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Original Research

Twenty-Year Trends in Upper-Extremity Infections at a Single Urban Institution

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Purpose: Empiric antibiotic therapy for hand and upper-extremity infections aims to cover the most common causative organisms, which may change over time. The purpose of this study was to investigate the changes in the bacterial profile of upper-extremity infections over 2 decades at our institution.
Methods: We performed a retrospective chart review of patients with upper-extremity infections treated at a single level 1 trauma center between 2001 and 2019. Patients older than 18 years who underwent surgical treatment for infection with operative cultures available were included. Patient demographics, comorbidities, and culture results were reviewed. Then, the distribution of organisms was analyzed for overall prevalence, and the profile of 2001–2010 was compared with that of 2010–2019 using a chi-square test.
Results: A total of 237 patients (mean age, 43 years) met the criteria and were included in the study. Over the entire study period, the most isolated organism was *Staphylococcus aureus*, specifically the methicillin-resistant species. Methicillin-resistant *S aureus* remained the most common organism in both decades but declined over time from 47% in 2001–2010 to 27% in 2010–2019 ($P < .05$). There was a significant increase in the proportion of *Streptococcus* infections (from 6% to 17%; $P < .05$) and in polymicrobial infections (aerobic 8% to 28%, anaerobic 0% to 14%; $P < .05$). *Enterobacter* species were not isolated in 2001–2010 but comprised 13% of infections in the second decade ($P < .05$).
Conclusions: Methicillin-resistant *S aureus* remains the most common organism isolated from upper-extremity infections, though there has been a decline over the last 20 years. Conversely, *Streptococcal* spp., *Enterobacter* spp. and polymicrobial infections have increased. This study demonstrates longitudinal shifts in the distribution of bacteria responsible for upper-extremity infections at our institution, and these trends can be considered when choosing future empiric therapy.
Type of study/level of evidence: Prognostic IV.

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Acute infections of the hand and upper extremity are common, and without timely treatment they can lead to substantial morbidity and functional disability including stiffness, subsequent surgery, or even amputation.[1,2] For many of these infections, outcomes depend on surgical debridement and appropriate antibiotic administration.[2,3] Optimal antibiotic treatment is tailored to culture results, but the immediate empiric therapy is often based on the most likely causal organisms.[2,4]

Staphylococcus aureus, particularly methicillin-resistant *S aureus* (MRSA), is reported to be the most common organism isolated from cultures of acute hand infections at urban medical centers.[1,5–8] The Centers for Disease Control and Prevention recommend empiric MRSA coverage in regions with at least 10% to 15% community prevalence, but there is evidence of increasing resistance to traditional empiric antibiotics such as clindamycin and levofloxacin.[6,8–10] Furthermore, the bacterial profile on which empiric therapy is based can vary by geographic region and seasonal climate.[11] Kistler et al[9] previously demonstrated the shifts in the

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bacterial profile of infections over time. This highlights the utility of examining the epidemiology of hand and upper-extremity infections. The purpose of this study was to examine the bacterial profile of hand and upper-extremity infections at our institution from 2001–2019 and to compare the evolving trends between the 2 decades. The hypothesis was that notable shifts in the bacterial profile of common organisms would be observed from one decade to the next.

Materials and Methods

A retrospective chart review of upper-extremity infections that required surgical debridement from 2001–2019 at a single level 1 trauma center was performed. Institutional review board approval was obtained prior to the start of data collection, and reporting adhered to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines. Eligible patients were identified using Current Procedural Terminology codes for treatment of upper-extremity infections (Appendix 1, available on the *Journal's* website at www.jhsgo.org). Prior data collected from a pilot study spanning from 2001–2010 were used. These patients were identified using a surgical billing database, and their corresponding medical records were reviewed. Patient demographics, comorbidities, culture, and treatment data were recorded. Patients older than 18 years with any surgically-treated upper-extremity infection affecting bone, joints, or soft tissue with available culture results were included in the study. Specific indications for surgical debridement were met based upon the clinical judgment of the treating surgeon and were not recorded.

Causative bacteria were identified through operative culture results. Aerobic and anaerobic culture results were reviewed. Fungal and acid-fast bacilli cultures were not uniformly obtained and were therefore excluded. Bacteria were grouped by species except for *Staphylococcus* spp., which were grouped into MRSA, methicillin-sensitive *S aureus*, and "other *Staphylococcus* spp." The primary outcome measure of this study was the bacterial profile of isolated organisms in each decade. The frequency of each species was compared between 2 decades, 2001–2010 and 2010–2019, using a chi-square test. A P value < .05 was considered statistically significant. Descriptive statistics were reported as mean and standard deviation or median and range for continuous variables, whereas categorical variables were reported as frequency and percentage.

Results

There were 237 patients identified by the Current Procedural Terminology codes who met the inclusion criteria for the study. There were 107 infections identified in 2001–2010 and 130 identified in 2010–2019. Of all patients, the mean age was 43 ± 15 years, and the majority were men (70%). Common comorbidities included tobacco use (50%), diabetes mellitus (18%), and intravenous drug use (16%). The site of infection ranged from shoulder to fingertip, with finger infection being most common (40.1%). The distribution is detailed in the Table. Skin laceration was the most common mechanism of injury (26%). All other mechanisms, including bite wounds, intravenous drug use, surgical site infections, etc, each comprised <10% of infections. These are also detailed in the Table.

