JB&JS OPEN ACCESS

Preoperative Antibiotics Influence Culture Yield in the Treatment of Hand, Wrist, and Forearm Infections

Lauren K. Dutton, MD, Katharine M. Hinchcliff, MD, Anthony L. Logli, MD, Katherine E. Mallett, MD, Gina A. Suh, MD, and Marco Rizzo, MD

Investigation performed at the Department of Orthopedic Surgery, Mayo Clinic, Rochester, Minnesota

Background: When treating upper-extremity infections, clinicians frequently must decide whether to initiate antibiotics or delay them with the goal of optimizing culture yield at the time of surgical debridement. The purpose of this study was to determine whether the administration of preoperative antibiotics affects intraoperative culture yield and whether there is a "safe" interval prior to culture acquisition within which antibiotics can be administered without affecting culture yield.

Methods: We conducted a retrospective review of 470 consecutive patients who underwent debridement for a presumed acute infection of the hand, wrist, or forearm at a single tertiary care center between January 2015 and May 2020. Data including patient demographics, mechanism of infection and affected body part(s), and details of antibiotic administration, including type and timing with respect to culture acquisition, were collected.

Results: Three hundred and forty-one patients (73%) received preoperative antibiotics prior to debridement and culture acquisition. The rate of positive cultures among patients who received preoperative antibiotics was 81% compared with 95% among patients who did not receive preoperative antibiotics ($p < 0.01$; odds ratio, 4.73). Even a single dose of antibiotics imparted a significantly increased risk of obtaining negative intraoperative cultures, and an incremental increase in the likelihood of obtaining negative cultures was seen with each preoperative dose given up to 7 doses. We did not identify a "safe" interval of time between antibiotic administration and culture acquisition such that culture yield was not affected.

Conclusions: Patients who received preoperative antibiotics for the treatment of upper-extremity infections were approximately 5 times more likely to have negative cultures at the time of debridement than those who did not receive preoperative antibiotics. This effect persisted regardless of the number of doses given or the interval between antibiotic administration and culture acquisition.

Level of Evidence: Prognostic Level III. See Instructions for Authors for a complete description of levels of evidence.

In treating patients with presumed infections of the upper extremity, providers routinely must decide whether to begin antibiotics or alternatively, to delay their initiation in anticipation of optimizing culture yield at the time of debridement. On the one hand, antibiotics can potentially mitigate the infection or even provide curative treatment and may also allow for the safe transfer of care to an upper-extremity surgeon and decrease the need for overnight operative interventions, a practice which has been shown to be associated with increased adverse events[1,2]. Conversely, delaying the administration of antibiotics is thought to increase the chances of obtaining a positive culture, allowing the clinician to most accurately tailor postoperative antibiotics to the causative organism. This targeted therapy both improves the likelihood of successful treatment and diminishes the risks inherent to broad-spectrum antibiotics, including antibiotic resistance at both

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSOA/A370).

Disclaimer: The views expressed in this paper are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. Government.

One of the authors is a military service member and employee of the U.S. government. This work was prepared as part of their official duties. Title 17 U.S.C. 105 provides that "Copyright protection under this title is not available for any work of the United States Government." Title 17 U.S.C. 101 defines United States Government work as a work prepared by a military service member or employee of the United States Government as part of that person's official duties.

JBJS Open Access • 2022:e21.00084.

the individual and population levels as well as patient-specific side effects[3-5].

While the literature provides some guidance regarding the preoperative administration of antibiotics for periprosthetic joint infections in total joint arthroplasty—including multiple studies that have not demonstrated an effect of preoperative antibiotic administration on intraoperative culture yield[6-8]—the data concerning the association of preoperative antibiotic administration and culture yield in upper-extremity infections is sparse. The available literature is marked by diverse conclusions that are limited by the lack of comparison groups, power analyses, and in some cases, details about the percentage of patients who actually received preoperative antibiotics[9-11]. Because of these limitations, there is no clear evidence-based guidance for practitioners seeking to understand the association between preoperative antibiotic administration and culture yield. The purpose of this study was to determine whether the administration of preoperative antibiotics affects intraoperative culture yield and whether there is a "safe" interval prior to culture acquisition within which antibiotics can be administered without affecting culture yield. Our null hypothesis was that preoperative antibiotic administration would have no effect on culture yield.

