aureus* isolated [41,42]. Linezolid may be used when the isolate is resistant to other agents, but should be used under close supervision by an expert in infectious disease [40]. TMP-

SMX should not be used in the immediate neonatal period because it may displace bilirubin, increasing the risk for bilirubin toxicity. (See "Evaluation of unconjugated hyperbilirubinemia in term and late preterm infants", section on 'Bilirubin/albumin ratio'.)

FOLLOW-UP — Children who are treated for suspected MRSA in the outpatient setting should be instructed to seek medical care promptly if they develop systemic symptoms or if local symptoms worsen [10]. They should be seen for follow-up within 48 hours (whether or not antimicrobial therapy is prescribed) [26]. Follow-up is essential to ensure clinical improvement and determine the need for additional drainage or change in antimicrobial therapy [7].

Failure to respond — Initiation of or change in antimicrobial therapy (guided by culture and susceptibility results, if available) may be warranted for patients who have not improved after 48 hours of antimicrobial therapy.

- Alternatives for children who fail to improve while being treated with beta-lactam antibiotics include TMP-SMX, clindamycin, or a tetracycline (if ≥8 years of age).
- Alternatives for children who fail to improve with TMP-SMX, clindamycin, or a tetracycline include parenteral vancomycin or oral or parenteral linezolid.
- Alternatives for children who fail to improve with parenteral vancomycin or clindamycin include linezolid or daptomycin; consultation with an expert in infectious diseases is suggested.

Recurrence — The recurrence rate for MRSA SSTI is believed to be at least 10 percent [43]. Recurrence is usually treated in the same way as the initial episode. Strategies to eliminate colonization are sometimes used, but the effectiveness of this approach in reducing recurrences is not clear [43]. (See "Prevention and control of methicillin-resistant Staphylococcus aureus in children", section on 'Eradication of carriage'.)

ANTIMICROBIAL AGENTS — Most strains of MRSA that cause SSTI in the community are relatively susceptible to non-beta-lactam antibiotics [2,10,12,44-46]. However, there is temporal and geographic variability. Some strains are resistant to one or more non-beta-lactam antibiotics and some have susceptibility patterns similar to nosocomial isolates [47-50]. Local susceptibility data should be used to guide empiric treatment [12]. Definitive treatment is guided by results of susceptibility testing (if cultures are obtained). (See 'Definitive therapy' above.)

Topical agents — Topical therapy with mupirocin is an option for children with mild, localized, superficial infections and no systemic signs. Retapamulin (for children older than nine months) may be effective but is not approved for treatment of MRSA infections [43]. High-level resistance to mupirocin associated with treatment failure and *S. aureus* mutants with decreased activity to retapamulin have been reported [51-54].

Systemic agents

- TMP-SMX – Trimethoprim-sulfamethoxazole (TMP-SMX) is not approved by the US Food and Drug Administration (FDA) for the treatment of staphylococcal infection. Its use is supported by in vitro data demonstrating high levels of susceptibility and clinical experience [2,3,16,35,55-57]. In a large retrospective cohort of children with SSTI, treatment with TMP-SMX was associated with increased risk of treatment failure and recurrence compared with clindamycin [36]. TMP-SMX is available in oral (liquid and tablet) and parenteral formulations, although there is currently a shortage of the intravenous formulation [58].

  TMP-SMX is often used in communities with a high prevalence (>10 percent) of MRSA with resistance to clindamycin [2,15,59,60]. The preferential use of TMP-SMX rather than clindamycin in communities with low prevalence MRSA resistance to clindamycin may help minimize promotion of resistance to clindamycin, which is also used in invasive infections [16,47,61].

  TMP-SMX is not active against *Streptococcus pyogenes* (group A *streptococcus*), another

common cause of SSTI. It should not be used as a single agent if *S. pyogenes* SSTI is a consideration; some favor combination therapy with a beta-lactam antibiotic if *S. pyogenes* cannot be excluded [43].

