# PREVALENCE OF METHICILLIN RESISTANT STAPHYLOCOCCUS AUREUS IN UPPER EXTREMITY SOFT TISSUE INFECTIONS AT JACKSON MEMORIAL HOSPITAL, MIAMI-DADE COUNTY, FLORIDA

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## ABSTRACT

**Purpose**

**Methicillin resistant *Staphylococcus aureus* (MRSA) has been a hospital based problem since first being reported in the 1960s. Recent increases in outpatient MRSA infections suggest that there may be increased incidence of MRSA in upper extremity soft tissue infections (UESTIs). The aim of this study is to describe the current microbial flora responsible for UESTIs at an urban, tertiary care, teaching hospital.**

**Methods**

**A retrospective chart review was performed of all orthopaedic consultations for UESTIs from June 2006 to December 2007. The only exclusion criterion was a diagnosis of osteomyelitis. Logistic regression was used to describe the association between demographic and clinical characteristics identified on univariate analysis, and a MRSA positive culture. Odds ratios and confidence intervals are reported.**

**Results**

**There were 432 orthopaedic consultations for UESTIs. Twelve cases of osteomyelitis were excluded per protocol. Therefore, 420 patients comprised our study population, ranging in age from 4 months to 95 years, (mean: 40 years), with 327 (77.9%) men and 93 (22.1%) women.**

**Wound cultures were available in 335 of 420 patients (79.8%). Positive cultures were found in 292 patients with a 53.4% MRSA rate (156 of 292). Methicillin sensitive *Staphylococcus aureus* was the second most prevalent microbe, found in 73 of 292 patients (25.0%). All MRSA isolates were susceptible to gentamicin and linezolid, and 98% or more were sensitive to vancomycin, rifampin, and trimethoprim-sulfamethoxazole combination. Univariate analyses and logistic regression identified infection location proximal to the wrist (Odds Ratio = 1.81, 95% Confidence Interval = 1.06-3.09, $p<0.03$) and diagnosis of abscess or felon (Odds Ratio = 3.22, 95% Confidence Interval = 1.84-5.63, $p<0.001$) as significantly associated with a MRSA positive culture.**

**Conclusions**

**This is the largest study examining the prevalence of microbial flora in UESTIs. We found that MRSA has become the most common microbe in UESTIs comprising 53.4%, consistent with current trends at other urban medical centers.**

## INTRODUCTION

Methicillin resistant *Staphylococcus aureus* (MRSA) was first reported in the 1960s soon after the introduction of methicillin.[1] It remained a hospital based problem for decades. Since 2000, several reports have documented the presence of MRSA infections in previously unaffected outpatient populations. In 2007, Daum[2] reported that more than 10% of *Staphylococcus aureus* strains found in the community were MRSA. Recently, affected populations include children,[3] sports participants,[4] incarcerated persons,[5] and military recruits undergoing training.[6] Recent studies have also demonstrated an

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increasing prevalence of MRSA in various communities as a whole, with particular focus in the inner cities.[7-9] A meta-analysis by Salgado et al. in 2003 showed a community acquired MRSA infection rate among hospitalized patients of 30.2% in 27 retrospective studies and 37.3% in 5 prospective studies, and a community wide MRSA infection rate among non-hospitalized patients of 1.3%.[10]

This community acquired MRSA is distinct from hospital acquired MRSA in that it is often susceptible to antibiotics such as clindamycin and sulfonamides, whereas hospital acquired MRSA is typically resistant to these antibiotics. There is, however, an ever-blurring line in the behavior of community acquired versus hospital acquired MRSA.[11] USA 300 has been identified as the most common form of community acquired MRSA.[7,8] This strain of MRSA has also been noted to contain various virulence factors including Panton-Valentine leukocidin, which allows for necrosis of soft tissue.[12,13] The change in susceptibility patterns of the microbial flora in communities served by hospitals across the country has changed the empiric antibiotics initially chosen to treat common soft tissue infections.

