Methicillin-resistant Staphylococcus aureus (MRSA) in the Athlete

Abstract

Although once considered only a nosocomial pathogen, methicillin-resistant Staphylococcus aureus (MRSA) is a rapidly emerging, problematic infection in the community. Community acquired MRSA (CA-MRSA) is notably becoming more prevalent in athletic environments and unfortunately, can be easily transmitted via superficial abrasions and minor skin trauma. CA-MRSA infections are highly contagious and are associated with significant morbidity, with published reports of up to 70% of infected team members requiring hospitalization and intravenous antibiotics [7]. Risk factors for athletic related environments include contact sports with repeated close physical contact with other competitors, open abrasions, and sharing of personal equipment. Failure to correctly diagnose and appropriately treat skin and soft tissue lesions infected with CA-MRSA may contribute to large scale MRSA infections in athletic environments. The purpose of this review article is to help sports medicine physicians prevent, identify, and treat MRSA skin and superficial soft tissue infections in athletic environments.

Introduction

Staphylococcus aureus, a gram-positive coccus, is a common pathogen in soft tissue and skin infections. Approximately 30% of healthy, asymptomatic people and as many as 65% of patients with staphylococcal skin infections harbor S. aureus in their anterior nares [30]. Transmission is thought to occur from direct person-to-person, person-to-object, and object-to-person contact. Antibiotics have long been the mainstay of treatment for staphylococcal infections. Shortly after the advent of penicillin, S. aureus developed resistance secondary to plasmid mediated β-lactamase production, which breaks the β-lactam ring of penicillin [13]. Synthetic penicillins (mecillin) were then developed that are resistant to the effects of β-lactamase. Currently, based on antibiotic susceptibility, staphylococcal infections are grouped into two categories – methicillin-sensitive Staphylococcus aureus (MSSA) and methicillin-resistant Staphylococcus aureus (MRSA) [30,31].

Methicillin-resistant Staphylococcus aureus (MRSA) is an isolate of Staphylococcus aureus characterized by antibiotic resistance to penicillins and cephalosporins, including methicillin, oxacillin, and other narrow spectrum β-lactamase resistant penicillin antibiotics [17]. Penicillin binding proteins are necessary for correct synthesis of the bacterial cell wall, and when they are blocked by penicillin, the cell wall is incorrectly formed, and the cell becomes susceptible to lysis. Staphylococcus aureus develops methicillin resistance by acquiring a meca gene [22]. Expression of meca yields a penicillin binding protein (PBP2a) with reduced affinity for β-lactam antibiotic binding [22]. PBP2a allows the bacterium to synthesize the cell wall normally in the presence of methicillin [22].

Since the 1990s, strains of MRSA different from those found in healthcare settings, have been identified as community pathogens. Typically, MRSA has been associated with healthcare acquired (HA-MRSA) risk factors including a recent surgery or hospitalization, an indwelling catheter, kidney dialysis, or a prolonged stay in a long-term care facility [22]. Although MRSA has traditionally been seen as a hospital associated infection, community acquired MRSA (CA-MRSA) strains have been responsible for outbreaks of skin and soft tissue infections amongst children, high school, collegiate, and professional athletes.

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Bibliography

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CA-MRSA infection is often a difficult problem for sports medicine physicians to treat in a timely manner, primarily because early skin infections can mimic CA-MRSA infections such as folliculitis and cellulitis. Improperly treated cases of CA-MRSA can rapidly progress to sepsis with significant morbidity and mortality. Therefore, the purpose of this review article is to provide sports medicine physicians with a comprehensive understanding of CA-MRSA infections — including the requisite knowledge necessary to prevent, correctly identify, and adequately treat MRSA infections.

Epidemiology and case reports

In the United States, 35% of healthy individuals are colonized with MSSA and less than 10% are colonized with MRSA [3, 15, 17, 28]. To put the scope of the problem in perspective, a population review conducted in three communities in the United States showed the annual incidence of CA-MRSA during 2001–2002 to be 25/100,000 [7]. Although MRSA has traditionally been seen as a hospital associated infection, a recent review of CA-MRSA cases has identified skin infections among a variety of athletes from the high school to professional levels including football, wrestling, rugby, fencing, soccer, volleyball, and weight lifting [14]. A total of 55 athletes were infected with CA-MRSA and 16 (29%) required hospitalization for their skin and soft tissue infections [14]. Reported cases ranged from 1–13 athletes per team and involved up to 25% of the team [14]. Kazakova et al. reported an outbreak of CA-MRSA infections that involved 5 of 58 members of the St. Louis Rams professional football team during the 2003 season [13]. All identified infections developed at the site of previous skin injury, and all players had abscesses that required drainage. Risk of infection was associated with a linenman or linebacker position and a higher body mass index. All isolates of CA-MRSA cultured from skin lesions had identical antibiotic susceptibility patterns and contained the gene that encodes Panton-Valentine leukocidin. This isolate was also cultured from an infection in a member of a professional football team that occurred after a game with the St. Louis Rams.

