Brief Communication

Sensitivity and Specificity of prior Methicillin-Resistant *Staphylococcus aureus* Nasal Swab Results for Predicting Methicillin-Resistant *Staphylococcus aureus* Infections in Intensive Care Unit Admissions Over a 1-Year Period: A Pilot Study

Jonathan Wadle[1], Geoffrey C. Wall[2], Hayden S. Smith[3]

[1]Department of Medicine, Iowa Methodist Medical Center, Des Moines, Iowa, USA

[2]Department of Pharmacy, Iowa Methodist Medical Center, Des Moines, Iowa, USA

[3]Iowa Methodist Medical Center, Des Moines, Iowa, USA

ABSTRACT

Objective: Methicillin-resistant *Staphylococcus aureus* (MRSA) continues to be a pathogen worldwide. Empiric anti-MRSA therapy is often prescribed in hospital inpatients with potential infection. Recent studies have suggested, particularly for respiratory infections, that MRSA colonization as determined by nasal swab has a high negative predictive value (NPV) for MRSA infections during the index hospitalization. We examined the predictive value of a prior intensive care unit (ICU) MRSA nasal swab on the results from a subsequent ICU admission in the same patient and the results of the latter admission MRSA nasal swab. **Methods:** A retrospective chart review of patients 18 years or older admitted to a large tertiary care hospital in the Midwest of the United States in 2016 who had a MRSA nasal swab performed and had an ICU admission stay of over 24 h was conducted. This group of patients was matched to a patient list of subjects who were admitted as an inpatient to the same ICU at least once during the following year. Data were collected on demographic and clinical information, as well as the results of MRSA swabs and the presence of a MRSA infection during both hospitalizations. Predictive values were calculated using 2 × 2 tables including sensitivity and specificity of a first MRSA swab result with a MRSA infection during the subsequent ICU stay. **Findings:** Seventy-seven patients were matched who had MRSA swabs performed on two separate ICU admissions. The negative predictive value of the first MRSA swab result on a MRSA infection during the second ICU stay was 96%. **Conclusion:** In this pilot study, a previous negative MRSA nasal swab may predict a lack of a MRSA infection in a subsequent infection during a 1-year period.

Keywords: *Antimicrobial stewardship, infection, Methicillin-resistant Staphylococcus aureus, nasal swab*

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Introduction

Methicillin-resistant *Staphylococcus aureus* (MRSA) infections are common, expensive, and often, deadly problems.[1,2] In fact, in the USA, most hospitals have a MRSA prevalence rate of over 50%.[3] The increasing incidence of MRSA infections has forced clinicians to commonly employ empiric antimicrobial coverage for MRSA in high-risk patients, and concomitant anti-MRSA drug use has correspondingly increased across the country in the past 25 years. Empiric treatment for MRSA is often codified in clinical practice guidelines, such as the Infectious Disease

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Address for correspondence:
Dr. Geoffrey C. Wall, E-mail: geoff.wall@drake.edu

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Society of America's Community-Acquired Pneumonia guidelines.[4]

Vancomycin use is usually considered the anti-MRSA treatment of the first choice in most US hospitals. However, several reasons exist why limiting the use of vancomycin may be advantageous. Hospitals with low background use of vancomycin have shown lower numbers of MRSA isolates exhibiting minimum inhibitory concentration "Creep," which has been associated with worse infection outcomes.[5] Vancomycin has long been associated with nephrotoxicity by itself, and this association is stronger with concomitant piperacillin/tazobactam.[6] Thus, limiting empiric vancomycin use is an attractive target for antimicrobial stewardship programs. To this end, multiple articles have been published suggesting that surveillance cultures for MRSA obtained from the nares and often used for infection control purposes may also be used to predict infections with MRSA during that index hospitalization. To date, studies seeking to determine the positive and negative predictive values of MRSA nasal swabs for MRSA infections have been examined in pneumonia, skin and soft-tissue infections, and intra-abdominal infections[7,8] In general, previous studies have suggested that MRSA nasal swabs have a low positive predictive value (PPV) and a high negative predictive value (NPV), usually >90%, for actual MRSA infections during the index hospitalization. At our large tertiary community hospital, routine MRSA nasal swab results have been utilized for over a decade, and its use has become largely the standard of care to discontinue empiric vancomycin therapy for most suspected infections. However there appears to be no published data. concerning if in patients with multiple hospitalizations at an institution, the previous MRSA nasal swab results may predict MRSA infections in subsequent hospitalizations over a certain period of time. To this end, a retrospective cross-sectional study was conducted at our institution to determine the predictive characteristics of MRSA swab results on downstream hospitalization MRSA infections.