Materials and Methods

After obtaining institutional review board approval, we conducted a retrospective chart review of consecutive patients who underwent irrigation and debridement of a presumed acute infection of the hand, wrist, or forearm in either the emergency department or the operating room at a single academic tertiary care center between January 2015 and May 2020. All procedures were performed under the supervision of a fellowship-trained hand surgeon. Patient demographic and clinical information collected included age; sex; major comorbidities including diabetes, autoimmune disease, and other immunosuppressive conditions; tobacco use; affected body part(s); and postoperative diagnosis. We also recorded whether or not the patient had received antibiotics prior to surgery; whether these antibiotics were administered orally, intravenously, or both; the number of doses of intravenous and/or oral antibiotics given; and the time between the initial administration of antibiotics and the acquisition of the first culture.

Study patients were identified by means of a research tool that searched for patients at our institution who had undergone procedures with Current Procedural Terminology (CPT) codes related to debridement of infections of the hand, wrist, or forearm, and the records from these patients were reviewed to confirm the accuracy of coding prior to inclusion in the study. Exclusion criteria included patients on chronic or lifelong antibiotic suppression, patients for whom culture samples were not sent at the time of debridement, intraoperative findings positive for gout with negative culture results and no evidence of infection, and patients who sustained wounds at high risk for infection who were prophylactically taken to the operating room for irrigation and debridement without prior evidence of infection. The timing of the initial oral antibiotic dose was estimated according to the time of discharge from the emergency department, as this could not otherwise be specifically determined unless the first dose had been administered in the emergency department and recorded.

On the basis of an initial sample of the data, in which 72% of the patients received antibiotics and had a 19% negative culture rate while the 28% of patients who did not receive antibiotics had a 5% negative culture rate, we calculated that a sample size of 285 patients would be needed to detect a difference in positive culture rates between these 2 groups with 90% power. Ultimately, the study sample included a complete series of 470 patients meeting inclusion/exclusion criteria who were treated between January 1, 2015, and May 2, 2020, and was sufficiently powered. The antibiotic regimen was not standardized and was at the discretion of the treating surgeon and consulting infectious diseases team.

Statistical Methods

Patient characteristics and baseline clinical data were compared between patients who were treated with antibiotics prior to surgery and those who were not using 2-sample t tests (or Wilcoxon rank-sum tests when the data were not sufficiently normally distributed) for continuous variables and Fisher exact tests for categorical variables. The association between potential risk factors and negative culture rates was analyzed using logistic regression; odds ratios (ORs) were reported with 95% confidence intervals (CIs). All statistical tests were 2-sided, and p values of <0.05 were considered significant. All analyses were conducted using SAS (version 9.4M6; SAS Institute) and R (version 3.6.2; R Foundation for Statistical Computing).

Source of Funding

There was no external funding source for this study.

Results

Four hundred and seventy patients with infections of the hand, wrist, or forearm treated consecutively over a nearly 5.5-year period at a single institution were reviewed. The study population included 304 male (65%) and 166 female (35%) patients. Just over half of the patients (54%) were >50 years of age, and the mean age (and standard deviation) was 50 ± 19 years. Most patients presented with isolated infections of a finger (64%) or hand (18%) only. Diabetes and smoking were not significantly associated with an increased risk of having a positive culture ($p = 0.87$ for diabetes; $p = 0.40$ for smoking).

Three hundred and forty-one patients, representing nearly three-quarters (73%) of the study population, received preoperative antibiotics prior to debridement and culture acquisition. Approximately two-thirds of these patients received antibiotics in the emergency department. The mean number of specimens sent for culture was 3.2 ± 1.86 (range, 1 to 14). The overall positive-culture rate for all identified patients was 85%. Of the 341 patients who received preoperative antibiotics, 65 (19%) had negative cultures. Conversely, of the 129 patients who did not receive

JBJS Open Access • 2022:e21.00084.