The Center for Disease Control and Prevention (CDC) has reported several clusters of CA-MRSA infections that occurred among athletic teams throughout the United States [8]. In 2003 the Colorado Department of Public Health reported five cases of CA-MRSA infection among members of a fencing club [8]. Three patients required hospitalization and received intravenous antibiotics, of which one patient developed paraspinal myositis with bacteremia and was hospitalized for 11 days. The other two patients reported recurrent infections for which they received antimicrobial therapy and made multiple healthcare visits before a culture was obtained. A contaminated sensor wire shared among athletes during competition was most likely responsible for disease transmission [8].

In 2000, the CDC assisted the Pennsylvania Department of Health with an investigation of an outbreak of MRSA culture-positive skin and soft tissue infections among 10 members of a college football team [6]. Seven of ten infected players required hospitalization for intravenous antibiotics. All culture isolates from the athletes had indistinguishable pulsed field gel electrophoresis patterns, indicating that the outbreak was due to a single strain of CA-MRSA. Several risk factors were identified including, skin trauma, cosmetic shaving, and sharing towels [8]. In a large case report, an outbreak of CA-MRSA skin and soft tissue infections occurred in a college football team in Los Angeles, CA from August to September, 2003 [9, 28]. Eleven players were infected and linemen had the highest attack rate (18%). All MRSA isolates characterized had the community-associated pulsed-field type USA300 [9]. Sharing bars of soap and the presence of preexisting cuts or abrasions were associated with this infection outbreak. This study also demonstrated that having a locker near a teammate with a CA-MRSA skin infection, sharing towels, and living on campus were associated with nasal carriage. Therefore, the highly contagious nature of this organism can lead to clusters of infections among athletic teams that share equipment and space.

Transmission

Transmission of CA-MRSA usually occurs through close contact with a person who has a lesion. Common factors implicated in the development of CA-MRSA include exposure to infection, compromised skin integrity, and transmission via person-to-person or person-to-object contact [4, 8, 12, 14, 28, 30, 37]. Competitive sports participants often develop abrasions or other skin trauma which could provide entry for any number of pathogens. Open wounds and turf burns have been associated with CA-MRSA infections during past outbreaks among football players [9]. In addition, infection appears to be facilitated by interruptions of skin integrity, including those caused by cosmetic body shaving.

Infections also tend to occur most often on extremities that are not covered by athletic apparel (elbow, forearm, knee, lower leg) [2, 15]. However, areas covered by clothing or protective equipment are also at risk following skin trauma after shaving or abrasions [3]. Body shaving has been shown to produce microabrasions and was included as a possible risk factor in a CA-MRSA outbreak among a college football team [3].

Sports that involve frequent, close physical contact among players have reported outbreaks of CA-MRSA infections [8, 14, 30]. The association of a higher incidence of CA-MRSA outbreaks within individuals on specific “positions on a team” provides further evidence for person-to-person spread. For example, an outbreak in rugby players showed a higher incidence amongst those playing as “forwards” [35]. A second report showed that football linemen had a four-fold increase in risk for infection [28]. And, a report among wrestlers detailed teammates passed MRSA to each other during practice, but not to opponents who were exposed only for a three minute match [19], suggesting that the repetitive, close contact predisposes players to infection with CA-MRSA [28].

Athletes involved in sports that involve relatively less skin-to-skin contact are also at risk for CA-MRSA. The use of shared equipment or personal items that are not cleaned or laundered
between users could potentially serve as a vehicle for CA-MRSA infections. Furthermore, protective clothing and equipment can become abrasive and lead to a breakdown in skin integrity. This scenario was suspected in an outbreak involving fencers, suggesting that sharing equipment or personal items may facilitate CA-MRSA transmission [8]. And, in two previous outbreaks, elbow pads were shown to significantly increase the risk of infection by promoting moisture collection with subsequent skin chafing [34].