The objective was to assess the sensitivity, specificity, and positive and negative predictive value of previous MRSA nasal swab results and subsequent MRSA infections on subsequent hospitalization swabs that occurred within 1 year.

Methods

This is a cross-sectional study. After obtaining the institutional review board approval (Approval # 028-2019), a chart review was conducted by the authors of patients. We reviewed patients 18 years or older admitted to a Midwestern community tertiary hospital from January 1, 2016 to December 31, 2016 with a MRSA nasal swab performed and had an intensive care unit (ICU) hospital stay of at least 24 h. The authors did random cross chart abstractions of their co-authors first 20 charts to minimize errors. A standard online data collection sheet was used for all charts. This patient list was matched to a patient list of subjects who were admitted to the same hospital ICU for more than 24 h during the same study period. Patients listed in both databases were considered the study sample of interest. Data were collected on patient demographics, admission reason, MRSA swab results during the first index hospital stay, any MRSA infections that occurred during that hospitalization, MRSA swab data collected within the next hospitalization (if any), and any MRSA infections reported during that subsequent hospital stay. Electronic medical records were also reviewed for microbiologic data for evidence of an MRSA infection, including blood, respiratory, urinary, wound, or body fluid cultures. MRSA recovered from any sterile site was considered a positive infection for purposes of the study. If a patient was hospitalized more than twice during the study period, the index and the first subsequent hospitalization were solely used. The different types of infections (e.g., respiratory, skin and skin structure, bacteremia, etc.,) caused by MRSA were recorded. Attending physicians decided the empirical and definite antibiotic therapies in all cases. At the study hospital, MRSA nasal carriage was determined using polymerase chain reaction (Xpert MRSA [GeneXpert] system [Cepheid, Sunnyvale, CA, USA]). The sensitivity, specificity, PPV, and NPV of the MRSA nasal swab for detecting culture-proven MRSA pneumonia were calculated. Calculations were performed with 2 × 2 tables using Microsoft Excel (Microsoft, Seattle, WA, USA).

Results

The study sample consisted of 88 patients who were admitted to our ICU at least twice during the study period and had a MRSA swab during their first hospitalization. Seventy-seven patients had two MRSA swabs performed, one on each admission. The average age was 60 (standard deviation [SD]: 15.53, 95% confidence interval [CI] [57.05–63.52]) years with 42% of patients in the cohort being female. Thirty-eight of 88 (43%) patients had diabetes and 11 of 88 (12.5%) were considered immunosuppressed (e.g., taking immunosuppressive drugs or had active hematologic cancer). The primary reasons for admission related to infectious diseases were pneumonia, known or suspected, 24/88 (27%) for the first admission, and 20/88 (23%) second admission. Sepsis/septic shock was present in 16/88 (18%) first admission and

14/88 (16%) second admission. The mean number of days between admission one and two in the 77 matched patients was 141 days (SD: 53 days, 95% CI 102–178). The MRSA swab result and MRSA infection rate for each hospitalization are listed in Table 1. Predictive results of the first MRSA swab on the index (first) and subsequent (second) hospitalization are listed in Table 2. As a group, MRSA infections occurred in 3/88 (3%) patients during the first hospitalization in 5/88 patients (5.7%) during the second hospitalization. The MRSA infections during the first hospitalization were skin/wound (1), pneumonia (1), and bacteremia (1). During the second hospitalization, MRSA infections were skin/wound (1), bone (2), bacteremia/endocarditis (1), and pneumonia (1). The NPV of a MRSA swab taken during the first hospitalization for a MRSA infection during the first hospitalization was 99% and for a second hospitalization was 96%.