TABLE I Comparison of Baseline Characteristics and Demographic Data Stratified by Preoperative Antibiotic Administration

	Received Antibiotics Before Debridement and Culture Acquisition		
	No (N = 129)	Yes (N = 341)	P Value
Age *(yr)*			0.0062*
Mean (SD)#	45.8 (19.19)	51.5 (18.31)	
Median	51.0	53.0	
Range	1.0-88.0	2.0-92.0	
Age group *(no. [%])*			0.5340†
>50 years	66 (51.2%)	187 (54.8%)	
≤50 years	63 (48.8%)	154 (45.2%)	
Sex *(no. [%])*			0.4517†
Male	87 (67.4%)	217 (63.6%)	
Female	42 (32.6%)	124 (36.4%)	
Laterality of affected side *(no. [%])*			0.4698†
Left	64 (49.6%)	156 (45.7%)	
Right	65 (50.4%)	185 (54.3%)	
Immunosuppressed state‡ *(no. [%])*			0.7577†
Yes	9 (7.0%)	24 (7.0%)	
No	117 (90.7%)	303 (88.9%)	
Prior§	3 (2.3%)	14 (4.1%)	
Hardware *(no. [%])*			0.1887†
Yes	7 (5.4%)	15 (4.4%)	
No	119 (92.2%)	324 (95.0%)	
Prior§	3 (2.3%)	2 (0.6%)	
Diabetes *(no. [%])*			0.0398†
No	111 (86.0%)	264 (77.4%)	
Yes	18 (14.0%)	77 (22.6%)	
Autoimmune disease *(no. [%])*			>0.99†
No	118 (91.5%)	310 (90.9%)	
Yes	11 (8.5%)	31 (9.1%)	
Current tobacco use *(no. [%])*			0.7358†
No	92 (71.3%)	236 (69.2%)	
Yes	37 (28.7%)	105 (30.8%)	

*Kruskal-Wallis test. †Fisher exact test. #SD = standard deviation. ‡Immunosuppressed state was defined as a history of chemotherapy, end-stage renal disease, autoimmune disease on immunosuppressant medications, or intravenous drug use. §"Prior" was defined as the patient reportedly having had these conditions at any point in their history and was not bound by specific timelines.

antibiotics prior to surgery, only 6 (5%) had negative cultures. The mean time between the first antibiotic administration and first obtained culture was 2.5 days, although this timing was heterogeneous (standard deviation, 4 days; range, 0.1 hours to 36 days). Patients received an average of 5.5 ± 8.6 doses (range, 0 to 64 doses) of antibiotics prior to debridement, and this antibiotic was typically intravenous (58%) or both intravenous and oral (26%). Patients received an average of 1.6 ± 1.39 (range, 0 to 10) different antibiotics ahead of culture acquisition. The most common settings of antibiotic administration following the emergency department (67%) were an outpatient clinic (16%) and the inpatient ward (8%). Patients underwent an average of 1.5 ± 1.3 procedures (range, 1 to 20 procedures) to treat the infection. Baseline patient characteristics and demographic data stratified by the presence or absence of preoperative antibiotic administration are shown in Table I. Descriptive statistics regarding antibiotic administration, surgical intervention, and infection characteristics are summarized in Tables II, III, and IV, respectively.

Antibiotics and Culture Yield

Preoperative antibiotic treatment was associated with a lower rate of positive cultures (81% versus 95%; $p < 0.01$; OR, 4.73) (Table II). When this relationship was separated by route of administration, intravenous administration conferred an increased risk of

