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Major article

Risk of methicillin-resistant *Staphylococcus aureus* surgical site infection in patients with nasal MRSA colonization

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Background: Patients colonized with methicillin-resistant *Staphylococcus aureus* (MRSA) are at increased risk for invasive infection compared with noncolonized patients; however, the magnitude of risk for MRSA surgical site infection (SSI) is unclear. To aid in planning of infection prevention strategies, we sought to assess the incidence of MRSA SSI in MRSA carriers.

Methods: We conducted a retrospective cohort study at our tertiary care center of inpatients who underwent MRSA polymerase chain reaction (PCR) screen of the nares within 30 days before a National Healthcare Safety Network principal procedure between April 2008 and July 2010.

Results: The rate of MRSA SSI was 1.86% in the MRSA PCR-positive group (n = 431) and 0.20% in the MRSA PCR-negative group (n = 9432). Multivariate analysis identified MRSA PCR-positive status as an independent risk factor for MRSA SSI (odds ratio, 9.20; 95% confidence interval, 3.81-20.47; $P < .0001$); other risk factors included duration of surgery ≥137 minutes, American Society of Anesthesiologists score ≥3, and abdominal surgery.

Conclusions: Surgical patients with a positive nasal MRSA PCR screen had a 9-fold greater odds of developing a subsequent MRSA SSI compared with patients with a negative nasal MRSA PCR screen. The incidence of MRSA SSI in PCR-positive patients was low (1.86%), however, and identifying subsets of patients at greatest risk for SSI may help target decolonization and other interventions.

Staphylococcus aureus is a common bacterial pathogen that causes significant morbidity and mortality in the community and in hospitals.[1,2] Nationwide surveys estimated that *S aureus* nasal colonization occurred in 28% of the general US population during 2003-2004; methicillin-resistant *Staphylococcus aureus* (MRSA) nasal colonization was found in 1.5% of this population.[3] A large study of US Veterans Administration Hospitals found that an average of 13.6% of patients had MRSA colonization or infection.[4] MRSA-colonized patients are at increased risk for subsequent clinical infection (eg, MRSA bacteremia and pneumonia) compared with non–MRSA-colonized patients.[5]

According to 2006-2008 national surveillance data, surgical site infection (SSI) complicates 1.9% of surgical procedures.[6] Each SSI can lead to at least 1 additional week of hospitalization and can increase the risk of death by 2- to 11-fold compared with cases without an SSI.[7] These infections are associated with additional costs of $12,000-$35,000 per case in the United States.[8] Risk factors for SSIs described in the literature include diabetes mellitus, malnutrition, smoking, obesity, and colonization with *S aureus* (for subsequent *S aureus* SSI).[9] The SSI risk stratification scoring system used by the US National Nosocomial Infection Surveillance, now known as the National Healthcare Safety Network (NHSN), includes duration of surgery, American Society of Anesthesiologists (ASA) physical status classification, and wound class.[10] MRSA SSIs constitute approximately 20% of SSIs in the United States annually.[11]

In 2003, the Society for Healthcare Epidemiology of America (SHEA) recommended the use of MRSA screening of hospitalized patients as a tool for controlling the nosocomial spread of MRSA.[12] The primary purpose of screening is to rapidly identify inpatients with MRSA colonization; for MRSA screen-positive patients, contact

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precautions are implemented to reduce the risk of transmission in the hospital setting. MRSA screening was implemented at our hospital in April 2008 for inpatients at the time of admission, and MRSA-colonized patients were routinely assigned to contact precautions. Decolonization procedures were not standard, and the preoperative administration of prophylactic vancomycin for MRSA carriers was not routine at our hospital. The aims of this study were to measure the magnitude of risk for MRSA SSI among MRSA carriers, and to assess whether institutional changes in practice are warranted to reduce MRSA SSI risk. We conducted a retrospective cohort study to assess rates of MRSA SSI in patients with a MRSA-positive screen who subsequently underwent a surgical procedure at our institution.

METHODS

This study was conducted at the Penn State Hershey Medical Center, a 500-bed tertiary care teaching hospital (with primarily single patient rooms) located in south-central Pennsylvania. The hospital's Institutional Review Board approved this study. As part of an ongoing hospital surveillance program, nasal swabs were performed on admission for all patients except those admitted to the obstetrics service. Nasal swabs were screened using the BD Gene Ohm MRSA polymerase chain reaction (PCR) assay (BD Diagnostics, San Diego, CA). To reduce testing costs, screening was not performed on patients with a history of MRSA colonization or MRSA clinical infection within the previous year; this strategy was based on studies reporting high rates of persistent MRSA colonization in hospitalized patients.[13]

Using the electronic medical record, we identified inpatients who underwent nasal MRSA screening and a surgical procedure within 30 days after the screening. These patients were eligible for inclusion in the study. The study was limited to the types of surgical procedures that are monitored under the NHSN. Only the surgery coded as the principal procedure (hereinafter referred to as the principal NHSN procedure) was included. The study period covered surgeries performed between April 2008 and July 2010. In patients with more than 1 hospitalization for NHSN surgical procedures during the study period, the principal NHSN procedure for each hospitalization was included.

