BRIEF PRACTICE REPORT

**Preoperative Antibiotic Orders:
Protocol-Initiated Pharmacist Order Entry**

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OBJECTIVE: To evaluate the antibiotic selection of preoperative orders before and after a pharmacist order entry protocol for patients with methicillin-resistant *Staphylococcus aureus* (MRSA) colonization.

METHODS: A retrospective chart review of orthopedic surgery procedures on patients with MRSA colonization at a free-standing, academic pediatric hospital, between February 2010 and February 2012.

RESULTS: Procedures that were performed pre protocol (n = 27) implementation had a 63% rate of appropriate antibiotic selection compared to 81% in the postprotocol group (n = 32; p = 0.1155). The preprotocol group dose accuracy was 96% compared to 97% in the postprotocol group (p = 0.81). Two procedures, 1 in each group, were redosed appropriately for extended surgery duration. Correct timing of antibiotic administration occurred in 82% of cases pre protocol versus 68% post protocol (p = 0.42).

CONCLUSIONS: Patients with MRSA colonization had a greater rate of appropriate drug selection after the implementation of a pharmacist-initiated preoperative protocol. Correct antibiotic dose and redose remained consistent between the study groups. Most of the orthopedic procedures performed included patients on antibiotic coverage at steady state for ongoing infections, which impacted the analysis of preoperative timing. Further studies should be conducted to assess whether the increase in the number of appropriate antibiotic selections decreases the rate of postoperative MRSA infections.

INDEX TERMS: antibiotic prophylaxis, medical order entry systems, methicillin-resistant *Staphylococcus aureus*

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INTRODUCTION

The risk of surgical site infections has become a focal point in hospitals for infection prevention. *Staphylococcus aureus* is the most prevalent pathogen causing surgical site infections, and it has been documented in up to 50% of orthopedic procedure isolates.^{1–3} Of the documented *S aureus* organisms, 49% of those isolates demonstrate a resistance to oxacillin.¹ Methicillin-resistant *S aureus* (MRSA) has been steadily increasing over the past few decades. In the early 1980s, reports of MRSA were 5% to 10% and found in larger urban areas.⁴ By 2004, MRSA was reported in the United States at a rate upwards of 55%.^{2,4,5}

Bundle strategies are often used to reduce postoperative infection rates, including preoperative baths, sterile field preparation, and preoperative antibiotics.³ Antibiotic use has demonstrated significant reduction in morbidity and mortality

since the introduction to surgical practices.⁶ The selection and use of proper prophylactic agents should be based on the antimicrobial's activity against the most likely surgical site pathogens, giving the appropriate dose in the appropriate time frame, and the safety profile of the medication with consideration of patient allergies.^{3,6} The recommended agent for use in orthopedic procedure prophylaxis is cefazolin, with clindamycin or vancomycin reserved for patients with a history of resistant pathogens or drug allergy.

At our institution, a multidisciplinary task force created a preoperative antibiotic protocol that was established in February 2011 to ensure all patients who undergo surgery receive antibiotics in a consistent, evidence-based approach. The protocol was designed as a standing order for improved care practice so that a pharmacist may initiate antibiotic orders by way of the electronic medical record. The orthopedic service was

the first to embrace and implement the protocol and currently has the highest integration of the pharmacist-initiated protocol.

METHODS

The retrospective chart review was approved by the hospital's institutional review board. The requirement for informed consent was waived. Patients younger than 21 years who had an orthopedic procedure between February 2010 and February 2012 were identified through the hospital electronic medical records for potential inclusion in the study. Criteria for inclusion were patients with both a positive MRSA culture (documented infection or surveillance colonization) and procedures that warranted administration of preoperative antibiotics (i.e., irrigation and debridement, spinal instrumentation placement, open reduction). Procedures that did not require antibiotic prophylaxis (i.e., closed reduction or cast change) were excluded.

The primary objective of this study was to evaluate the appropriate antibiotic selection for MRSA-colonized patients receiving surgical prophylaxis before and after protocol implementation. Appropriate antibiotic selection was defined by the use of clindamycin for procedures that had no known MRSA susceptibilities before surgery or vancomycin in the setting of clindamycin-resistant MRSA susceptibilities. Inappropriate antibiotic selection was defined as no antibiotic received preoperatively when one was indicated, any use of cefazolin, or clindamycin administered in the setting of clindamycin-resistant MRSA susceptibilities.

Secondary endpoints were the assessment of correct antibiotic dose, correct preoperative antibiotic administration timing, and correct antibiotic redose for extended procedure duration. Correct dose for the pediatric population was defined as per-kilogram dose with an allowance of $\pm 10\%$ deviation to account for dose rounding. Doses were accepted as appropriate when meeting the maximum range for the patient weight (900 mg clindamycin or 1000 mg vancomycin). Appropriate administration timing was based on completion of antibiotic delivery to patient by anesthesia 0 to 60 minutes before incision. Lastly, correct antibiotic redose was assessed for procedure duration exceeding 3 hours for clindamycin or 6 hours with vancomycin in accordance with

Figure. Inclusion of procedures identified. MRSA, methicillin-resistant *Staphylococcus aureus*

institutional practice.