The aim of this study is to describe the current microbial flora responsible for community acquired upper extremity soft tissue infections seen at a large, urban teaching hospital, examining the prevalence of MRSA in these infections. Our data will help increase awareness amongst healthcare providers of current microbial trends in upper extremity soft tissue infections. This is especially important for early identification and intervention when MRSA presents as a localized soft tissue infection,[7] as it can progress to systemic infection, i.e., pneumonia[14] or necrotizing fasciitis.[15]

## METHODS

A retrospective chart review of all orthopaedic consultations for upper extremity soft tissue infections (UESTIs) at Jackson Memorial Hospital (JMH) consecutively from June 29, 2006 to December 31, 2007 was performed. JMH is a large, 1550 bed, urban, tertiary care, teaching hospital serving Miami-Dade County, Florida. All consultations for upper extremity soft tissue infections at JMH are handled by the orthopaedics service. Institutional Review Board approval was obtained for this study. Patients with presence of osteomyelitis were excluded from this study. Demographic and history of present illness data was collected on each patient. Demographically, age, gender and hand dominance were recorded. Information on history of present illness included the following parameters: location of infection, injury diagnosis, bacterial culture, anti-microbial sensitivity, white blood cell count (WBC), sedimentation rate (ESR), C-reactive protein levels (CRP), admission to hospital, length of stay in hospital, number of operating room visits, and number of incisions and debridements.

Logistic regression was performed to identify if any of the variables identified on univariate analysis with a p value less than or equal to 0.05, were significantly associated with a MRSA positive culture. Odds ratios with 95% confidence intervals are reported. Variables examined in univariate analysis included age, gender, infection location, diagnosis, WBC, CRP, and ESR.

## RESULTS

In the period from June 29, 2006 to December 31, 2007 (552 days), a total of 432 orthopaedic consultations for upper extremity soft tissue infections were performed. There were twelve cases of osteomyelitis that were excluded per protocol from the study. Therefore, 420 patients comprised the study population.

77.9% (327 patients) of the infected patients were men, and 22.1% (93 patients) were women (see Table 1). The ages of patients ranged from four months to ninety-five years of age, with the average age being forty years old.

**TABLE 1**
**Subject Demographics**

| Subject Characteristic | N (%) |
|---|---|
| **Age (years)** | |
| 0-18 | 20 (4.8) |
| 19-44 | 246 (58.6) |
| 45-64 | 135 (32.1) |
| 65-79 | 16 (3.8) |
| > 80 | 3 (0.7) |
| **Gender** | |
| Male | 327 (77.9) |
| Female | 93 (22.1) |
| **Dominant Upper Extremity** | |
| Right | 268 (89.6) |
| Left | 31 (10.4) |
| **WBC Count** | |
| < 10 | 171 (42.5) |
| < 15 | 165 (41.0) |
| < 20 | 53 (13.2) |
| 20 + | 13 (3.2) |
| **C-Reactive Protein (CRP)** | (Median=3.1) |
| < 1 | 78 (21.7) |
| 1-3 | 96 (26.7) |
| 3-10 | 160 (44.6) |
| > 10 | 25 (7.0) |
| **Sedimentation Rate (ESR)** | (Median=25) |
| < 20 | 141 (41.3) |
| 20-35 | 81 (23.8) |
| 35-75 | 88 (25.8) |
| > 75 | 31 (9.1) |

The distribution of ages was 4.7% (20 patients) between 0-18 years old, 58.2% (246 patients) 19-44 years old, 31.9% (135 patients) 45-64 years old, 3.8% (16 patients) 65-79 years old, and 0.7% (3 patients) 80-95 years old. None of our population was 96 years or older (see Table 1).

Injuries occurred in the dominant upper extremity in 58.9% (175 patients) of cases (see Table 2). The finger was the most common site of infection at 50.2% (210 patients). The second most prevalent site of infection was the in hand with 23.2% (97 patients). Other common sites for infection of the upper extremity included the forearm and the elbow (see Table 2). There was one case involving multiple sites including both the hand and the forearm.

The diagnosis of abscess was most common, found in 256 patients (61.0%). Cellulitis was the second most common diagnosis, present in 53 patients (12.6%). A felon, defined as an abscess of the distal finger pulp, was found in 21 patients (6.4%) (see Table 2).