We compared the period of 2001–2010 with 2010–2019 to assess any significant change in the frequency of organisms. MRSA was the most commonly isolated organism overall. However, its frequency declined significantly from the first decade to the second, falling from 47% of all infections in 2001–2010 to 27% in 2010–2019 ($P < .05$). Methicillin-sensitive *S aureus* was constant at 16% and 15% from one decade to the next. There was an increase in the percentage of *Streptococcus* spp. infections from 6% to 17% ($P < .05$). *Enterobacter* spp. were not isolated in the first decade but comprised 13% of infections in the second decade ($P < .05$). Polymicrobial infections also increased over the 2 decades. Multiple organisms isolated from aerobic cultures increased from 8% to 28% ($P < .05$), and those isolated from anaerobic cultures increased from 0% to 14% ($P < .05$).

Table
Descriptive Characteristics of Upper-Extremity Infections Including Both Decades

Site	N (%)	Mechanism	N (%)
Digit	95 (40.1)	Laceration	61 (25.7)
Hand, other than digit	75 (31.6)	Intravenous drug use	20 (8.4)
Wrist	13 (5.5)	Surgical site infection	11 (4.6)
Forearm	34 (14.3)	Animal bite	22 (9.3)
Elbow	11 (4.6)	Human bite	9 (3.8)
Arm	4 (1.7)	Insect bite	22 (9.3)
Shoulder	2 (0.8)	Splinter	6 (2.5)
Unspecified upper extremity	5 (2.1)	Vascular	8 (3.4)
		Explosive	21 (8.9)
		Chemical	7 (2.9)
		Marine	2 (0.8)
		Unknown	48 (20.2)

A total of 25% (59/237) of all cultures over the 20-year study period grew anaerobic bacteria. Among these samples, *Entercoccus*, *Peptostreptococcus*, *Fusobacterium*, *Prevotella*, and *Streptococcus* were most commonly isolated. There were significant increases in *Fusobacterium* (0% to 5%; $P < .05$) and *Prevotella* (2% to 9%; $P < .05$) over the 2 decades.

Discussion

There have been several studies on the epidemiology of hand infections, particularly at urban medical centers, citing MRSA as the most common offending organism.[6,7,12,13] Kistler et al[6] recently demonstrated a decrease in the rate of MRSA infections over 10 years, although the overall incidence remained high. Our results are consistent with these findings, showing a statistically significant decline from 47% to 27% over the 2 decades. This change is consistent with a larger downtrend in both hospital-onset and community-onset MRSA infections in the United States, as reported by the Centers for Disease Control and Prevention.[14] One possible explanation for this decline is improved infection control protocols that can mitigate hospital-onset infections and therefore decrease community colonization, although there are little data to directly support this correlation.[14]

Despite its decline over the 2 decades, MRSA remained the most common organism overall. The Centers for Disease Control and Prevention recommend that empiric antibiotic therapy include MRSA coverage in communities with at least 10% to 15% prevalence.[10] Though the rate of MRSA isolated in this study does not necessarily translate to community prevalence, we can infer the utility of empiric MRSA coverage in the setting of upper-extremity infections. *S aureus*, including both methicillin-resistant and methicillin-sensitive strains, comprised the overwhelming majority of infections from 2001–2010. In contrast, the infections from 2010–2019 shifted to include a wider variety of common organisms, including *Streptococcus* spp. and *Enterobacter* spp.

The rate of *Streptococcus* spp. increased from 6% to 17%. It has been widely reported that *Streptococcus* is the second most common species behind *Staphylococcus* in hand infections.[1,5,7] Though this was a statistically significant shift in the distribution of organisms over the study period, the clinical significance may be minimal as both *Staphylococcus* and *Streptococcus* often have similar antibiotic sensitivities.[15–17] In contrast, the rate of *Enterobacter*-related infections, which are a result of aerobic gram-negative bacilli that have established resistance to traditional empiric therapy with early generation cephalosporins, increased from 0% to 13%.[17,18]

The rate of polymicrobial infections also increased significantly in this study, consistent with the 10-year trend demonstrated by Kistler et al.[6] Polymicrobial infections occur more often in individuals with diabetes and intravenous drug users and are associated with higher complication rates.[5,7,19] At our institution, the most common organisms isolated from polymicrobial infections were MRSA, methicillin-sensitive *S aureus*, and *Streptococcal* spp. These were commonly covered by broad spectrum empiric antibiotics such as vancomycin and cefepime used at our institution.

We acknowledge that there are limitations to this study. The method of identifying patients by Current Procedural Terminology codes may have resulted in the loss of potential study candidates with surgically-treated hand infections, as there was not a uniform coding strategy used for all upper-extremity infection cases, and similar codes were also used for open fracture cases. In this study, we chose to select surgically-treated hand infections because of our ability to consistently identify them and because of the availability of cultures over the 20-year study period. This resulted in the exclusion of hand infections treated with bedside drainage in the emergency department. The study may have also been strengthened by investigating trends in antibiotic sensitivities, but these data were not recorded. Our results describe the bacterial profile at one institution, which may limit the generalizability to other centers, but they reflect similar trends reported in shorter term studies. Despite its limitations, the major strength of this study is the ability to analyze longitudinal trends over a 20-year study period.

Hand and upper-extremity infections are common and require appropriate empiric therapy to prevent further complications. From 2001 to 2019, MRSA was the most isolated organism, though the prevalence declined over time. Conversely, *Streptococcal* spp., *Enterobacter* spp., and polymicrobial infections increased over time and should be considered when choosing empiric antibiotic therapy.

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