Methicillin-resistant *Staphylococcus aureus* and athletes

Eugene Brent Kirkland, BS,[a] and Brian B. Adams, MD, MPH[b,c]
Cleveland and Cincinnati, Ohio

Methicillin-resistant *Staphylococcus aureus* infections have become an increasingly common condition among athletes. Physical contact, shared facilities and equipment, and hygienic practices of athletes all contribute to methicillin-resistant *S aureus* transmission among sports participants. This review elucidates the risk factors predisposing to methicillin-resistant *S aureus* infection in athletes and provides guidance for treatment and prevention. (J Am Acad Dermatol 2008;59:494-502.)

The first reported case of methicillin-resistant *Staphylococcus aureus* (MRSA) in the United States dates back to 1968, only 9 years after the synthesis of methicillin.[1,2] Since that time, MRSA infections have become a source of significant morbidity with sometimes fatal consequences. Costs related to its management continue to increase while the list of effective antibiotics remains relatively stagnant. An infection that investigators once associated with extended stays in the hospital or intensive care department has transitioned into the community. In fact, community-associated MRSA (CA-MRSA) now threatens the young and healthy, especially those involved in athletic activities.[3,4] This review will discuss the evidence regarding the connection between cutaneous CA-MRSA infections and athletes while providing insight into current techniques for combating the organism in this particular population.

Abbreviations used:

CA-MRSA:	community-associated methicillin-resistant *Staphylococcus aureus*
CDC:	Centers for Disease Control and Prevention
HA-MRSA:	hospital-associated methicillin-resistant *Staphylococcus aureus*
IDSA:	Infectious Diseases Society of America
MRSA:	methicillin-resistant *Staphylococcus aureus*
MSSA:	methicillin-sensitive *Staphylococcus aureus*
NCAA:	National Collegiate Athletic Association
RR:	relative risk

WHAT IS CA-MRSA?

CA-MRSA first emerged on the health care stage in the early 1980s.[5] Its growing prevalence since that time, which may represent an evolving epidemic, deserves attention.[6] A recent study of individuals presenting to various university-affiliated emergency departments with skin/soft-tissue infections identified *S aureus* as the causative agent in 76% of cases (320 of 422 patients), with 59% of all infections attributable to MRSA (249 of 422 patients). Further investigation of 218 available MRSA isolates (CA-MRSA plus hospital-associated—MRSA [HA-MRSA]) revealed that CA-MRSA caused 99% of these MRSA infections.[7] Although studies in athletes have not involved such a large group of subjects, reports indicate that MRSA infections have become increasingly common among sports participants. A survey of licensed athletic trainers at various Texas high schools found that approximately 32% of the trainers noted MRSA infections within their respective athletic departments.[8] Because of the large number of individuals affected by MRSA infections, health care providers must maintain a high suspicion for MRSA when confronted with skin/soft-tissue infections.[9] Furthermore, health care providers should realize that these infections can occur in the setting of larger outbreaks, which affect not only athletes but also coaches, staff, and other close contacts.[10]

CA-MRSA possesses many distinguishing characteristics beyond its distinct genetic makeup. Although HA-MRSA typically differs from CA-MRSA by displaying resistance to multiple antibiotics, one reported case of a cutaneous infection in a Japanese

From Case Western Reserve University School of Medicine, Cleveland[a]; Department of Dermatology, University of Cincinnati[b]; and Section of Dermatology, Veterans Affairs Medical Center, Cincinnati.[c]
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Reprint requests: Brian B. Adams, MD, MPH, PO Box 670592, Cincinnati, OH 45267-0592. E-mail: adamsbb@email.uc.edu.
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basketball player involved multidrug-resistant CA-MRSA.[11] A study of 1100 MRSA infections revealed CA-MRSA affects individuals with a median age of 23 years compared with a median age of 68 years for HA-MRSA.[12] Consequently, CA-MRSA more frequently causes infections in younger individuals who often participate in organized athletic activities. Colonization rates differ between CA-MRSA and methicillin-sensitive *S aureus* (MSSA). An estimated 37% of the general population carries *S aureus* (MRSA and MSSA) intranasally and nasal carriage plays a significant role in the pathogenesis of infection.[13] A 2003 meta-analysis indicated that only 1.3% of the general population carries CA-MRSA intranasally in contrast to 5.4% of sports team members or day care contacts of MRSA-colonized individuals.[14,15] Although some authors contend that MRSA carriage poses an increased risk of infection over carriage of MSSA, in vitro analyses and clinical outcome comparisons contest this observation.[13,16,17]