JBJS Open Access • 2022:e21.00084. **openaccess.jbjs.org**

TABLE II Logistic Regression of Antibiotic Administration Characteristics

	No. (%)	Negative Culture Events *(no. [%])*	Odds Ratio (95% CI)*	P Value*
Preoperative antibiotics				
No	129 (27.4)	6 (4.7)	1.0 (reference)	
Yes	341 (72.6)	65 (19.1)	4.73 (1.98, 11.3)	**<0.01**
Setting of initial antibiotic administration				
Emergency department	228 (66.9)	45 (19.7)	1.0 (reference)	
Outpatient clinic	53 (15.5)	9 (17.0)	0.76 (0.35, 1.68)	0.499
Inpatient	27 (7.9)	6 (22.2)	1.18 (0.43, 3.19)	0.750
Urgent care	17 (5.0)	4 (23.5)	1.25 (0.39, 3.97)	0.706
Operating room	15 (4.4)	1 (6.7)	0.46 (0.08, 2.70)	0.392
Other	1 (0.3)	0	1.78 (0.03, 121)	0.788
Route of antibiotic administration				
No antibiotics	129	6 (4.7)	1.0 (reference)	
Intravenous	199 (58.4)	38 (19.1)	4.91 (1.99, 12.1)	**<0.01**
Oral	53 (15.5)	6 (11.3)	2.52 (0.77, 8.25)	0.127
Both	89 (26.1)	21 (23.6)	5.94 (2.27, 15.6)	**<0.01**
No. of preoperative antibiotic doses				
Continuous			1.04 (1.02, 1.07)	**<0.01**
0	129	6 (4.7)	1.0 (reference)	
1	44	9 (20.5)	5.47 (1.80, 16.6)	**<0.01**
2	48	7 (14.6)	3.37 (1.06, 10.7)	**0.040**
3	44	4 (9.1)	1.85 (0.49, 6.98)	0.361
4	34	7 (20.6)	5.20 (1.59, 16.9)	**<0.01**
>4	171	38 (22.2)	5.83 (2.36, 14.4)	**<0.01**
Hours between antibiotic administration and culture acquisition†				
Continuous			1.00 (0.99, 1.00)	0.410
≤1 hr	20	4 (20)	1.0 (reference)	
>1 hr	297	57 (19.2)	0.87 (0.27, 2.75)	0.812
≤12 hr	89	12 (13.5)	1.0 (reference)	
>12 hr	228	49 (21.5)	1.70 (0.84, 3.44)	0.141

*Adjusted for age, sex, diabetes, autoimmune disease, current tobacco use, and setting of initial irrigation and debridement. †When the timing was broken down as <1 hour, 1 to <2 hours, 2 to <12 hours, 12 to 24 hours, and >24 hours, differences were also nonsignificant. For 4 of the 65 patients who received antibiotics and had negative cultures, information on the duration of time between antibiotic administration and culture acquisition was not available.

negative cultures ($p < 0.01$), whereas oral antibiotics alone did not significantly increase the rate of negative cultures when compared with the absence of preoperative antibiotics ($p = 0.13$). Patients who received both oral and intravenous antibiotics were 5.9 times more likely to have negative cultures than patients who received no preoperative antibiotics ($p < 0.01$); patients who received intravenous antibiotics only were 4.9 times more likely to have negative cultures ($p < 0.01$). The number of different antibiotics given did not confer an increased risk of negative cultures ($p = 0.48$). This held true whether the antibiotics were administered intravenously ($p = 0.14$) or orally ($p = 0.14$).

The relationship between the preoperative administration of antibiotics and negative cultures was dose-dependent (OR, 1.04 [95% CI, 1.02 to 1.07]; $p < 0.01$) (Table II). Even a single dose of antibiotics was found to be significantly associated with an increased risk of obtaining negative cultures ($p < 0.01$; OR, 5.5), and as such, there was no "safe" number of doses administered without which an effect on positive culture yield was identified. Interestingly, the amount of time elapsed between the antibiotic dose and obtaining cultures did not significantly impact culture yield ($p = 0.41$) (Table II).

An additional finding of interest was the relationship between the number of specimens sent and the risk of obtaining negative cultures (OR, 0.87 [95% CI, 0.75 to 1.01]; $p = 0.07$) (Table III). While this did not reach significance, we did

JBJS Open Access • 2022:e21.00084. **openaccess.jbjs.org** 5

TABLE III Logistic Regression of Surgical Characteristics*

	Mean ± SD or No. (%)	Rate of Negative Culture *(no. [%])*	OR for Negative Culture (95% CI)	P Value
No. of specimens sent	3.2 ± 1.86		0.87 (0.75, 1.01)	0.07
Setting of initial I & D				
Emergency department	77 (16.4%)	13 (16.9%)	1.0 (reference)	
Operating room	393 (83.6%)	58 (14.8%)	0.85 (0.44, 1.65)	0.63
No. of I & Ds	1.5 ± 1.26			
Positive culture rate on subsequent I & D	76 (16.2%)			

*SD = standard deviation, OR = odds ratio, CI = confidence interval, and I & D = irrigation and debridement.

find a trend toward >4 samples being protective against negative intraoperative culture yield.

