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CONCISE COMMUNICATION

Risk Factors for Methicillin-Resistant *Staphylococcus aureus* Surgical Site Infection

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We prospectively evaluated 46 possible risk factors for methicillin-resistant *Staphylococcus aureus* (MRSA) surgical site infection (SSI) among patients with MRSA carriage in a large intervention study. Of 6,130 study patients, 68 (1.1%) developed MRSA SSI, which occurred a median of 14 days after surgery. Risk factors associated with MRSA SSI were receipt of emergency surgery, presence of comorbid condition, receipt of immunosuppressive therapy, receipt of contaminated surgery, and a surgical duration longer than the 75th percentile. MRSA carriage on admission did not predict MRSA SSI.

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Carriage of methicillin-resistant *Staphylococcus aureus* (MRSA) increases the risk of nosocomial infection.¹ However, there is scant information about easily modifiable risk factors associated with MRSA surgical site infection (SSI).² Manian et al.³ suggested that postoperative factors may play an important role in the causation of MRSA SSI. We conducted the present study to determine whether previously identified risk factors (including MRSA carriage on admission) are associated with MRSA SSI.

METHODS

This study was performed in the surgical department of the Geneva University Hospitals. Data analyzed for this study were part of a prospective MRSA screening study performed from July 2004 through June 2006.⁴ During this period, patients hospitalized for more than 24 hours were screened for MRSA carriage on admission, by means of a cross-over design. MRSA carriers received topical decolonization therapy (nasal mupirocin treatment and washing with chlorhexidine soap) for 5 days. A complete description of the study design, patient population, microbiologic studies, and surveillance methods has been reported elsewhere.⁴

For the present study, we included only patients from the 2 intervention periods of the previously mentioned study⁴ who had been screened for MRSA carriage on admission. Patients from the 2 control periods were excluded. We performed a risk factor analysis for MRSA SSI among patients who underwent at least 1 surgical procedure and who had a positive test result for MRSA carriage during the 2 intervention periods. Patients with non-SSI types of nosocomial

MRSA infection were excluded, except patients with MRSA bacteremia secondary to SSI.

For all patients with MRSA carriage, research assistants extracted information from the medical records on sociodemographic data, comorbidities, severity of underlying illness, patient's prior location and transfer status, previous hospitalization, presence of indwelling device or skin lesions, past history of MRSA carriage, receipt of antibiotic treatment within the previous 6 months, receipt of perioperative antibiotic prophylaxis, and the National Nosocomial Infections Surveillance system risk score.⁵ The study was approved by the institutional review board of the study hospital as a continuous quality improvement project; therefore, no informed consent was required.

The primary outcome of interest was occurrence of MRSA SSI, defined on the basis of standard Centers for Disease Control and Prevention criteria.⁵ If a patient was admitted more than once during the study period, only the first hospitalization was included in the logistic regression analysis. In addition, 46 variables were evaluated by bivariate analysis as predictors of MRSA SSI. Variables with a *P* value less than .1 in the bivariate analysis were candidates for multivariable modeling, which was performed by stepwise logistic regression analysis. The statistical software used was Stata, version 9.0 (StataCorp).

RESULTS

Of 6,130 patients who underwent operations, 68 developed 70 MRSA SSIs, corresponding to an overall rate of 1.14 MRSA SSIs per 100 surgical procedures. The median interval from surgery to occurrence of MRSA SSI was 14 days (interquartile range [IQR], 6–28 days). Table 1 summarizes the characteristics of the 68 included patients, stratified by

TABLE 1. Characteristics of Patients With Methicillin-Resistant *Staphylococcus aureus* (MRSA) Surgical Site Infection (SSI)

Characteristic	No. of patients (<i>n</i> = 68)
Surgical subspecialty	
Abdominal	26
Orthopedics	24
Urology	8
Cardiovascular and thoracic	5
Other ^a	5
Type of SSI	
Superficial	24
Deep	24
Organ space	20
With secondary MRSA bacteremia	3

^a Other includes neurosurgery, plastic surgery, and transplant surgery.