Of CA-MRSA infections, 75% localize to the skin or soft tissue and present with varied morphologies including abscesses, cellulitis, furuncles, carbuncles, folliculitis, impetigo, or paronychia.[2,12,18,19] Other sites of CA-MRSA infection include the respiratory tract, bloodstream, urinary tract, bone, peritoneal fluid, joints, and ears (otitis media/externa).[12] Typically, though, sports-related CA-MRSA appears as an abscess with surrounding cellulitis in an athletic young adult with pain out of proportion to physical examination.[3,20] Less frequently, clinical findings include nonspecific papules, crusted erosions, staphylococcal scalded skin syndrome, and necrotizing fasciitis or myositis.[3,18] Although some authors report the lower extremities as the most common location, studies in athletes have identified diverse patterns of presentation within the different sports settings.[18]

SPORTS-RELATED MRSA INFECTIONS

Football

Reports linking MRSA infections to athletes have focused predominantly on football. As participants in a contact team sport, football players experience a variety of factors predisposing them to infection. Case reports indicate that high-risk sites include areas of compromised skin resulting from athletic injury.[21-23] Artificial turf can exacerbate the extent of skin trauma that commonly occurs in these players in the form of turf burns, but even an athlete's ingrown toenail can lead to MRSA infection.[23,24] Multiple investigations of outbreaks at the high school, collegiate, and professional levels have identified other risk factors for this particular cohort. The resulting data confirm the significance of MRSA infections in athletes and provides guidance for preventive efforts.

One of the most recognized studies of cutaneous infections in professional football involved members of the St Louis Rams. During the 2003 football season, Kazakova et al[23] reported 8 occurrences of MRSA infection among 5 of the 58 Rams players (9%). Although recurrent infections developed in 3 players, no one required hospitalization. All of the lesions presented at noncovered sites where turf burns had occurred. Furthermore, risk factors for infection included a higher body mass index and the lineman or linebacker positions (relative risk [RR] = 10.6). Investigators did not identify any nasal carriage or environmental reservoirs of MRSA (cultures from whirlpool water and a gel-applicator stick used for taping ankles grew MSSA); however, the prior treatment of infected players with antibiotics may have eliminated nasal carriage.[23] The use of antibiotics correlates with the risk of MRSA colonization and subsequent infection; in this case, a significant association did not exist between antibiotic use during the previous year and MRSA infection even though players on the team received an average of 2.6 antimicrobial drug prescriptions per year (a rate 10 times that of the general population of similar sex and age).[18,23] Considering all factors, the authors concluded that frequent antibiotic use, compromised skin barriers, skin contact between players, close proximity of teammates, a contaminated environment (despite negative MRSA cultures), and inadequate hand and personal hygiene by trainers and athletes may have all contributed to the outbreak. In addition, infections found in players from an opposing team suggested that transmission may have occurred during play. The authors noted only one case of MRSA infection after institution of appropriate preventive measures including the use of chlorhexidine-containing soaps, adequate wound care, MRSA-directed antimicrobial therapy, and routine examination for potential skin infections.[23]

In a similar investigation to elucidate risk factors for MRSA infection among athletes, the Connecticut Department of Public Health conducted a retrospective review of 100 college players and identified 13 MRSA infections (9 abscesses and 4 cases of cellulitis) involving 10 team members. The infections caused hospitalization in two players; however, no one on the team carried MRSA intranasally. The most common locations for infection included the elbow (n = 4), followed by the thigh (n = 2), hip (n = 2), chin (n = 1), forearm (n = 1), wrist (n = 1), knee (n = 1), and tibial plateau (n = 1). In addition to the presence of turf burns (RR = 7.2), MRSA infection correlated with the cornerback (RR = 17.5) or wide receiver position (RR = 11.7) and body shaving (RR = 6.1). Four infections occurred at covered sites (hip/thigh) where

Table I. Centers for Disease Control and Prevention—Measures for preventing staphylococcal skin infections among sports participants

1. Cover all wounds. If a wound cannot be covered adequately, consider excluding players with potentially infectious skin lesions from practice or competitions until the lesions are healed or can be covered adequately.
2. Encourage good hygiene, including showering and washing with soap after all practices and competitions.
3. Ensure availability of adequate soap and hot water.
4. Discourage sharing of towels and personal items (eg, clothing or equipment).
5. Establish routine cleaning schedules for shared equipment.
6. Train athletes and coaches in first aid for wounds and recognition of wounds that are potentially infected.
7. Encourage athletes to report skin lesions to coaches to assess athletes regularly for skin lesions.