The surgical cases were classified into 2 groups based on the MRSA PCR screen results: a MRSA PCR-positive group (patients with a positive MRSA PCR screen who underwent surgery on the same day or within the subsequent 30 days) and a MRSA PCR-negative group (patients with a negative MRSA PCR screen who underwent surgery on the same day or within the subsequent 30 days). The primary outcome was development of a MRSA SSI within 30 days after a nonimplant surgery or within 1 year after implant surgery, as defined by the NHSN.

Data sources

Data were extracted from electronic medical records. Baseline characteristics of the MRSA PCR-positive and MRSA PCR-negative groups included age, sex, presence or absence of diabetes (based on International Classification of Diseases, Ninth Revision, Clinical Modification codes), wound class, ASA class, duration of surgery, case status (emergent, urgent, or elective), and vancomycin administration on the same day as surgery.

Statistical analysis

Descriptive analyses were performed to compare demographic and clinical characteristics between MRSA PCR-positive and MRSA PCR-negative groups. The t test was used for all continuous variables, and the χ^2 test and Fisher's exact test were used for comparisons of proportions, as appropriate. Results were comparable, and thus only Fisher's exact P values are shown in the tables. A small percentage of patients who had more than 1 admission in which a principal NHSN procedure was performed were included more than once in the database. Complete data were available for all variables except ASA class; approximately 10% of cases did not have a recorded ASA class. To enable the inclusion of cases with missing ASA class data, a multiple imputation procedure using a sequential regression imputation method was performed to estimate a predicted ASA class.[14] Five separate imputed datasets were created. Statistical analysis was conducted on each dataset, and results were combined according to the formulas used for multiple imputation.

A multivariate logistic regression model using the Firth bias reduction method[15] and profile penalized likelihood confidence intervals (CIs) to reduce estimation bias in samples with small event sizes was performed on the imputed data. For this, MRSA SSI was treated as the dependent variable and positive MRSA PCR was treated as a predictor, adjusting for other covariates found to have a significant association with positive MRSA PCR or MRSA SSI in the bivariate analysis. Adjusted odds ratios (ORs) and their 95% CIs were computed to assess statistical significance. The final model results were compared with results from an exact logistic regression and results after removal of nonsignificant variables. All statistical analyses were performed using SAS version 9.3 (SAS Institute, Cary, NC) with the imputation program[16] to produce the imputed datasets.

RESULTS

Surgical cases

A total of 13,017 principal NHSN procedures were performed during the study period. Of these 13,017 surgical cases, 9,873 had at least 1 nasal MRSA PCR screen done within the 30 days before the surgery or on the day of the procedure. Ten surgical cases were not included because the duration of surgery was not documented correctly. Consequently, a total of 9006 patients who underwent 9863 surgical procedures were included in this study (Fig 1). The most frequently performed procedures were abdominal surgery (29.8%), orthopedic surgery (21.8%), neurosurgery (19.7%), and cardiothoracic and vascular surgery (16.7%). The remainder of the procedures were breast, head and neck, gynecologic, transplantation, and urologic surgeries.

MRSA PCR-positive versus MRSA PCR-negative groups

Of the 9,006 patients, 387 (4.3%) had at least 1 positive MRSA PCR screen either on the same day or within 30 days before surgery. The median age for the cohort was 56 years, and the median duration of surgery was 137 minutes. Compared with the MRSA PCR-negative cases, the MRSA PCR-positive cases were significantly older (mean age, 56.2 $\pm$ 22.6 years vs 51.3 $\pm$ 23.2 years; $P < .001$) and were more likely to have a ASA class ≥ 3 (64% vs 52.9%; $P < .0001$) and diabetes (25.3% vs 17.3%; $P < .0001$) (Table 1). There were no significant between-group differences in distributions of sex, case status, duration of surgery, and types of surgery. The rate of administration of preoperative vancomycin-containing regimens was significantly higher in the MRSA PCR-positive group (20.2% vs 10.2%; $P < .0001$).

MRSA SSI

MRSA SSI occurred in 27 of 9,863 cases (0.27%). Eight of the 431 MRSA PCR-positive patients (1.86%) developed MRSA SSI, compared