**TABLE 2**
**Injury Characteristics**

| Characteristic | N (%) |
|---|---|
| **Injured Extremity** | |
| Dominant | 175 (58.9) |
| Non-Dominant | 122 (41.1) |
| **Location** | |
| Finger | 210 (50.2) |
| Multiple Fingers | 6 (1.4) |
| Hand | 97 (23.2) |
| Wrist | 14 (3.4) |
| Forearm | 49 (11.7) |
| Elbow | 31 (7.4) |
| Arm | 5 (1.2) |
| Shoulder | 5 (1.2) |
| Hand and Forearm | 1 (.2) |
| **Diagnosis** | |
| Abscess | 256 (61.0) |
| Cellulitis | 53 (12.6) |
| Felon | 27 (6.4) |
| Fight Bite | 21 (5.0) |
| Paronychia | 16 (3.8) |
| Flexor Tenosynovitis | 14 (3.3) |
| Septic Bursitis | 10 (2.4) |
| Postoperative Infection | 8 (1.9) |
| Septic Arthritis | 7 (1.7) |
| Animal Bite | 6 (1.4) |
| Other | 2 (0.5) |
| **Culture** | |
| Positive Culture | 292 (69.5) |
| Negative Culture | 43 (10.2) |
| No Culture | 85 (20.2) |

Wound culture results were available in 335 of 420 patients (79.8%). 43 (12.7%) cultures were negative (see Table 2). Of all patients, methicillin resistant *Staphylococcus aureus* was found in 37.1%. Of positive cultures, methicillin resistant *Staphylococcus aureus* was found in 156 of 292 cultures (53.4%). The second largest group, at 25.0% (73 patients), had cultures that were positive for methicillin sensitive *Staphylococcus aureus* (MSSA). A third group (17 patients, 5.8%) was found to have a positive culture for coagulase negative *Staphylococcus aureus*. There were 27 patients (9.2%) with cultures positive for Alpha Hemolytic *Streptococcus* and 33 patients (11.3%) found to have positive cultures for Beta Hemolytic *Streptococcus*. One patient was found to have vancomycin resistant enterococcus. 48 patients had positive cultures for more than one bacterial species (see Table 3).

All of the MRSA isolates were sensitive to gentamicin and linezolid. 99.4% of isolates were susceptible to vancomycin and rifampin, and 98.0% of isolates were sensitive to trimethoprim-sulfamethoxazole combination. Clindamycin and tetracycline also had high MRSA sensitivity (90.8% & 89.8% respectively), but only 7.8% of isolates were sensitive to erythromycin, implying there is potential to develop resistance to clindamycin if exposed to erythromycin. All MRSA isolates were resistant to penicillin, augmentin, imipenem, oxazolidone, and cephalosporins such as cefaclor, cefazolin, and cefuroxime, and 92.2% were resistant to erythromycin (see Table 4).

**TABLE 3**
**Microbial Prevalence in Patients with a Positive Culture***

| Microbe | N (%) |
|---|---|
| *Staphylococcus aureus* | |
| Methicillin Resistant | 156 (53.4) |
| Methicillin Sensitive | 73 (25.0) |
| Coagulase Negative | 17 (5.8) |
| Epidermidis | 1 (0.3) |
| Not Otherwise Specified | 1 (0.3) |
| *Streptococcus* | |
| Alpha Hemolytic | 27 (9.2) |
| Beta Hemolytic | 33 (11.3) |
| *Corynebacterium* | 11 (3.8) |
| *Enterobacter* | 5 (1.7) |
| *Eikenella* | 4 (1.4) |
| *Enterococcus* | 4 (1.4) |
| *Klebsiella* | 3 (1.0) |
| *Proteus Mirabilis* | 3 (1.0) |
| *Other* | 15 (5.1) |

*48 Subjects had positive cultures for more than one species of bacteria

198 patients (47.1%) were admitted to the hospital for treatment. Of those admitted, all but 27 patients (13.6%) underwent at least one incision and debridement in the emergency room or the operating room. Of the 222 patients not admitted, 186 (84.9%) underwent incision and debridement in the emergency room (see Table 5). The number of days spent in the hospital was recorded for 197 of the 198 admitted patients. Hospital stays ranged from one to 34 days, with a median of five days and an interquartile range of four to seven days.

Univariate analyses identified both infection location and diagnosis as associated with a MRSA positive culture. Logistic regression was performed using both variables. Infections located proximal to the wrist were significantly associated with a MRSA positive culture (Odds Ratio = 1.81, 95% Confidence Interval = 1.06-3.09, p = 0.03). A diagnosis of abscess or felon (abscess of the finger nail pulp) was also significantly associated with a MRSA positive culture (Odds Ratio = 3.22, 95% Confidence Interval = 1.84-5.63, p<0.001).