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players had previously shaved, which could have potentially compromised skin barrier function in a manner similar to turf burns. In addition, whirlpool use greater than or equal to two times per week increased the infection risk (RR = 12.2) in players with covered lesions, indicating that shared facilities may have played a role in transmission for this subgroup.[22]

Other authors have also targeted shared facilities as a likely culprit of transmission. In 2005, a study reported MRSA infections in two high school football players, one of whom required hospitalization. Consistent with other reports, the main risk factor included greater than 10 cuts, abrasions, or turf burns. However, the authors noted that a member of the dance team developed a MRSA infection as well; the only link to football involved the use of a shared weight room where the dance team changed into their uniforms before football games. Thus, fomites in the weight room may have facilitated the spread of MRSA.[25]

Like communal facilities, shared personal items may also contribute to MRSA transmission. The Centers for Disease Control and Prevention (CDC) suggested this particular theory after two separate outbreaks at the collegiate level. One outbreak, involving 10 athletes in Pennsylvania, resulted in the hospitalization of 7 football players. Another incident in Los Angeles, Calif, also resulted in the hospitalization of two football teammates; one of the players required surgical debridement and skin grafts.[26] The reporting health departments recognized the sharing of unwashed bath towels, balms, and lubricants as possible modes of transmission although they failed to discuss the culture results of personal items.[26]

Although several studies have identified potential risk factors and modes of transmission, few studies have examined the effect of preventative hygienic practices. The University of Southern California investigated this particular issue over the course of 3 football seasons (2002-2004) in a study that included the same college players from the two reports published by the CDC and the Los Angeles County Department of Health Services.[20,26,27] During the 2002 season, two players developed MRSA infections and required hospitalization, one of whom needed surgical treatment for necrotizing fasciitis. These infections prompted subsequent interventions including covering wounds, using hexachlorophene 3%, prohibiting multiuse pump lotions or other topical massage products, and educating players and trainers about hygiene and the importance of not sharing equipment, towels, or other personal items. Although no additional infections occurred that season, numerous lesions appeared at the start of the next season despite re-education and prophylactic wound covering. Just 3 weeks into the season, this outbreak led to the adoption of the CDC measures for preventing staphylococcal skin infections among sports participants (Table I). Throughout the 2003 season, a total of 17 players developed MRSA infections (only 11 confirmed with culture) and 6 of these players required hospitalization. In addition, 11 players carrying MRSA nasally received decolonization treatment with intranasal topical mupirocin and oral rifampin. During the 2004 season, the team performed nasal cultures on the first day and the two carriers who remained on the team received decolonization treatment with the same regimen. Investigators identified only one MRSA infection that season indicating the potential benefit associated with broad preventive measures.[20]

Because prevention can fail, clinicians should recognize potential treatment options for these athletes. Authors from one study described their experience with therapy in 13 players from a high school team who experienced 21 lesions of cutaneous MRSA infection (11 confirmed by culture). The most common locations for infection included the arm/elbow/forearm (n = 11) followed by knee/leg (n = 5), face (n = 3), neck (n = 1), and abdomen (n = 1); one player experienced two lesions simultaneously, 5 players experienced two episodes of infection, and one player experienced 3 episodes of infection whereas 6 players each developed only

one lesion. Four players required hospitalization; only one of these hospitalizations resulted from failure to respond to beta-lactam antibiotics. Physicians treated 18 of the 21 lesions with incision and drainage. In addition, 5 players received culture-directed antibiotics, 7 players received cephalexin or amoxicillin/clavulanate, and one player received clindamycin.[28] Although 7 of the 8 lesions incorrectly treated with beta-lactams healed, CA-MRSA infections sometimes respond to incision and drainage alone.[3,28] Nevertheless, those players who received empiric treatment (without culture-directed therapy) had a 33-fold increased risk of developing recurrent infection when compared with players who received culture-guided treatment. The success of culture-guided therapy in this case underscores the importance of selecting appropriate antibiotics. Physicians prescribed intranasal mupirocin for the whole team including the 3 MRSA carriers; however, the authors recognized this therapy as ineffective because MRSA infections subsequently appeared among team members. Players did not use the mupirocin simultaneously and only 36% of players complied with the treatment, which may have contributed to the lack of observed effect. The authors failed to comment on the amount of time between treatment with mupirocin and the appearance of subsequent infections.[28]