Mechanism and Organism-Specific Results

Gram-positive monomicrobial infections accounted for 51% of positive cultures, with about half of these being methicillin-resistant *Staphylococcus aureus* (MRSA) infections (Table V). Although more monomicrobial infections were seen in patients who did not receive antibiotics prior to culture (72% versus 63%), this was not significant (p = 0.067).

The most common mechanism of infection was a penetrating soft-tissue injury (31%), followed by cat bite (15%) and postoperative infection (11%); however, in many circumstances, the mechanism of infection was not known or not charted (22%) (Fig. 1). Retained hardware was present in 5% of patients but was not associated with an increased risk of positive cultures (p = 0.45).

TABLE IV Logistic Regression of Infectious Characteristics*

	No. (%)	Negative Culture Events *(no. [%])*	Odds Ratio (95% CI)	P Value
Affected body part				
Hand	85 (18.1)	13 (15.3)	1.0 (reference)	
Finger	299 (63.6)	44 (14.7)	0.96 (0.49, 1.87)	0.89
Hand and finger	11 (2.3)	3 (27.3)	2.08 (0.49, 8.88)	0.32
Hand and wrist	36 (7.7)	8 (22.2)	1.58 (0.59, 4.23)	0.36
Elbow to hand	39 (8.3)	3 (7.7)	0.46 (0.12, 1.72)	0.25
Diagnosis				
Abscess	237 (50.4)	35 (14.8)	1.0 (reference)	
Septic joint	83 (17.7)	16 (19.3)	1.39 (0.73, 2.67)	0.31
Flexor tenosynovitis	73 (15.5)	16 (21.9)	1.64 (0.85, 3.16)	0.14
Paronychia	34 (7.2)	2 (5.9)	0.44 (0.11, 1.70)	0.23
Felon	15 (3.2)	2 (13.3)	1.06 (0.25, 4.45)	0.94
Osteomyelitis	13 (2.8)	0	0.21 (0.01, 4.04)	0.30
Hardware infection	9 (1.9)	0	0.30 (0.02, 6.14)	0.43
Necrotizing fasciitis	6 (1.3)	0	0.44 (0.02, 10.01)	0.61
Mechanism of infection				
Penetrating soft-tissue injury	147 (31.3)	20 (13.6)	1.0 (reference)	
Cat bite	68 (14.5)	19 (27.9)	2.46 (1.21, 5.00)	**0.01**
Dog bite	35 (7.4)	6 (17.1)	1.31 (0.48, 3.56)	0.59
Human bite	7 (1.5)	1 (14.3)	1.06 (0.12, 9.26)	0.96
Bacteremia	14 (3.0)	5 (35.7)	3.53 (1.07, 11.60)	**0.04**
Postoperative infection	53 (11.3)	4 (7.5)	0.52 (0.17, 1.59)	0.25
Other/unknown	146 (31.1)	16 (11.0)	0.78 (0.39, 1.58)	0.49

*The analysis summarized in this table was designed to determine whether any specific infection-related factors (including the particular body part that was affected, the specific diagnosis, and/or the mechanism of infection) were significantly associated with the risk of obtaining negative intraoperative cultures. The risk of this association was quantified as the odds ratio (OR). CI = confidence interval.

JBJS Open Access • 2022:e21.00084.

