Original Research

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Reevaluating the Need for Antibiotic Prophylaxis in Adult Upper Extremity Surgery With Hardware

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Abstract

Background: Although it is well established that antibiotic prophylaxis is not needed in soft tissue upper extremity cases, there is still no definitive consensus when hardware implantation is involved. We hypothesize that antibiotic prophylaxis is not necessary and there is no difference in postoperative surgical site infection rates regardless of preoperative antibiotic administration. **Methods:** A retrospective cohort analysis was performed on upper extremity surgical cases with hardware implantation performed at a single institution amongst 5 hand surgeons between November 2021 and November 2023. Implants included plates, screws, Kirschner wires, and suture anchors. Primary outcome measures were diagnosis of surgical site infection by 14 and 30 days postoperatively. Secondary outcomes included the type of management used to treat infection. Categorical variables were compared using Fisher exact test, and continuous variables were compared using Wilcoxon rank-sum test. **Results:** A total of 232 patients were included for analysis—152 received antibiotic prophylaxis and 80 did not. There were no differences between the 2 groups in terms of demographic factors, comorbidities, or smoking status. There was no difference in infection rates between the group who received antibiotic prophylaxis and the group who did not. Infection rate in the antibiotic prophylaxis group was 4.6% and in the sans antibiotics group was 2.5%. All infections were treated with antibiotics, and there were no differences in the rates of operative washout and hardware removal between the 2 groups. **Conclusions:** Antibiotic prophylaxis is not necessary in upper extremity surgical cases even when implantation of hardware is involved.

Keywords: infection, diagnosis, outcomes, research & health outcomes, surgery, specialty, trauma, fracture/dislocation

Introduction

Preoperative antibiotic prophylaxis is a common preventive measure against surgical site infections. Over a decade ago, the *Clinical Practice Guidelines for Antimicrobial Prophylaxis in Surgery*[1] recommended that antimicrobial prophylaxis should be given in procedures involving the implantation of foreign materials[2] due to association with significant negative consequences such as hospital readmission, extended hospital length of stay, need for additional procedures, and increases in direct hospital costs related to postoperative surgical site infections.[3,4] However, widespread antibiotic use also increases other risks including *Clostridium difficile* colitis, allergic reactions, contribution to antibiotic resistance, and unnecessary health care costs, which are concerns that demand antibiotics stewardship and judicious use.[5-9]

The necessity of antibiotic prophylaxis and the utility of routine postoperative antibiotics in patients undergoing hardware implantation during upper extremity surgery have yet to be determined as there is a paucity of data in the existing literature. Although there are now subspecialty specific recommendations that antibiotic prophylaxis should not be administered for clean hand surgery cases without implantation, such as carpal tunnel release,[10-12] there are no guidelines for when hardware implantation is involved. Out of precaution, the vast majority of hand surgeons continue to routinely administer preoperative antibiotic prophylaxis for all upper extremity procedures as indicated by a 2020 survey of 178 American Society for Surgery of the Hand-certified

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surgeons.[9] At our institution, although no hand surgeon routinely administers prophylactic antibiotics prior to elective upper extremity soft tissue procedures, the practice differs between surgeons when hardware implantation is involved.

The variability in preoperative antibiotic prophylaxis administration among surgeons in our institution provided an opportunity to investigate whether antibiotic prophylaxis has an impact on surgical site infection rate. This study aims to investigate whether preoperative antibiotic prophylaxis has an appreciable effect on the postoperative infection rate for upper extremity surgeries involving hardware implantation.

Materials and Methods

This retrospective cohort study was conducted in accordance with the protocol approved by the institutional review board following the Strengthening the Reporting of Observational Studies in Epidemiology guidelines for cohort studies. A retrospective review was performed on all patients who underwent upper extremity surgical intervention by 5 hand surgeons at a single institution between November 2021 and November 2023. Adult patients who underwent clean upper extremity surgery with implantation of hardware devices were included. Hardware devices included plates, screws, Kirschner wires (K-wires), and suture anchors. Plates, screws, and K-wires were used for fracture fixation, and suture anchors were used for ligamentous repairs. Exclusion criteria were age under 18, usage of antibiotics within 30 days of surgery other than for a postoperative infection, infections diagnosed prior to surgery, and less than 30 days of follow-up. Patients were stratified into 2 groups: those who did not receive perioperative antibiotic prophylaxis and those who did receive perioperative antibiotic prophylaxis. Those in the antibiotic prophylaxis group received a single dose of cefazolin or alternative antibiotic in cases of known allergy to cefazolin immediately prior to the start of surgery in the operating room as per institutional protocol. A separate group of patients who underwent clean, soft tissue only upper extremity surgery with no antibiotic prophylaxis was also collected to determine the baseline surgical site infection (SSI) rate at our institution (Supplemental Table 1).