Rugby

Like football, rugby involves intense physical contact; however, different risk factors for acquiring MRSA infection exist. The limited use of padded equipment in rugby creates potential for more skin-to-skin contact but also reduces the risks associated with abrasive, shared, or unclean equipment. In a United Kingdom report, 5 members of a rugby team developed large abscesses on the upper aspects of their arms, back, neck, and face. Only one of the 5 players carried MRSA intranasally and investigators did not isolate the organism from any petroleum jelly containers shared among teammates. To combat the outbreak, infected players refrained from participating in subsequent matches and training sessions until they were "deemed fit to resume," stopped sharing lubricants, and used disinfected training equipment. Because infections developed only in forward players, the outbreak probably resulted from sustained physical contact rather than transmission via communal facilities or equipment.[29]

Wrestling

Wrestlers, who often engage in prolonged physical contact and experience frequent mat burns, have also experienced MRSA infections.[30] The Texas Department of Health noted a total of 6 infections involving wrestlers in a statewide survey of high school athletic trainers. The infection rate for wrestlers (0.3%) was slightly below the infection rate for football players (0.4%).[8] In a more detailed report, the Indiana Department of Health identified two high school wrestlers neither of whom required hospitalization. The two affected teammates had never wrestled each other because they competed in separate weight classes. Consequently, transmission may have occurred through the use of shared items instead of close physical contact.[26] Nevertheless, the level of person-to-person contact in this sport remains a potentially significant mode of transmission.

In a separate study, Lindenmayer et al[30] investigated a 32-member high school wrestling team and found 6 MRSA infections (one of which resulted in hospitalization). Two teammates carried MRSA nasally including one person who also developed a cutaneous lesion. The wrestlers noticed infections on their forearm (n = 2), calf (n = 2), knee (n = 1), and lower aspect of leg (n = 1); however, investigators found no infections among competing teams. In addition, 11 nonwrestlers connected with the high school or wrestling team in various ways developed infections. Environmental cultures remained negative and the authors did not identify any pertinent risk factors. To prevent new infections, the team implemented control measures including banning affected wrestlers from practice/competition and encouraging better hygienic practices through the use of bactericidal soap and routine cleaning of wrestling mats. No carriers or infections appeared in the following wrestling season, suggesting that the preventive guidelines had a favorable effect.[30]

To better understand the extent of MRSA infections, some authors have also discussed complications pertaining to this particular group of athletes. One report identified a case of MRSA infective endocarditis in a collegiate wrestler. Although the wrestler did not present with any cutaneous findings, he did admit to wrestling with uncovered wounds. Evidence did not conclusively link contaminated wrestling surfaces with the patient's resulting infection; however, the authors still stressed the need for proper hygiene and wound care among wrestlers along with the routine cleaning of mats and other potentially contaminated equipment.[31]

Fencing

Not all reports of MRSA have occurred in association with contact sports. In 2003, the CDC identified an outbreak of 5 MRSA infections among fencers and their household contacts. The investigators confirmed 3 cases of these infections through culture and suspected two others based on the fact that the

infections appeared during the course of the outbreak. One of the infections involved a household contact rather than a fencer. Three of the 5 patients required hospitalization and two of the 5 patients experienced recurrent infections. Clinical presentations varied among patients ranging from abscesses to paraspinal myositis with bacteremia; athletes with abscesses developed lesions on the legs/thighs (n = 4), abdomen (n = 3), axilla (n = 1), hand (n = 1), buttock (n = 1), and behind the knee (n = 1). A survey found that fencing club members regularly shared an unsterilized fencing sensor wire worn under their clothes. Furthermore, the fencers frequently experienced skin rashes beneath protective clothing because of its abrasive nature. Team members frequently shared equipment; however, the affected individuals denied sharing any equipment among themselves.[26] Because fencing rarely involves direct skin-to-skin contact, fencers may acquire MRSA through fomites.