TABLE V Distribution of Cultured Organisms*

Organism	No. (%)†
MRSA	104 (26.1%)
Polymicrobial gram-positive-predominant	55 (13.8%)
MSSA	44 (11.1%)
Polymicrobial mixture without predominance	41 (10.3%)
Anaerobic monomicrobial or anaerobic-predominant polymicrobial	37 (9.3%)
Streptococcus/Enterococcus	37 (9.3%)
Pasteurella	27 (6.8%)
Coagulase-negative staphylococci (CoNS)	19 (4.8%)
Polymicrobial gram-negative predominant	10 (2.5%)
Other	8 (2.0%)
Gram-negative	8 (2.0%)
Mycobacteria	8 (2.0%)

*MRSA = methicillin-resistant *Staphylococcus aureus*, and MSSA = methicillin-sensitive *S. aureus*. †N = 398 patients with microorganism information available.

When a penetrating soft-tissue injury was used as the reference, patients with an infectious mechanism of bacteremia were 3.5 times more likely to have negative cultures ($p = 0.04$); this may be secondary to all patients with bacteremia having received multiple doses of intravenous antibiotics prior to surgical debridement. Patients with cat-bite injuries were 2.5 times more likely to have negative cultures ($p = 0.01$) (Table IV). The species of organism cultured was significantly related to the mechanism of injury ($p < 0.001$) (Table VI). Most notably, all positive cultures related to bacteremia and most positive cultures related to postoperative infections had gram-positive monomicrobial growth. Bite injuries were relatively less likely to be gram-positive and more likely to have Pasteurella species or other gram-negative or anaerobic monomicrobial growth.

An abscess (50%), a septic joint (18%), and flexor tenosynovitis (16%) were the most common clinical presentations (Table IV).

The type of infectious presentation did not significantly impact the rate of culture positivity.

Discussion

The decision as to whether or not to administer antibiotics in the treatment of infections of the hand, wrist, or forearm presents a challenge to primary care physicians, emergency department providers, and upper-extremity surgeons. Our study demonstrated a significant and marked negative association between the rate of positive cultures and the administration of preoperative antibiotics. Our hypothesis that antibiotics would not influence culture yield was not confirmed.

The magnitude of the effect of preoperative antibiotic administration was such that patients who received even 1 dose of intravenous antibiotics were approximately 5 times more likely to have negative cultures compared with those who did not receive preoperative antibiotics. We did not identify a "safe" number of doses or duration between the administration of the first dose of antibiotics and culture acquisition that was protective against this effect. Overall, there was an increase in the likelihood of having negative cultures with increasing doses of preoperative antibiotics, up to 7 doses. While the administration of oral antibiotics exclusively was not significantly associated with a decreased risk of negative cultures ($p = 0.13$), the odds of obtaining a negative culture were substantially higher for patients who received preoperative oral antibiotics compared to those who did not (OR, 2.52).

There was a low (4.7%) but non-zero rate of negative cultures in the group of patients who did not receive antibiotics ahead of debridement. This result is consistent with the finding in clinical practice that the distinction between cellulitis and

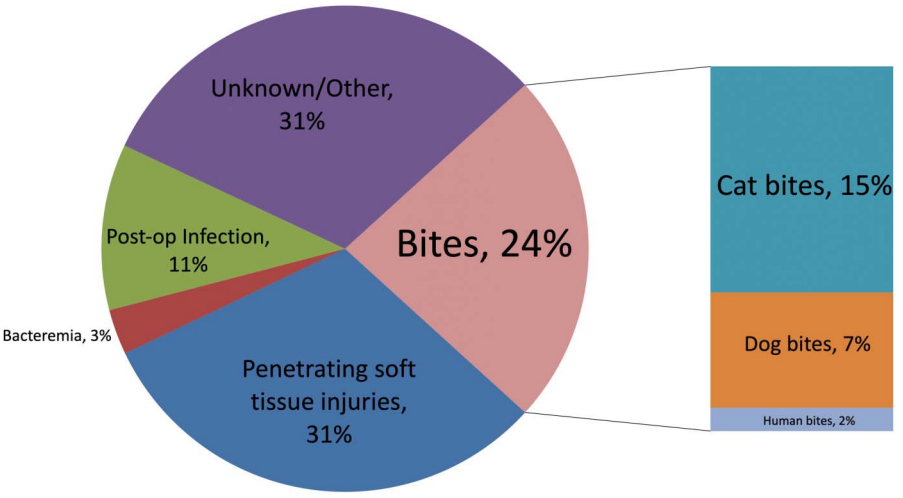


Fig. 1
Mechanism of infection.