## DISCUSSION

Our study showed that the rate of methicillin resistant *Staphylococcus aureus* infections in upper extremity soft tissue infections was 53.4% (156 patients) in patients who underwent culture. Our study is the largest of its kind, with a patient population over eight times greater than previous studies examining the prevalence of microbial flora in soft tissue infections of the upper extremity. Our study is consistent with the findings of multiple studies across the country examining the prevalence of MRSA in both rural and urban settings. Of particular comparative importance are studies examining similar inner city populations.

Our study's results most closely compare to those of Bach et al in 2007 who reported data on 52 patients from Chicago's Cook County Hospital with a 73% (38 patients) predominance of MRSA infections in the hand.[9] King et al. in 2006 reported 389 patients from Atlanta's Grady Memorial Hospital which showed that community acquired MRSA was the predominant *Staphylococcus aureus* (63%) responsible for generalized skin and soft tissue infections.[7] King et al. had a similar inner city population to our own primarily inner city study population. Moran et al in 2006 reported data from 11 different emergency departments which similarly demonstrated 59% of isolates were MRSA.[8] Interestingly, a study out of the same institution as Bach et al. by Weinzweig in 2002 looked at data from 1992-1995 as opposed to 2005, where only 16.2% of *Staphylococcus aureus* infections were methicillin resistant.[16] Thus, a dramatic shift in the microbial flora of soft tissue infections has occurred recently in the United States. Popovich et al. in 2008 reported data from 2000-2006 in Chicago's Stroger Hospital/Rush University Medical Center that showed a stable rate of hospital acquired strains of MRSA infections, but a rapidly increasing rate of community acquired strains of MRSA seen in the hospital from 24% between January 2000 and June 2003 to 49% between July 2003 and December 2006.[11] While rates may differ slightly in a city to city basis, our study and other similar studies indicate that there is an increasing trend of the prevalence of community acquired MRSA infections.

The strength of this study is the large sample size at 420 patients seen by the orthopaedic service for upper extremity infection consultation in a 552 day period

**TABLE 4**
**Antimicrobial Agent Susceptibility of 156 MRSA Positive Cultures**

| Antimicrobial Agent | Susceptible/Tested (%) |
|---|---|
| Augmentin | 0/155 (0.0) |
| Cefaclor | 0/152 (0.0) |
| Cefazolin | 0/151 (0.0) |
| Cefuroxime | 0/151 (0.0) |
| Clindamycin | 138/152 (90.8) |
| Erythromycin | 12/155 (7.8) |
| Gentamicin | 155/155 (100.0) |
| Imipenem | 0/152 (0.0) |
| Linezolid | 151/151 (100.0) |
| Oxazolidone | 0/156 (0.0) |
| Penicillin | 0/154 (0.0) |
| Rifampin | 151/152 (99.4) |
| Tetracycline | 140/156 (89.8) |
| Trimethoprim-Sulfamethoxazole Combination | 150/153 (98.0) |
| Vancomycin | 155/156 (99.4) |

**TABLE 5**
**Subject Management**

| Management | N (%) |
|---|---|
| **Admitted** | **198 (47.1)** |
| Emergency Room Incision and Debridement | 88 (44.4) |
| Operating Room Incision and Debridement | 64 (32.3) |
| OR and ER Incision and Debridement | 19 (9.6) |
| No Incision and Debridement | 27 (13.6) |
| **Not Admitted** | **222* (52.9)** |
| Emergency Room Incision and Debridement | 186 (84.9) |
| No Incision and Debridement | 33 (15.1) |

*For 3 subjects not admitted, no data was obtained regarding incision and debridement.

from June 29, 2006 to December 31, 2007. Based on being at a large, county teaching hospital in an urban setting, patients were able to be seen in the hospital and emergency department regardless of insurance status, which is an on-going barrier to care in many institutions. The markedly larger study population at 420 patients far exceeds that of the next largest study by Bach et al. whose study population comprised of 52 patients.[9] The increased study size enabled us to go beyond simply describing the microbial flora present in upper extremity soft tissue infections, and search for correlations between certain patient clinical characteristics and a MRSA positive culture. A diagnosis of abscess or felon (Odds Ratio = 3.22, 95% Confidence Interval = 1.84-5.63, $p<0.001$), and infection location proximal to the wrist (Odds Ratio = 1.81, 95% Confidence Interval = 1.06-3.09, $p = 0.03$) were both found to be significantly associated with a MRSA positive culture on logistic regression, a form of multivariate analysis. Statistically significant correlation between a MRSA positive culture and diagnosis of abscess is further supported by similar findings by Jacobus et al in a study of 182 patients from three urban medical centers.[17] Therefore, diagnosis of abscess and infection location proximal to the wrist should be used in working to establish a clinical diagnostic algorithm for identification of patients likely to have MRSA based on injury characteristics alone so that effective treatment can be started before cultures are available.