Cross-country

Another noncontact sport affected by MRSA is cross-country. The Texas Department of Health recently identified 7 cases of MRSA infection from a total of 5088 high school runners. Three schools had solitary incidents whereas one school experienced an outbreak involving 4 team members. The lack of direct contact associated with this sport might make the sharing of equipment and personal items the more likely cause of transmission even though no direct evidence presented in the report supports this conclusion. Furthermore, 5 of the 7 cases (including the 4-person outbreak from one school) occurred at schools that also experienced outbreaks in other sports, indicating that social or classroom contacts may have played a role in transmission.[8] Although the relative paucity of infections in nonathletes fails to support this conclusion, limited evidence exists because licensed athletic trainers reported only on team members, team managers, student athletic trainers, coaches, and themselves.

Volleyball

Similar to cross-country runners, the role of direct skin contact remains unclear in the transmission of MRSA infection among volleyball players. The Texas Department of Health reported 17 MRSA infections in a survey that involved 7053 fall high school volleyball players. The survey, which focused only on fall sports, noted that 12 of the 17 MRSA infections occurred at only 3 schools; of interest, these 3 schools also had concomitant football epidemics. Because women's volleyball teams compete in the gym (fall sports do not include men's volleyball) and men's football teams compete outside, shared athletic facilities and personal items were probably not responsible for transmission between the different sports teams. Therefore, as with the cases demonstrated by the cross-country teams, classroom and social contact among students may have contributed to MRSA infections.[8]

Two other cases of MRSA infection associated with volleyball exist. The two women played on the same team, so transmission between them could have occurred secondary to incidental skin-to-skin contact, cutaneous injury from frictional contact of the players' skin with the wooden court, or sharing of other personal items. The sites of infection included the back aspect of the thigh in one player and the buttock and chin in another.[24] Both players originally thought their lesions resulted from an insect or spider bite; Moran et al[7] found a significant association between individuals believing they had been bitten by a spider and isolation of MRSA from a cutaneous lesion compared with isolation of other types of bacteria (odds ratio = 3.0).[24]

Weight lifting

Just one published report links MRSA infection to weight lifters. In the report, 3 weight lifters developed MRSA infections that involved or bordered the axilla. Because all 3 individuals belonged to the same recreational facility, their use of shared contaminated gym equipment could have caused the infections. Two of the male weight lifters had isolates resistant to fluoroquinolones and one of these individuals experienced recurrence of his skin infection after initial treatment with empiric beta-lactam antibiotics. All weight lifters cleared after incision and drainage, sensitivity-directed antibiotic therapy, topical mupirocin, and cleansing with an antibacterial agent (povidone-iodine or chlorhexidine).[24]

Basketball

Only two cases of MRSA infection in basketball players exist in the literature. One case involved a collegiate player with concurrent presence of group B beta-hemolytic *Streptococcus*. This player's infection localized to the anterolateral aspect of the thigh, buttock, and labia majora and received definitive therapy for MRSA infection at the initial visit; her condition improved without any recurrence of infection.[24] In a separate report, one Japanese basketball player developed a multidrug-resistant MRSA infection; the authors did not identify any risk factors or helpful interventions.[11]

Soccer

MRSA infection also may occur in soccer players. In one report conducted from October 2005 to

January 2006, investigators identified MRSA infections in 9 of 35 (26%) players on a Dutch soccer team. Lesions localized to the leg (n = 3), knee (n = 1), heel (n = 1), buttock (n = 1), arm (n = 1), and forearm (n = 1); the authors did not report the lesion site of one of the soccer players. Six of these players (17%) carried MRSA intranasally. Screening of an additional 21 people in close contact with the team identified two other MRSA infections in roommates of the soccer players. These lesions localized to the face (n = 1) and axilla (n = 1). The roommate with the axillary infection did not live with an infected soccer player. In November 2005, investigators also identified a MRSA infection on the leg of a player from an opposing team. His infection developed 1 month after competing against the Dutch soccer team. Subsequent screening of all members of the opposing team revealed no other MRSA infections. All of the Dutch soccer players received treatment with trimethoprim-sulfamethoxazole; however, 4 players experienced recurrent infection after initial therapy. To prevent MRSA transmission, team officials encouraged better hygiene practices including washing hands, using disposable towels, sitting on a towel while on the bench, increasing locker room and shower ventilation, and cleaning facilities regularly. The authors concluded that transmission may have occurred through shared equipment or personal items in addition to skin-to-skin contact.[32]