Recognition

The onset of symptoms, a history of skin trauma, compromised skin integrity, skin lesions, and any exposure to other symptomatic athletes should be noted, as the majority of reported cases affecting athletes involve clusters of infections among teammates [8, 14, 30, 37]. A history of S. aureus infections in the athlete or his/her family or close contacts is also relevant. Skin and soft tissue lesions are the most common sequelae of CA-MRSA infection [2–4, 10, 11, 23, 26, 30–32, 39]. Typically, athletes present with skin lesions or swellings that are painful and erythematous with purulent drainage. CA-MRSA skin lesions may appear in a variety of ways including folliculitis, impetigo, mild to moderate cellulitis, large soft tissue abscesses measuring up to 7 cm in diameter, and can occur simultaneously on different areas of the body [31]. Clinicians should be especially attentive to the fact that CA-MRSA skin lesions can mimic several common skin and soft tissue lesions. The differential diagnosis includes impetigo, folliculitis, furunculosis, cellulitis, contact dermatitis, and herpes gladiatorum. Impetigo, one of the most common bacterial infections of athletes, is characterized by “honey crusted” lesions. Impetigo usually starts as isolated vesicular or pustular lesions and can progress to a bullous form. Folliculitis is inflammation of the superficial portion of hair follicles which usually present as small pustules on an erythematous base. Furuncles occur when an abscess forms in the deeper portion of the hair follicle. Carbuncles form when several inflamed hair follicles coalesce together and present as painful, erythematous, circumscribed masses. The majority of these lesions are usually caused by Streptococcus or Staphylococcus species. Many of these lesions in the early phases of evolution can be indistinguishable from a CA-MRSA soft tissue infection. CA-MRSA infections should be suspected if not responding to antibiotics traditionally effective against gram-positive organisms. In these cases, close follow-up is recommended to ensure resolution. CA-MRSA lesions can also be mistaken for spider bites, which are commonly observed in clinical practice (Fig. 1) [10].

It is critically important to note the presence of systemic signs and symptoms. The presence of constitutional symptoms, including yet not limited to, malaise, fever, chills, regional tender lymphadenopathy, nausea, vomiting, should serve as “red flags” leading to emergent referral to either the emergency department or hospital for intravenous antibiotics, further evaluation, and potential hospitalization. Failure to recognize and expeditiously treat systemic infection can potentially cause severe infections including paraspinal myositis, pneumonia, and sepsis [30].

Diagnosis

When CA-MRSA is suspected by either history, presence of infection in a teammate, clinical appearance, or relevant signs and symptoms, it is important to promptly incise, drain, and obtain a culture of the wound. Certain culture results require additional testing due to inducible resistance. Many CA-MRSA isolates are resistant to erythromycin and are sensitive to clindamycin. In this setting a double-disk diffusion test (D-Test) should be obtained to assess clindamycin efficacy. A positive D-Test suggests an inducible macrolide-lincosamide-streptogramin B resistance (iMLS) due to erythromycin ribosomal methylase genes and subsequent development of clindamycin resistance [33]. These strains of CA-MRSA possess the genetic potential to become resistant to clindamycin during the course of therapy. Siberry et al. found that 51% of adult and 43% of pediatric MRSA isolates possessed iMLS [33].
Treatment

In contrast to HA-MRSA, CA-MRSA is usually susceptible to oral antibiotics. A number of antibiotics are efficacious against CA-MRSA infections. Most CA-MRSA isolates are usually susceptible to trimethoprim-sulfamethoxazole (TMP-SMX), doxycycline, linezolid, clindamycin, daptomycin, gentamicin, quinupristin/dalfopristin, and vancomycin [4]. Rifampin has been used in combination with other antibiotics, yet should never be used alone. First-line empiric treatment of suspected CA-MRSA infections is either TMP-SMX, doxycycline, or clindamycin. Linezolid, a relatively new antibiotic, is effective against CA-MRSA but it should only be used for severe refractory infections to prevent acquisition of resistance. Despite the efficacy of several antibiotics, the gold standard of treatment for CA-MRSA abscesses remains incision, drainage, and treatment driven by culture and sensitivity to antibiotics. Drainage of all suspected lesions should be complete and the wound should not be packed because an abscess can reform behind the packing. Lee and Liera et al. showed significant improvement following incision and drainage, regardless of antibiotic administration [18,20]. However, because of the recent increase in CA-MRSA infections among athletes and the potential for rapid spread and complications, we have adopted a diagnostic and treatment algorithm that has been successful in treating potential CA-MRSA skin infections. Following culture and based on drug allergies, we treat patients with a beta lactam antibiotic. Provided there are no known drug allergies, we treat patients with cephalexin 500 mg every 6 hours. After obtaining the culture and antibiotics sensitivity results, usually within 72 h, we then modify treatment accordingly. If the culture is positive for CA-MRSA then trimethoprim-sulfamethoxazole is given twice a day for 7–10 days. Topical mupirocin is used and the dressing is changed twice a day in order to closely monitor any change in skin characteristics. We also request that our athletes contact us expeditiously with any signs or symptoms of systemic infection that would necessitate blood cultures, intravenous antibiotics after blood cultures, and potential hospitalization. Intravenous antibiotics are usually reserved for systemic symptoms, refractory cases, severe infections, or mild to moderate infections that involve a larger surface area. Length of treatment usually continues for 7–14 days depending on the severity of the infection and response to treatment, as guided by serial blood cultures. For CA-MRSA cases requiring hospitalization and intravenous antibiotics, we also recommend obtaining a consult with an infectious disease specialist. Any suspicious skin lesions can also be referred to a dermatologist for diagnosis and definitive treatment if the sports medicine physician would like a second opinion.