Outcome Measures

Primary outcome measures were diagnosis of SSI by 14 or 30 days postoperatively. The SSI was determined by the operating surgeon based on clinical signs and symptoms as documented in the medical record upon review. Secondary outcomes included the type of management used to treat infection—oral antibiotics, intravenous antibiotics, operative washout, and/or hardware removal. Demographic factors such as age, sex, race, smoking history, marijuana use history, and comorbidities estimated using the Charlson Comorbidity Index (CCI) as well as procedural details were extracted from the patient's electronic medical records.

Statistical Analysis

Fisher exact tests were performed to compare categorical variables, and Wilcoxon rank-sum tests were performed for continuous variables. A P-value of less than .05 was defined as significant.

Results

A total of 232 patients were included for analysis—152 received antibiotic prophylaxis and 80 did not. There were no differences between the 2 groups in terms of demographic factors, comorbidities, smoking status, or marijuana use except for age (Table 1). The group that received antibiotics was older with a mean age of 47 years compared with 39 years ($P = .018$). Most patients had implantation of metallic hardware such as a plate and/or screws (71%). Suture anchors accounted for 16%, and K-wires for 10%. The remaining patients received a combination of metallic hardware, suture anchors, and K-wires. Surgeon preference for routine antibiotic prophylaxis dictated whether the majority of their patients received preoperative antibiotics as detailed in Table 1.

Overall postoperative infection rate in our patient cohort was 3% with 9 patients diagnosed. There was no difference in infection rates between the 2 groups (Table 2). The infection rate in the antibiotic prophylaxis group was 4.6% and in the sans antibiotics group was 2.5%. All patients with a diagnosed infection were treated with antibiotics. There were no differences between the 2 groups in the rates of operative washout and hardware removal for diagnosed infections. The 2 groups also had similar rates of other postoperative complications which included wound dehiscence, hardware exposure, and prolonged edema or pain—7.5% in the antibiotics group versus 5.9% in the sans antibiotics group (P-value = .8). Based on the control group of 400 patients who underwent soft tissue only cases with no antibiotic prophylaxis, the baseline SSI rate for upper extremity surgery at our institution is 2.3%, which was similar to the rate of infection in the cohort of all hardware implantation cases (3%, $P = .3$) as well as the group of hardware implantation cases with no antibiotic prophylaxis (2.5%, $P = 1$).

Of the 9 cases of SSI, 8 were diagnosed in patients who underwent implantation of plates and screws and 1 was in a patient who had K-wire placement. Only 2 patients required return to the operating room for washout and hardware removal (Table 2), 1 each from the antibiotics and sans antibiotics groups. Microbiology data was available for these 2 patients as bacterial cultures were collected during their washout procedures. Staphylococcus aureus was identified in both cases, although one was methicillin-sensitive and the other methicillin-resistant. We also examined the

Table 1. Demographics.

Median (IQR)	Sans antibiotics (N = 80)	Antibiotics (N = 152)	*P*-value
Age, years	39 (28-55)	47 (32-62)	**.018**
BMI	27 (23-30)	27 (24-31)	.8
N (%)			
Laterality			
Left	40 (50)	70 (46)	.8
Right	40 (50)	81 (53)	
Bilateral	0 (0)	1 (1)	
Sex			.3
Male	41 (51)	65 (43)	
Female	39 (49)	87 (57)	
Race			.13
Non-Hispanic White	11 (14)	23 (15)	
Non-Hispanic Black	23 (29)	25 (16)	
Hispanic	30 (38)	70 (46)	
Asian/Pacific Islander	0 (0)	5 (3.3)	
Other/Unknown	16 (20)	29 (19)	
Smoker	24 (31)	46 (30)	.9
Marijuana user	21 (30)	31 (21)	.17
Diabetes	8 (10)	17 (11)	1
CCI			.067
0	68 (85)	108 (72)	
1	6 (7.5)	25 (17)	
≥2	6 (7.5)	18 (12)	
Hardware Type			.051
Plate/Screw	60 (75)	105 (69)	
K-wire	11 (14)	13 (8.6)	
Anchor	8 (10)	29 (19)	
Plate/Screw/K-wire	0 (0)	5 (3.3)	
K-wire/Anchor	1 (1.3)	0 (0)	
Surgeon			<**.001**
1	3 (3.8)	50 (33)	
2	33 (41)	13 (8.6)	
3	1 (1.3)	38 (25)	
4	0 (0)	45 (29.6)	
5	43 (53.8)	6 (3.9)	

Note. IQR = interquartile range; BMI = body mass index; CCI = Charlson Comorbidity Index; K-wire = Kirschner wire. A *P*-value less than .05 is considered statistically significant and bolded.