PREVENTION/TREATMENT

It appears that the primary mode of MRSA transmission involves person-to-person contact; however, the significance of this risk factor varies among different sports. Therefore, athletes may benefit from taking broad preventive measures (Table I). Some authors have concluded that following the CDC guidelines listed in Table I reduces the risk of cutaneous MRSA infection.[20] In addition to the methods detailed in Table I, disposable paper towels, alcohol-based hand sanitizers, and appropriate water temperatures for laundering purposes (at least 140°F) augment established hygienic practices.[20,26] The National Collegiate Athletic Association (NCAA) also recommends keeping nail tips less than 0.25 inches in length and removing jewelry to prevent scratches.[33] Because the degree of contamination remains the most significant factor regarding fomite transmission of staphylococci, teams should also use alcohol-based sanitizers containing chlorhexidine or triclosan to sterilize wrestling mats and other shared equipment on a routine basis.[3,34] Although MRSA exhibits low levels of resistance to chlorhexidine, triclosan, and other quaternary ammonium compounds such as benzalkonium chloride, all of these agents kill MRSA effectively.[35] Alcohol displays significant bactericidal activity alone, and the addition of alcohol to chlorhexidine preparations potentiates its bactericidal effects.[3,36,37] The NCAA medical guidelines do not endorse one particular disinfectant; however, they do suggest the use of intermediate- or low-level disinfectants. Low-level disinfectants such as the quaternary ammonium compounds can inactivate most bacteria, some viruses, and some fungi. Intermediate-level disinfectants such as a 1:10 dilution of bleach possess the added ability to inactivate *Mycobacterium tuberculosis*. With regard to sterilizing fomites, the NCAA medical guidelines recommend both cleaning and disinfecting wrestling mats before use and laundering mops, towels, and athletic gear daily.[33,38]

In an attempt to create comprehensive standards to prevent transmission, the NCAA has developed regulations in certain sports such as wrestling regarding the banning of infected players from competition. Wrestlers must remain free of new lesions for 48 hours, complete at least 72 hours of antibiotic therapy, and remain free of moist, draining, or exudative lesions before competition. In addition, questionable lesions require Gram stain. The NCAA goes one step further than the CDC by stating that wrestlers cannot cover active bacterial infections to participate.[39] Although these recommendations provide guidance, they lack appropriate evidence-based support. Furthermore, other sports lack similar guidelines.

Regarding the role of nasal carriage, most reports found few or no MRSA-positive nasal cultures. Individuals with positive nasal cultures may only carry the organism transiently although persistent carriers do exist.[16] Some authors argue against surveillance cultures as a means of establishing risk for infection, citing a lack of published data supporting surveillance cultures and the questionable effects of decolonization.[2,20] Nasal decolonization remains a controversial issue considering that it may not prevent disease and can possibly lead to drug resistance.[2] Although not indicated in an endemic setting, nasal eradication may control outbreaks along with the use of other infection control measures; however, demonstrating the true effect of nasal decolonization among sports teams requires more studies.[13,23] The regimen for decolonization involves intranasal application of topical mupirocin twice daily for 5 days.[16] Concomitant use of povidone-iodine soap or 4% chlorhexidine gluconate helps eliminate nasal carriage and treat infections.[18] The authors of one study advocate the use of 4% chlorhexidine over 3% hexachlorophene, citing toxicity, cost, and induction of resistance associated

Table II. Antimicrobials for cutaneous methicillin-resistant *Staphylococcus aureus* infection[2,40]

Oral therapy	Adult dose
Clindamycin	300-450 mg 3 times daily
Doxycycline	100 mg twice daily
Minocycline	100 mg twice daily
Trimethoprim-sulfamethoxazole	1-2 double-strength tablets twice daily
Linezolid	600 mg twice daily
Rifampin	600 mg once daily (do not use alone)
Intravenous therapy	**Adult dose**
Clindamycin	600 mg/kg every 8 h
Daptomycin	4 mg/kg every 24 h
Linezolid	600 mg every 12 h
Quinupristin-dalfopristin	7.5 mg/kg every 8-12 h
Vancomycin	30 mg/kg every 24 hours in two divided doses

with long-term hexachlorophene use. The intermittent use of either soap can control MRSA infections although the degree to which the use of these soaps prevents MRSA infection has not been studied.[20] Rifampin remains effective for decolonization purposes, but the rapid development of resistance limits its use.[2,16]