JBJS Open Access • 2022:e21.00084. **openaccess.jbjs.org** 7

TABLE VI Comparison of Isolated Organisms and Mechanism of Infection*

Organism Isolated	Mechanism of Infection *(no.)*					
	Bacteremia	Bite	Penetrating Soft-Tissue Injury	Postoperative Infection	Other/ Unknown	Total
Gram-positive	9	14	75	34	72	204
Gram-negative or anaerobic (mono- and polymicrobial)	0	43	48	14	46	151
Other (including mycobacteria)	0	2	4	0	10	16
Pasteurella	0	25	0	0	2	27
Total	9	84	127	48	130	398

*P < 0.001, chi-square test.

deeper infections from which cultures may be isolated is not always obvious, nor is the process of culture acquisition and interpretation free of potential error and variability. Our goal was to reflect all cases of potential upper-extremity infections deemed concerning enough to warrant debridement by the treating hand surgeon.

While some studies have examined the potential role of preoperative antibiotics in affecting culture yield, the literature regarding this topic is sparse. Trionfo et al.[9] retrospectively reviewed 88 patients who received antimicrobial intravenous prophylaxis prior to surgical debridement of hand abscesses. The rate of positive cultures in that study was 90%, leading the authors to conclude that preoperative antibiotic administration did not significantly decrease bacterial culture growth. This study did not include a control group who did not receive antibiotics, nor was there an a priori power analysis.

Fowler and Ilyas identified culture-positive infections in only 30% of cases in their review of 458 acute hand infections[10]. The authors were unable to distinguish which patients received antibiotics prior to culture acquisition and which did not. In our study, there was an 85% overall rate of positive cultures and an 81% culture-positive rate among patients who received preoperative antibiotics. The discrepancy between the findings in the present study and the notably lower rate of positive cultures in the study by Fowler and Ilyas may be due to their inclusion of not just infections but also open wounds. Houshian et al. identified 418 patients who underwent surgical debridement for a hand infection and encountered positive cultures in 89% of the cases[11]. These authors did not delineate whether the patients in their study received preoperative antibiotics.

An independent risk factor for obtaining negative intraoperative cultures was the mechanism of a cat bite. This finding remained significant even when the number and type of preoperative antibiotic doses were controlled for. Cat bites have been historically appropriately recognized by surgeons as a "bad actor."[12] As such, surgeons may have adopted a lower threshold to intervene for these infections early, presumably before they are given the opportunity to coalesce into an abscess that would yield positive culture results, as well as to initiate early intravenous antibiotic therapy.

We also sought to discover whether the mechanism of an infection is associated with the organism that is ultimately identified. The results of this comparison, which can be found in Table VI, were significant ($p < 0.001$) and provide a roadmap for prescribing appropriate antibiotics based on the mechanism of infection when cultures are negative and thus not able to specifically guide antibiotic therapy.

There were multiple limitations of this study, one of which was the limitation inherent to any retrospective study in that our data were subject to the contents of the medical record. Moreover, while we recognize that the heterogeneity of infections may introduce bias, the purpose of this study was to look at the spectrum of hand and upper-extremity infections presenting to a tertiary care center over a 5.5-year period and to determine the effects of preoperative antibiotic administration across this spectrum so as to make this study as applicable and beneficial to clinicians as possible.

Another limitation was the exclusion of patients in whom intraoperative findings were positive for gout. These patients were excluded because of the relatively low risk of bacterial superinfection in conjunction with the favorable odds of detecting gout in the preoperative work-up. An additional limitation of this study was the inability to precisely determine the time between the administration of oral antibiotics in the outpatient setting and the acquisition of cultures; this information was extrapolated based on the medical record. As oral antibiotic administration was not found to be significantly associated with an increased rate of negative cultures, the effect of this estimated time lapse is likely not substantial. Furthermore, we were not able to reliably determine whether intraoperative cultures were obtained in the form of culture swabs versus tissue samples. This may have introduced bias in light of the reported diagnostic superiority of tissue samples over swabs[13].