A power calculation was performed by using nQuery Advisor (Statistical Solutions, Boston, MA) to aid in the determination of sample size and power for the study. A 2-group χ^2 test with a 0.05 two-sided significance level would provide 87% power to detect a 15% difference between the study groups (before and after protocol initiation) with a sample size of 150 in each group. Statistical significance was determined for $p < 0.05$.

Nominal data were obtained retrospectively. The goal was to compare the primary endpoint between the preprotocol and postprotocol groups (February 2010–January 2011 and February 2011–February 2012, respectively) in the specified population. The χ^2 test was performed to compare the percentages at each interval. Data were analyzed through SPSS (IBM Corporation, Armonk, NY) and summarized with descriptive statistics.

RESULTS

A total of 4499 orthopedic procedures were performed between February 2010 and February 2012. Fifty-nine procedures were included for analysis on the basis of the inclusion and exclusion criteria (Figure). Procedures that were performed pre protocol implementation had a 63% ($n = 27$) rate of appropriate antibiotic selection compared to 81% in the postprotocol group ($n = 32$; $p = 0.1155$).

Table. Results of Preprotocol and Postprotocol Outcomes

	Preprotocol (n = 27)	Postprotocol (n = 32)	p Value
Correct antibiotic selection, n (%)	17 (63)	26 (81)	0.1155
Correct antibiotic dose ($\pm 10\%$), n (%)	22 (96)*	31 (97)	0.81
Correct antibiotic redosed (procedure duration > 3 hr), n (%)	1 (100)	1 (100)	—
Correct preoperative antibiotic administration timing (0-60 min), n (%)	9 (82)†	11 (58)‡	0.42

* Excludes 4 procedures that did not receive antibiotics when prophylaxis was warranted

† Excludes 12 procedures that were receiving previous antibiotic coverage, 4 patients did not receive preoperative antibiotic

‡ Excludes 13 procedures that were receiving previous antibiotic coverage for an active infection, required no preoperative dose

The correct dose and redose of antibiotics in both groups remained consistent for the study period (Table). The preprotocol group dose accuracy was at 96% compared to 97% in the postprotocol group ($p = 0.81$). Four of the procedures in the preprotocol group were not assessed for correct dose, as they were not administered antibiotics before the procedure when prophylaxis was warranted. Two procedures, 1 in each group, were redosed appropriately for extended surgery duration.

Twelve patients in the preprotocol group and 13 in the postprotocol group were noted to have received antibiotics (clindamycin or vancomycin) on a scheduled basis for active skin or bone infections before surgery. These patients were at steady state with antibiotic dose and did not require intraoperative administration. The antibiotic selections for these were analyzed for appropriateness, but they were not analyzed for timing. Timing was also not assessed for 4 patients in the preprotocol group who did not receive any preoperative antibiotic coverage. Correct timing of antibiotic administration occurred in 82% of cases pre protocol versus 58% post protocol ($p = 0.42$).

DISCUSSION

This study helped to demonstrate the impact of pharmacist involvement in order entry of preoperative antibiotics for prophylaxis at our institution. Patients with MRSA colonization had a greater rate of appropriate drug selection after the implementation of a pharmacist-initiated preoperative protocol. The results demonstrate there was not a statistically significant difference between the two; however, there is likely a clinically significant impact for appropriate antibiotic

selection. This was likely a result of the lower than anticipated study population.

Correct antibiotic dose and redose remained consistent between the study groups. Most of the orthopedic procedures performed included patients on antibiotic coverage at steady state for ongoing infections, which impacted the secondary outcome of preoperative timing.

A larger percentage of antibiotics were administered with the appropriate preoperative timing in the preprotocol group. Further review was warranted to determine why the correct timing of preoperative antibiotics decreased after protocol initiation. Upon review of the procedures that were inappropriately timed, most were due to procedural precedence that required a sterile environment culture be obtained at the infected site (i.e., abscess, joint) before antibiotic administration. This may indicate appropriate procedural processes but does not allow for appropriately timed prophylaxis administration. However, the result of this *post hoc* analysis does demonstrate that the timing was not worse as a result of pharmacist order entry and/or medication delivery.

There were several limitations with this study. The results of this analysis were dependent upon the retrospective chart review process and susceptible to selection bias. It is difficult to ascertain the patients that may have been left out of our study analysis as a result of delayed or poor reporting of MRSA status in the electronic medical record. As a result of these limitations, the small patient population was unable to meet power. Broadening the patient database to include other surgical services may be able to elucidate a statistically significant result in the future.

Pediatric orthopedic surgery patients with MRSA had a greater percentage of appropriate antibiotic selection after the preoperative proto-

col than those 1 year prior. Continued improvements in antibiotic selection are expected with closer monitoring of patient culture surveillance and MRSA history per the electronic medical record.

The results of this study will hopefully aid in the review of other surgical services that have now adopted the protocol-initiated pharmacist order entry procedure. Further studies should be conducted to assess whether the increase in the number of appropriate antibiotic selections decreases the rate of postoperative MRSA infections.

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Abbreviations MRSA, methicillin-resistant *Staphylococcus aureus*

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