Discussion

This retrospective study performed at a large community hospital with average MRSA infection rate comparable to the rest of the US Midwest found that a negative nasal MRSA carriage had a high NPV to rule out not only index hospitalization MRSA infection but also any MRSA infection that occurs within 1 year of that index ICU stay. A high NPV may allow clinicians who are seeing patients admitted to the same facility twice in a 1 year, to review the previous MRSA swab results and not initiate anti-MRSA therapy in a patient with a potential infection. Such actions may save resources as patients who had a recent MRSA swab that was negative would not need a subsequent test to effectively choose empiric antibiotic therapy. However, as others have reported a positive MRSA swab does not confer confidence that an MRSA infection is likely.[7] In our study, the PPV of an index MRSA swab was only 20%. Thus, a positive MRSA nasal swab results did not reliably predict an MRSA infection at either first or second hospitalization.

This study should be broadly generalizable to other health-care centers that have a similar background rate of MRSA infections. We did not exclude any type of infection in our review, and suspected infection included pulmonary, skin and soft tissue, bacteremia, endocarditis, osteomyelitis, and diabetic foot infections. Although the bulk of the published data concerning the utility of MRSA swabs to predict clinical infection has been in pneumonia, the institutional experience at the study center and the results of this study suggest that for most common suspected clinical infections, a negative MRSA swab could be used to discontinue anti-MRSA empiric therapy.

The presented study had several limitations. First, the overall small total number of patients with a MRSA swab done during a first ICU stay who were hospitalized in the same ICU a second time within a year was low. Larger studies done over a longer period of time may increase the robustness of results. Second, this study was not designed nor powered to identify the risk factors for developing MRSA colonization between the first and second hospitalizations. Certainly, other larger studies have already been published and explore those risk factors in more detail.[9] Third, clinical isolates were not

Table 1: Methicillin-resistant *Staphylococcus aureus* nasal and infection results from a large Midwestern community hospital

	First hospitalization (*n*=88)	Second hospitalization (*n*=88)	First MRSA results on second hospitalization (*n*=77)
MRSA nasal swab (+)/MRSA infection (+)	10/2	6/3	10/2
MRSA nasal swab (+)/MRSA infection (−)	10/8	6/3	10/8
MRSA nasal swab (−)/MRSA infection (−)	78/76	82/81	67/64
MRSA nasal swab (−)/MRSA infection (+)	78/1	82/1	67/3

MRSA: Methicillin-resistant *Staphylococcus aureus*

Table 2: Predictive results of methicillin-resistant *Staphylococcus aureus* nasal swab on and infection results from a large Midwestern community hospital

	First MRSA swab to MRSA infection first hospitalization	Second MRSA swab to MRSA infection second hospitalization	First MRSA swab to MRSA infection second hospitalization
Sensitivity (%), 95% CI	67 (9-99)	75 (19-99)	40 (5-85)
Specificity (%), 95% CI	90 (82-96)	96 (90-99)	89 (79-95)
PPV (%), 95% CI	20 (3-56)	50 (12-88)	20 (3-56)
NPV (%), 95% CI	99 (93-100)	99 (93-100)	96 (87-99)
Accuracy (%), 95% CI	90 (81-95)	95 (89-99)	86 (76-93)

CI: Confidence interval, NPV: Negative predictive value, PPV: Positive predictive value, MRSA: Methicillin-resistant *Staphylococcus aureus*

available for pulsed-field gel electrophoresis to assess the clonality of the paired isolates from clinical and nasal swabs in our patients. Thus, it was impossible to determine if those with MRSA colonization are actually infected with that strain of MRSA. Finally, some infections, notably meningitis, were not included in the cohort at all, and we would not recommend utilizing a previous MRSA swab to decide on empiric anti-MRSA therapy in these patients.

In conclusion our pilot study found that a negative nasal MRSA carriage result in a previous ICU hospitalization is specific in ruling out a subsequent MRSA infection in that same patient up to 1 year after the initial test. These results, if corroborated in larger studies, may allow the clinician to forgo empiric anti-MRSA therapy in these patients, thereby reducing exposure to these drugs as well as performing multiple MRSA swab testing on the same patient.

Authors' Contribution

The authors confirm contribution to the paper as follows: study conception and design: Jonathan Wadle, Geoffrey C. Wall, Hayden S. Smith; data collection: Jonathan Wadle, Geoffrey C. Wall; Analysis and interpretation of results: Jonathan Wadle, Geoffrey C. Wall, Hayden S. Smith; draft manuscript preparation: Jonathan Wadle, Geoffrey C. Wall, Hayden S. Smith. All authors reviewed the results and approved the final version of the manuscript.

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Conflicts of interest

There are no conflicts of interest.

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