Prevention

The CDC reports the main transmission mode of CA-MRSA is via contact with colonized or infected individuals, devices, or environmental surfaces contaminated with body fluids containing the bacterium [8]. Therefore, primary prevention is pivotal in the management of CA-MRSA infections. The National Athletic Trainers’ Association (NATA) (Table 1) and the CDC (Table 2) have outlined recommendations regarding the primary prevention and management of CA-MRSA infections. Hand hygiene is the single most important method of prevention for transmission of CA-MRSA [8]. Athletes should be encouraged to use liquid antibacterial soap (3% hexachlorophene or 4% chlorhexidine) for hand washing and showers. Sports medicine physicians should wash their hands thoroughly before and after examining every athlete. And, universal precautions should be used when treating suspicious skin lesions. Other proven prevention strategies include vigilant screening for skin lesions, personal hygiene, and wound care as demonstrated in a study at a correctional facility known to have outbreaks of CA-MRSA infections [7]. Results revealed a pre-intervention infection rate of 11.6% and a post-intervention infection rate of 0% [7].

"Prevention by education" is a potent tool in preventing the spread of CA-MRSA. Athletes should also be instructed to report skin lesions or breaks immediately to either the team physician or athletic trainer. Coaches, athletic trainers, and other medical care providers who interact with athletes on a regular basis should be educated on the early signs and symptoms of CA-MRSA infection. All athletes should be advised to shower immediately after practice or athletic events, before using the training room facilities or weight rooms, to prevent the spread of CA-MRSA. They should not share personal hygiene products, including soap and towels. We recommend installing soap dispensers with antibacterial soap in team showers. Towels should be washed with water warmer than 71°F Fahrenheit, using detergent and chlorine bleach after each use [6]. Cosmetic body shaving should be discouraged because of a 6.1% increased risk of developing CA-MRSA infection [3]. And finally, all care providers should be educated on the importance of using universal contact

Table 1 Official recommendations from the National Athletic Trainers’ Association (NATA) regarding CA-MRSA [2].

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<tbody>
<tr>
<td>1. Keep hands clean by washing thoroughly with soap and warm water or using an alcohol-based hand sanitizer routinely.</td>
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<td>2. Encourage immediate showers following activity.</td>
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<td>3. Avoid whirlpools or common tubs with open wounds, scrapes or scratches.</td>
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<td>4. Avoid sharing towels, razors, and daily athletic gear.</td>
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<td>5. Properly wash athletic gear and towels after each use.</td>
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<td>6. Maintain clean facilities and equipment.</td>
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<td>7. Inform or refer to appropriate health care personnel for all active skin lesions and lesions that do not respond to initial therapy.</td>
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<td>8. Administer or seek proper first aid.</td>
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<td>9. Encourage health care personnel to seek bacterial cultures to establish a diagnosis.</td>
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<td>10. Care and cover skin lesions appropriately before participation.</td>
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Table 2 Centers for Disease Control (CDC) recommendations for preventing MRSA among sport participants [1].