- Clindamycin – Clindamycin is approved by the FDA for the treatment of serious *S. aureus* infections in children, including neonates. Its use is supported by in vitro susceptibility studies and clinical experience [36,47,61-63]. In a large retrospective cohort of children with SSTI, treatment with clindamycin was associated with decreased risk of treatment failure and recurrence than treatment with TMP-SMX [36]. Clindamycin is available in parenteral and oral (capsules and granules for oral solution) formulations. The oral solution may have an unpleasant taste for some children, which can be overcome by the addition of flavoring [64].

  MRSA resistance to clindamycin varies from community to community, and appears to be increasing [16,45,47]. Clindamycin resistance is more likely in children with risk factors for MRSA than in previously healthy children [8,9]. In addition, resistance to clindamycin may emerge during therapy in MRSA strains with inducible resistance; these isolates appear susceptible to clindamycin and resistant to erythromycin by most standard techniques, but can be detected using the "D test" (picture 2) [47,48,65,66]. (See "Overview of antibacterial susceptibility testing", section on 'D test'.)

  Clindamycin is an option for the empiric treatment of suspected MRSA SSTI in communities where the prevalence of clindamycin resistance is <10 percent. Although there are case reports of successful clindamycin therapy for SSTI caused by *S. aureus* with inducible clindamycin resistance [67,68], clindamycin is best avoided when the D test (picture 2) is positive.
- Tetracyclines – Doxycycline is FDA-approved for the treatment of *S. aureus* skin infections (but not specifically for those caused by MRSA) [12]. Support for the use of tetracyclines comes from observational studies in adults [69,70] and in vitro susceptibility data [31]. In a small case-series, doxycycline and minocycline appeared to be adequate for the treatment of MRSA SSTI [69]. Doxycycline is available in parenteral and oral formulations; minocycline is only available in an oral formulation.

  Tetracyclines are an option for the treatment of SSTI in children ≥8 years of age. Similar to TMP-SMX, tetracyclines are not active against *S. pyogenes* and should not be used as a single agent if *S. pyogenes* SSTI is a consideration [71]; some favor combination therapy with a beta-lactam antibiotic if *S. pyogenes* cannot be excluded [43].
- Linezolid – Linezolid is an oxazolidinone antibiotic active against many antibiotic-resistant gram-positive cocci. It is bacteriostatic for *S. aureus* and is approved by the FDA for use in complicated skin infections, including cases caused by MRSA in neonates, children, and adults [72,73]. It is available in oral (tablets and powder for oral suspension) and parenteral formulations.

  In controlled trials, linezolid was as effective as cefadroxil or vancomycin for uncomplicated SSTI in children [73-75]. In a study in adults with complicated SSTI, it was at least as effective as vancomycin [76].

  The use of linezolid for SSTI is limited by cost and toxicity (bone marrow suppression, peripheral and optic neuropathy) if used for a prolonged time [18,77]. It should be reserved for those who do not respond to or cannot tolerate other agents or whose isolates are resistant to clindamycin and TMP-SMX.
- Rifampin – Rifampin is not recommended in the treatment of SSTI [18].
- Vancomycin – Vancomycin is the drug of choice for the treatment of invasive infections caused by MRSA. Vancomycin (plus nafcillin or oxacillin) should be used for empiric treatment of critically ill children with SSTI. (See 'Critically ill patient' above and "Treatment of invasive methicillin-resistant Staphylococcus aureus infection in children", section on 'For critically ill'.)

  Vancomycin is also an option for children with moderate or severe SSTI in communities with a high prevalence of clindamycin resistance. (See 'Moderate SSTI' above and 'Severe SSTI' above.)

- Daptomycin – Daptomycin is a lipopeptide antibiotic that is approved for the treatment of complicated SSTI in adults. The pharmacokinetics, safety, and efficacy of daptomycin for children with SSTI are under investigation [78,79].
- Ceftaroline – Ceftaroline is a fifth generation cephalosporin that is approved for the treatment of complicated MRSA SSTI in adults. The pharmacokinetics, safety and efficacy of ceftaroline in children with SSTI are unknown.
- Other drugs – Fluoroquinolones (eg, ciprofloxacin) and macrolides (eg, erythromycin, azithromycin) are not suggested for the treatment of suspected MRSA SSTI because there is a relatively high prevalence of resistance among *S. aureus* isolates in the community [55].