Table 2. Outcomes.

N (%)	Sans antibiotics (n = 80)	Antibiotics (n = 152)	*P*-value
Any postoperative infection	2 (2.5)	7 (4.6)	.7
Infection by 14 days	2 (2.5)	4 (2.6)	1
Infection between 15 and 30 days	0 (0)	2 (1.3)	.5
Operative washout	1 (1.3)	1 (0.7)	1
Hardware removal	1 (1.3)	1 (0.7)	1
Other complications	6 (7.5)	9 (5.9)	.8

patients broken down by operating surgeon (Supplemental Table 2). We found that surgeon 4 was responsible for 6 out of the 9 total SSI diagnoses, while the remaining 3 infection cases came from 2 other surgeons (Supplemental Table 3).

Surgeon 4 administered antibiotic prophylaxis to all of his patients.

Discussion

Antibiotic stewardship has become an increasingly important topic in health care. Although the common concerns of *Clostridium difficile* colitis and contribution to antibiotic resistance might not be strongly associated with the single preoperative doses used in surgical prophylaxis, minimizing exposure could still be beneficial. In the survey of hand surgeons conducted by Dunn et al,[9] nearly a quarter of respondents reported witnessing a complication that they attributed to antibiotic use. Minimizing surgical antibiotic prophylaxis could also mean significant cost savings for the health care system, another valuable aspect to consider. In one study evaluating the trends and costs of antibiotic prophylaxis in hand surgery, the authors found that administration of preoperative intravenous antibiotics was associated with significantly higher average total health care expenditures per patient within 30 days of surgery ($6070 vs $4891; $P < .0001$).[13] There are no statistics on the exact number of upper extremity hardware cases performed each year. However, the incidence of traumatic upper extremity fractures can be estimated from epidemiologic data which shows over 1 million annual diagnoses of hand and forearm fractures in the United States.[14,15] Even if only a small portion of these cases undergo operative fixation, foregoing preoperative antibiotics would result in significant cost savings.

Despite the lack of clear guidelines for antibiotic usage in hardware procedures, current literature on soft tissue hand procedures has increasingly challenged conventional practices of routine antibiotic prophylaxis for surgical site infections (SSI).[10-13] First, the incidence of SSIs following upper extremity surgery is already very low. Goyal et al[16] evaluated the rates of adverse events in hand and upper extremity surgical procedures for 28 737 cases in the outpatient setting. Only 58 cases (0.2%) reported adverse events with 14 of those being major infections requiring a return to the operation room or admission for intravenous antibiotic treatment. A retrospective population-based analysis by Li et al[17] employed propensity score matching to examine 516 986 clean soft-tissue hand surgeries in inpatient and outpatient settings and found that antibiotic prophylaxis had no appreciable impact on the rates of postoperative SSIs. Similarly, in a retrospective single-center study of 8850 patients, Bykowski et al[18] found that there was no difference in SSI rates between patients who received antibiotic prophylaxis and those who did not. These studies underscore the very low incidence of major infections following upper extremity surgeries and challenge the need for routine antibiotic prophylaxis.

Although there is a growing body of literature on antibiotic prophylaxis and its impact on postoperative infection rates in soft tissue hand surgery, investigations into the subject of hardware-based implantation in upper extremity surgery remain comparatively scarce and underexplored. To address this challenge in the available literature, Dahmus et al[19] recently published a single-surgeon retrospective cohort analysis of 365 patients who underwent both temporary and permanent hardware implantation procedures to assess the effect of antibiotic prophylaxis on infection rates. They found no differences in infection rates at 30 and 90 days postoperatively for patients who did and did not receive preoperative antibiotics. Infection rates at 30 days were 3.4% in the preoperative antibiotics group and 5.9% in the no preoperative antibiotics group ($P = .288$) and at 90 days were 7.3% and 5.5%, respectively ($P = .508$). There are significant differences when compared with our investigation. In their study all cases were performed by a single operating surgeon, and the decision to administer preoperative antibiotics was arbitrary and relied on the decision of the surgeon's assistant (physician assistants and residents). Our results combine patients from 5 independent hand surgeons. Two of these surgeons do not routinely prescribe antibiotic prophylaxis for clean, hardware cases of the upper extremity, while the remaining surgeons generally do. This mix of routine practice helps remove confounding due to selection bias. Our study also benefits from having an additional control group of soft tissue upper extremity cases that received no antibiotic prophylaxis. Both the Dahmus et al study and our study contribute valuable new data in a severely deficient area of surgical research. And both studies agree that antibiotic prophylaxis might not be necessary in upper extremity surgery with hardware implantation.