Our study is limited by the demographics of the patient population. Results found in a large, urban, county hospital setting may vary from smaller community hospitals in the region, and may not be as applicable to non-urban hospitals and clinics. While such variance needs to be taken into the account when advising healthcare practitioners in the community, this study still demonstrates that MRSA is an ever increasing problem in the community we serve. As such, rates are also likely to be on the rise at other institutions nearby. Expanded study of nearby community hospital MRSA rates would be beneficial in analyzing the applicability of this study's results to the broader surrounding community. Further prospective investigation with elevated diagnostic and therapeutic modalities would be beneficial.

Our study is further limited by its retrospective nature. Due to lack of completely electronic medical record system for the entire study period, some data was unavailable on certain patients. The use of the computer-based hospital medical records system made obtaining lab results possible for a majority of patients; however, not all data was present for every patient. Comprehensive and consistent past medical and social histories were not able to be established to a significant level due to lack of available data. Therefore, social risk factors associated with MRSA infection were not able to be determined from this study. Due to the retrospective nature, genotyping to confirm that MRSA strains were community acquired was not able to be performed, but should be examined in future study. Future prospective study utilizing a standardized information gathering modality would be beneficial in remedying the limitations of a retrospective analysis, further analyzing the results of this study, and establishing demographic and social characteristics associated with MRSA infection.

The study is potentially limited in the diagnostic results due to hospital consultation protocols. While upper extremity soft tissue infections are not handled by other surgical services such as plastic surgery or general surgery, an orthopaedics consultation may not be ordered for less advanced infections, as in the case of a cellulitis where oral antibiotics may be given by emergency room physicians, without notifying the orthopaedics service. Additionally, when diagnosed with cellulitis, as per treatment protocol, no culture is performed, which dilutes our ability to determine the microbial etiology of the infection.

The increasing trend in MRSA should indicate new approaches to therapy that are sensitive to community acquired strains of MRSA. With the growing prevalence of increasingly virulent community-acquired MRSA strains, antibiotic usage is indicated along with incision and drainage, particularly with the presence of an abscess with surrounding cellulitis.[18] Ruhe et al. in a 2007 retrospective study reported that incision and drainage occurred in most patients with community-acquired MRSA skin and soft tissue infections, and that active antibiotic therapy was 95% successful.[19] Therefore, therapy modalities that take into account the growing prevalence of community acquired MRSA infections would be beneficial.

Our current treatment algorithm for patients with suspected soft tissue infections of the upper extremity is as follows. All patients are evaluated for a fluid collection. If they have a distinct collection, the fluid collection is incised, debrided, and cultured. If the patient is immunocompetent and there are no systemic symptoms or signs of infection such as an elevated white blood cell count or temperature elevation, then the patient is discharged home on oral antibiotics with soap and water washes to the wound. If they have systemic signs or symptoms of infection or they are immunocompromised, then they are admitted to the hospital where intravenous antibiotics are given until the resolution of symptoms. Infections of the flexor tendon sheath or joints are admitted regardless of the presence of systemic signs or symptoms. Based on the high prevalence of MRSA in our patient population, most of our patients are started empirically on vanco-

mycin in conjunction with piperacillin and tazobactam, and then switched to an appropriate antibiotic based on culture sensitivities. Empiric oral antibiotics for patients being discharged had been levofloxacin in addition to clindamycin, before our study was performed. After this study was performed, based on MRSA prevalence and susceptibilities, oral antibiotic therapy has been switched to trimethoprim-sulfamethoxazole combination.

## CONCLUSION

Our study is the largest reported cohort of upper extremity soft tissue infections. As in other studies of inner-city populations, we have shown a marked increase in community acquired methicillin resistant *Staphylococcus aureus* infections. The increasing rate of MRSA necessitates careful monitoring, vigilance and treatment by healthcare professionals. The prevalence of MRSA isolates in relation to both traditional methicillin sensitive *Staphylococcus aureus* strains as well as other non-*Staphylococcal* bacterial infections make MRSA a prime target for both therapy and study, currently and into the future.

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