INFORMATION FOR PATIENTS — UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5th to 6th grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10th to 12th grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or e-mail these topics to your patients. (You can also locate patient education articles on a variety of subjects by searching on "patient info" and the keyword(s) of interest.)

- Beyond the Basics topics (see "Patient information: Methicillin-resistant Staphylococcus aureus (MRSA) (Beyond the Basics)")

SUMMARY AND RECOMMENDATIONS

General

- We recommend drainage of purulent or fluctuant lesions (**Grade 1B**). Purulent fluid should be sent for Gram stain, culture, and susceptibility testing. Blood culture should be obtained from patients with signs of systemic infection. (See 'Drainage' above and 'Laboratory evaluation' above.)
- We suggest that localized superficial infections (eg, impetigo, pustulosis, folliculitis) be treated with topical antibiotic therapy in the outpatient setting (**Grade 2C**). (See 'Treatment overview' above and 'Topical agents' above.)

Children >30 days

- Incision and drainage alone may be adequate therapy for skin and soft-tissue infections (SSTI) <5 cm in diameter in previously healthy children without systemic signs. However, when methicillin-resistant *Staphylococcus aureus* (MRSA) is a consideration in such children with selected features including young age, underlying condition, and certain sites of infection, we suggest adjunctive oral antimicrobial therapy (**Grade 2B**). (See 'Drainage' above and 'Mild SSTI' above.)
- Options for oral therapy include trimethoprim-sulfamethoxazole (if *Streptococcus pyogenes* is not a consideration), clindamycin (if local resistance is <10 percent), or tetracyclines (if *S. pyogenes* is not a consideration and the child is ≥8 years old) (table 1). (See 'Mild SSTI' above and 'Systemic agents' above.)
- We suggest parenteral antimicrobial therapy for children with SSTI and systemic signs of illness, underlying medical conditions, or limb-threatening infections (**Grade 2C**). The location of the infection, age of the child, and presence of multiple sites of infection also influence the decision to hospitalize the child. We also suggest initial parenteral therapy (one to two doses) for children (of any age) with multiple sites of infection; and for preschool children with abscesses on the face or perineum, or lesions larger than 5 cm in diameter (**Grade 2C**). Initial parenteral therapy may be administered in an emergency department observation or "short-stay" unit if one is available. (See 'Moderate SSTI' above and 'Severe SSTI' above.)

- Options for empiric parenteral therapy include vancomycin, clindamycin (if the prevalence of clindamycin-resistant MRSA is less than 10 percent in the community), or linezolid. We suggest vancomycin plus nafcillin for critically ill patients with suspected MRSA SSTI (**Grade 2B**). (See 'Moderate SSTI' above and 'Critically ill patient' above and "Treatment of invasive methicillin-resistant Staphylococcus aureus infection in children", section on 'For critically ill'.)

Children ≤30 days

- We recommend hospital admission and parenteral antimicrobial therapy for local pustulosis in premature or very low-birth-weight infants (**Grade 1B**). We recommend hospital admission for infants ≤30 days with SSTI more severe than localized pustulosis (eg, pustulosis in multiple sites, cellulitis, abscess, mastitis) and for those who undergo evaluation for serious bacterial infection (eg, bacteremia, urinary tract infection, meningitis, arthritis, osteomyelitis) (**Grade 1B**). (See 'Approach for children ≤30 days of age' above.)
- Empiric parenteral antibiotics for SSTI in neonates should be based upon the local susceptibility pattern of community-associated *S. aureus* isolates. Vancomycin, clindamycin, and linezolid are appropriate alternatives for infection limited to the skin and soft tissues; gentamicin may be added to broaden coverage. (See 'Approach for children ≤30 days of age' above.)

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