In conclusion, the results of this study indicated a significant negative effect of preoperative intravenous antibiotic administration on intraoperative culture yield. The potential benefits of

antibiotic administration in the treatment of these infections must be weighed against the likelihood of altering culture yield. ■

Lauren K. Dutton, MD[1]
Katharine M. Hinchcliff, MD[1]
Anthony L. Logli, MD[1]
Katherine E. Mallett, MD[1]
Gina A. Suh, MD[1]
Marco Rizzo, MD[1]

[1]Department of Orthopedic Surgery, Mayo Clinic, Rochester, Minnesota

Email for corresponding author: rizzo.marco@mayo.edu

References

1. Cortegiani A, Gregoretti C, Neto AS, Hemmes SNT, Ball L, Canet J, Hiesmayr M, Hollmann MW, Mills GH, Melo MFV, Putensen C, Schmid W, Severgnini P, Wrigge H, Gama de Abreu M, Schultz MJ, Pelosi P; LAS VEGAS Investigators, the PROVE Network, and the Clinical Trial Network of the European Society of Anaesthesiology. Association between night-time surgery and occurrence of intraoperative adverse events and postoperative pulmonary complications. Br J Anaesth. 2019 Mar;122(3):361-9.

2. Taffinder NJ, McManus IC, Gul Y, Russell RCG, Darzi A. Effect of sleep deprivation on surgeons' dexterity on laparoscopy simulator. Lancet. 1998 Oct 10;352(9135):1191.

3. Langdon A, Crook N, Dantas G. The effects of antibiotics on the microbiome throughout development and alternative approaches for therapeutic modulation. Genome Med. 2016 Apr 13;8(1):39.

4. Fair RJ, Tor Y. Antibiotics and bacterial resistance in the 21st century. Perspect Medicin Chem. 2014 Aug 28;6(6):25-64.

5. Karam G, Chastre J, Wilcox MH, Vincent JL. Antibiotic strategies in the era of multidrug resistance. Crit Care. 2016 Jun 22;20(1):136.

6. Bedenčič K, Kavčič M, Faganeli N, Mihalič R, Mavčič B, Dolenc J, Bajc Z, Trebše R. Does Preoperative Antimicrobial Prophylaxis Influence the Diagnostic Potential of Periprosthetic Tissues in Hip or Knee Infections? Clin Orthop Relat Res. 2016 Jan;474(1):258-64.

7. Wouthuyzen-Bakker M, Tornero E, Claret G, Bosch J, Martinez-Pastor JC, Combalia A, Soriano A. Withholding Preoperative Antibiotic Prophylaxis in Knee Prosthesis Revision: A Retrospective Analysis on Culture Results and Risk of Infection. J Arthroplasty. 2017 Sep;32(9):2829-33.

8. Wouthuyzen-Bakker M, Benito N, Soriano A. The effect of preoperative antimicrobial prophylaxis on intraoperative culture results in patients with a suspected or confirmed prosthetic joint infection: A systematic review. J Clin Microbiol. 2017 Sep;55(9):2765-74.

9. Trionfo A, Thoder JJ, Tosti R. The Effects of Early Antibiotic Administration on Bacterial Culture Growth From Hand Abscesses. Hand (N Y). 2016 Jun;11(2):216-20.

10. Fowler JR, Ilyas AM. Epidemiology of adult acute hand infections at an urban medical center. J Hand Surg Am. 2013 Jun;38(6):1189-93.

11. Houshian S, Seyedipour S, Wedderkopp N. Epidemiology of bacterial hand infections. Int J Infect Dis. 2006 Jul;10(4):315-9.

12. Babovic N, Cayci C, Carlsen BT. Cat bite infections of the hand: assessment of morbidity and predictors of severe infection. J Hand Surg Am. 2014 Feb;39(2):286-90.

13. Aggarwal VK, Higuera C, Deirmengian G, Parvizi J, Austin MS. Swab cultures are not as effective as tissue cultures for diagnosis of periprosthetic joint infection. Clin Orthop Relat Res. 2013 Oct;471(10):3196-203.