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<tr>
<td>1. Cover all wounds. If a wound cannot be covered adequately, consider excluding athlete with potentially infectious skin lesions from practice or competitions until the lesions are healed or can be covered adequately.</td>
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<tr>
<td>2. Encourage good hygiene, including showering and washing with soap after all practices and competitions.</td>
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<td>3. Ensure availability of adequate soap and hot water.</td>
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<tr>
<td>4. Discourage sharing of towels and personal items (for example, clothing or equipment).</td>
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<td>5. Establish routine cleaning schedules for shared equipment.</td>
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<td>6. Train athletes and coaches in first aid for wounds and recognition of wounds that are potentially infected.</td>
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<td>7. Encourage athletes to report skin lesions to coaches and encourage coaches to assess athletes regularly for skin lesions.</td>
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precautions when managing an athlete with a suspected CA-MRSA infection. Wrestling guidelines set forth by the US-based National Collegiate Athletic Association (NCAA) states that athletes with mild to moderate skin infections may return to play 72 h after the initiation of therapy, provided they show clinical improvement as demonstrated by the absence of “new” skin lesions for 48 h [27]. The wound should be completely covered during any sports participation and routinely checked during competition to prevent exposure to other participants. If the lesions cannot be covered because of large size or body location, then the athlete should be excluded from play. The dressing may be removed when the lesion has developed a firm, adherent crust and all signs of infection have resolved [11].

Common areas in athletic environments which may facilitate transmission include training equipment, treatment tables, weight room equipment, and whirlpools. Increased risk of infection has been associated with an increased frequency of sharing the cold whirlpool in the athletics training room [2]. Transmission of MRSA has also been linked to contaminated hydrotherapy equipment and bathtubs in nosocomial outbreaks [38]. And, CA-MRSA cases in non-contact sports have been associated with shared equipment in facilities such as the locker room and the athletic training room [6-9]. Therefore, all equipment in athletic training rooms, including rehabilitative devices, treadmills, stationary bicycles, treatment tables, and whirlpools should be disinfected after each use with solutions that possess anti-viral and anti-microbial qualities.

Research concerning infectivity of whirlpools has documented that staphylococci can persist in whirlpools after the water has been changed between users and after chlorine disinfection [24,36]. To disinfect circulating tubes effectively, an Environmental Protection Agency (EPA) registered disinfectant should be circulated in the spa for 10 min, followed by a rinse with water, and then air-dried [6]. Non-circulating tubes should be scrubbed, rinsed, drained, sprayed with an EPA registered disinfectant, allowed to sit for 10 min, rinsed with water, and then air-dried [6]. Athletes with suspected infections should be prevented from using the cold tanks, spas, and pools until complete healing of skin lesions.

**Eradication**

During outbreaks, applying topical Mupirocin to nares may attenuate the spread of MRSA [25]. However, there is insufficient evidence for the use of either topical or systemic therapy to eradicate CA-MRSA [21]. Furthermore, studies have shown a one year recolonization rate of greater than 50% [29]. Therefore, following CA-MRSA outbreaks on teams, preventing further spread to healthy teammates by treatment of nasal colonization, may be beneficial in decreasing infectivity and transmission only over the course of a short athletic season without significant long-term effectiveness [29].

**Conclusions**

MRSA soft tissue infections can be extremely problematic for sports medicine staff. The purpose of this review article is to help the sports medicine physician to properly identify, treat, and prevent MRSA infections in the athletic environment. The gold standard of treatment for an abscess suspicious for infection with CA-MRSA is incision and drainage, wound culture, and antibiotic treatment guided by sensitivity testing. First-line empiric treatment of suspected CA-MRSA infections is either TMP-SMX, doxycycline, or clindamycin. Intravenous antibiotics should be reserved for moderate to serious cases and should be administered in a controlled setting. Athletes with mild to moderate skin infections may return to play 72 h after the initiation of therapy given clinical improvement with no new skin lesions for 48 h [27]. Length of treatment usually continues for 7–14 days depending on the severity of the infection and the response to treatment. The wound should be completely covered during any sports participation and routinely checked during competition to prevent exposure. The dressing may be removed when the lesion has developed a firm adherent crust and all signs and symptoms of infection have resolved. Proper disinfection techniques should be implemented for the training room equipment and all treatment areas. “Prevention is the best cure” for CA-MRSA transmission. Lastly, all CA-MRSA outbreaks should be reported to the public health department according to local guidelines. The public health department may have information on other outbreaks within the same community or new information on resistance or treatment patterns. Educating sports medicine staff regarding the signs and symptoms, and prevention techniques is critical in controlling the spread of CA-MRSA. More studies are needed on the efficacy of either topical or systemic antibiotics on eradication of the carrier state.

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