In our patient cohort, the antibiotic prophylaxis group had a slightly higher SSI rate at 4.6% compared with 2.5% in the sans antibiotics group. Other than random chance, there are a few possible explanations for this difference, even though it was not statistically significant. This difference could possibly have been due to selection bias as our surgeons might have been more likely to prescribe antibiotics for certain cases that they felt were at higher infection risk. The surgeons who do not routinely administer preoperative antibiotics will do so when they estimate a case will take longer than 4 hours. However, we did not see an association between duration of surgery and infection rate. Another explanation is that we found surgeon 4 had a much higher SSI rate and diagnosed 6 out of the 9 total infections. Since surgeon 4 administered antibiotic prophylaxis to all patients, this could have skewed the results toward higher SSI in the antibiotics group. This much higher SSI rate for surgeon 4 could be related to surgeon technique or could be related to this surgeon having a lower threshold for diagnosing an infection as there is some subjectivity in clinical assessment. However, it is still supportive of our study results since the surgeons who did not routinely prescribe antibiotic prophylaxis did not have higher infection rates

than the other surgeons. Our results are also strengthened by the fact that hardware implantation overall and hardware implantation with no antibiotic prophylaxis both did not increase the SSI rate when using soft tissue cases with no antibiotics as an institutional baseline for comparison.

Inherent limitations of the study include its retrospective design and the potential introduction of biases. The retrospective nature of this study means that the results demonstrate only correlation and cannot be used to determine actual causal relationships. Our sample size is also relatively small given the low incidence of SSI in upper extremity surgery. The small sample size and low number of infections prevented more detailed analysis to elucidate whether prophylactic antibiotics could be beneficial in certain high-risk populations such as those with diabetes, high CCI, or immunosuppression. Similarly, a much larger study could examine whether the type of implanted hardware could have had an impact as the number of patients who had K-wire placement in our cohort was very small. A recent meta-analysis showed that K-wire in hand fracture fixation has a much higher SSI risk compared with internal fixation (7% vs 2%, respectively).[20] Whether this is actually true, however, is uncertain as one of our own authors has published a large K-wire case series reporting 0% infection rate sans antibiotic prophylaxis.[21] Our data analysis was also limited by short follow-up length. Postoperative infection is often examined up to 90 days after surgery. However, in our patient cohort, many patients did not return for follow-up past 1 month if their initial postoperative recovery was uncomplicated. Our assumption is that patients who did not return had no additional complications, but this significant loss to follow-up prevented longer term analysis in our patient cohort. Despite the presumption of accurate and complete medical records (these patients did undergo anesthesia and had complete records), the reliance on electronic medical records for data collection is another limitation of this study. Among the 5 surgeons, variations in clinical diagnosis of SSI and in documentation may lead to inconsistencies in capturing data relevant to postoperative infection onset, type, and severity. In addition, the dichotomy in practice among the surgeons with 3 routinely administering antibiotic prophylaxis and 2 who do not is a potential source of bias in our study. Surgeon technique is, therefore, a possible confounding factor that is difficult to account for. However, having multiple surgeons in each group does help decrease the risk of surgical technique as a confounding factor as well as the fact that we found no differences between the 2 groups. Although no statistical difference was observed in postoperative infection rates between the 2 treatment groups, our results are limited in their direct clinical application, and future prospective studies are needed. Nonetheless, we believe our results provide supporting data that antibiotic prophylaxis is not necessary in upper extremity surgery with hardware implantation.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

Informed consent was waived by the Institutional Review Board for this study as it was a retrospective chart review, and all patient data was de-identified.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: SMK is a committee member of the American Society for Surgery of the Hand (ASSH) and a stockholder and member of the medical advisory board for Reactiv, Inc. The remaining authors have no potential conflicts of interest.

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