Incision and drainage represents the definitive treatment for cutaneous MRSA infection.[3] Although the Infectious Diseases Society of America (IDSA) guidelines state that physicians can treat minor skin/soft-tissue infections empirically with beta-lactams, clinicians should expect resistance to beta-lactams when they suspect MRSA as the causative agent.[2,40] Tetracyclines, quinolones, trimethoprim-sulfamethoxazole, rifampin, and clindamycin usually remain effective against MRSA infection.[2] Dosages for antibiotics commonly used for cutaneous MRSA infections, including those recommended by the IDSA, appear in Table II.[41] Naimi et al[12] demonstrated that most CA-MRSA infections (96%) retain susceptibility to trimethoprim-sulfamethoxazole, which often costs less than other antibiotics.[3] Combination of rifampin with other antibiotics such as doxycycline or trimethoprim-sulfamethoxazole prevents the emergence of resistance to rifampin. Similarly, quinolones typically provide adequate coverage but the rapid appearance of resistance precludes their use.[2]

Laboratories should test for inducible resistance to clindamycin using the erythromycin-clindamycin D-zone test if resistance to erythromycin exists.[3,21] This test involves placing clindamycin and erythromycin disks in close proximity on a culture plate. In a positive test, the zone of inhibition around the clindamycin disk resembles the letter "D" rather than assuming a circular shape. This shape occurs because the area of overlap between the two zones of inhibition represents a region of inducible clindamycin resistance where both clindamycin- and erythromycin-resistant bacteria can grow. In vivo, a person's treatment regimen does not necessarily need to include erythromycin for inducible resistance to clindamycin to occur.[3] In addition to ensuring appropriate antibiotic-susceptibility testing, clinicians must remember that cellulitis can result from other organisms such as group A streptococcus, which carries resistance to trimethoprim-sulfamethoxazole. In such cases, alternatives include the use of clindamycin or a combination of a beta-lactam plus trimethoprim-sulfamethoxazole.[7] Severe infections often require hospitalization and treatment with vancomycin, linezolid, quinupristin-dalfopristin, tigecycline, teicoplanin, meropenem, panipenem, ertapenem, ceftobiprol, or daptomycin.[2,3,7,18] According to IDSA guidelines, patients may require hospitalization if they have decreased blood pressure, elevated creatinine levels, elevated creatine phosphokinase (2-3 times normal limits), decreased serum bicarbonate, multiple neutrophilic band forms in the bloodstream, or an elevated C-reactive protein (>13 mg/L).[40]

CONCLUSIONS

Most of the evidence linking MRSA to athletes comes from scattered case reports. The level of skin-to-skin contact in football players, who comprise the largest group of affected athletes in the literature, suggests that direct contact contributes significantly to transmission. Other risk factors associated with MRSA infection in athletes include player position, shared facilities and equipment, and compromised skin barriers. Investigators have not yet identified risk factors for athletes in sports other than football, and no literature exists linking cutaneous MRSA infections to athletes in many popular sports such as swimming or surfing. Authors have mentioned baseball, softball, and canoeing in association with cutaneous MRSA infections, but, supporting evidence remains scant.[4,27,41] Nonetheless, clinicians must maintain a heightened awareness for MRSA infection in athletes presenting with skin/soft-tissue infection. Furthermore, clinicians should consider obtaining cultures in such cases so that they can tailor the therapy in an appropriate manner. Athletes may require nasal culture and decolonization with topical mupirocin to limit transmission and the appearance of new infections in the setting of an outbreak. Other helpful measures include improving

player/trainer hygiene, covering all wounds, increasing awareness and surveillance for infections, educating team members about techniques for limiting MRSA transmission, and ensuring that fomites are routinely cleaned. The role of direct contact in transmission suggests that inadequate hygiene practices warrant player exclusion from practice or competition; players who cannot keep wounds covered or do not comply with proper hygiene practices should not return to practice or competition. Coaches should also prevent athletes with open wounds from using whirlpools.[15] With regard to keeping facilities clean, clinicians should recommend regular disinfecting practices with greater emphasis on the frequency of cleaning when known infection exists, particularly before practice or competition.

Overall, MRSA plays a major role in the sports realm because of the multiple risk factors present among athletes. MRSA infections result in considerable loss of time for training and competition. Although future scientific developments in the realm of antibiotics may provide some relief, keeping infections at a minimum requires implementation of preventative measures. Ultimately, clinicians must take a comprehensive approach toward controlling infections in athletes.

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