TABLE 2. Characteristics of Patients With and Patients Without Methicillin-Resistant *Staphylococcus aureus* (MRSA) Surgical Site Infection (SSI)

Variable	Patients with MRSA SSI (n = 68)	Patients without MRSA SSI (n = 602)	P
General characteristics			
Age, mean \pm SD, years	64 \pm 18	64 \pm 18	.82
Male sex	37 (54)	361 (60)	.38
Emergency admission	47 (69)	289 (48)	.001
Previous antibiotic exposure (past 6 months)	23 (34)	163 (27)	.24
Immunosuppressive therapy	10 (15)	26 (4)	<.001
Previous hospital stay	40 (59)	305 (51)	.20
Transfer within hospital	41 (60)	227 (38)	<.001
Comorbidity factors			
Absence of comorbidities	12 (18)	214 (36)	.003
Chronic obstructive pulmonary disease	5 (7)	53 (9)	.69
Chronic renal insufficiency	8 (12)	56 (9)	.51
Ischemic heart disease	13 (19)	178 (30)	.07
Diabetes mellitus	21 (31)	94 (16)	.002
Chronic skin disease	5 (7)	11 (2)	.02
Rapidly or ultimately fatal disease	23 (34)	117 (19)	.006
Charlson comorbidity score ≥ 2	28 (41)	193 (32)	.13
ASA risk category ^a of ≥ 3	43 (63)	283 (47)	.01
Catheter use			
Central venous catheter in place for >24 h	20 (29)	76 (13)	<.001
Urinary catheter in place for >24 h	44 (65)	262 (44)	.001
Length of stay			
Duration of postoperative ICU care >24 h	25 (37)	92 (15)	<.001
Duration of preoperative hospitalization, median (IQR), days	1 (1–5)	1 (1–3)	.92
Duration of postoperative hospitalization, median (IQR), days	35 (19–62)	10 (6–17)	<.001
Surgery-related factors			
Surgical time > T ^b	33 (49)	136 (23)	<.001
Wound contamination class of “clean” or “clean-contaminated”	30 (44)	433 (72)	<.001
Receipt of perioperative prophylaxis active against MRSA	19 (28)	132 (22)	.26
MRSA status			
History of previous MRSA colonization	13 (19)	99 (16)	.58
Newly identified MRSA carriage on admission	15 (22)	218 (36)	.02
Absence of preoperative MRSA carriage	40 (59)	285 (47)	.07
Receipt of preoperative MRSA decolonization (≥ 5 days)	6 (9)	99 (16)	.097
Receipt of postoperative MRSA decolonization (≥ 5 days)	46 (68)	399 (66)	.88
Duration of decolonization treatment, mean \pm SD, days	4.8 (\pm 2.4)	4.6 (\pm 2.6)	.44

NOTE. Data are no. (%) unless otherwise specified. ASA, American Society of Anesthesiologists; ICU, intensive care unit; IQR, interquartile range; SD, standard deviation.

^a The ASA physical status classification defines class 1 as a healthy patient; class 2, a patient with mild systemic disease; class 3, a patient with severe systemic disease; and class 4, a patient with severe systemic disease that is a constant threat.

^b “Surgical time > T” is defined as duration of operation longer than the 75th percentile.

type of SSI and surgical subspecialty. Thirteen infected patients (19%) had a history of previous MRSA carriage, whereas 15 (22%) had MRSA carriage newly identified by admission screening.

We included in the present analysis 670 surgical patients who tested positive for MRSA carriage at any time during hospitalization. Of these, 233 patients (35%) had MRSA carriage newly detected on admission and 325 (48%) had MRSA carriage discovered only later during hospitalization (median interval from admission to detection, 8 days [IQR, 3–15 days]).

Important characteristics of patients with and patients without MRSA SSI are summarized in Table 2. By univariate logistic regression analysis, we found that 14 covariates were associated with MRSA SSI: receipt of emergency surgery (OR, 2.5 [95% confidence interval {CI}, 1.4–4.3]); intrahospital transfer (OR, 2.5 [95% CI, 1.5–4.2]); receipt of immunosuppressive therapy (OR, 3.8 [95% CI, 1.8–8.3]); number of comorbidities (OR per comorbidity, 1.2 [95% CI, 1.0–1.5]), including diabetes mellitus (OR, 2.4 [95% CI, 1.4–4.2]) and chronic skin conditions (OR, 4.2 [95% CI, 1.4–12.7]); presence of rapidly or

ultimately fatal disease (OR, 1.8 [95% CI, 1.2–2.7]); American Society of Anesthesiologists risk score of 3 or higher (OR, 1.6 [95% CI, 1.2–2.3]); use of a central venous catheter for more than 24 hours (OR, 2.9 [95% CI, 1.6–5.1]); use of a urinary catheter for more than 24 hours (OR, 2.4 [95% CI, 1.4–4.0]); stay in intensive care unit (OR, 3.2 [95% CI, 1.9–5.5]); duration of surgery longer than the 75th percentile (OR, 3.2 [95% CI, 1.9–5.3]); and wound contamination class of “contaminated” surgery (OR, 1.9 [95% CI, 1.5–2.5]). Receipt of postoperative decolonization treatment (OR, 1.0 [95% CI, 0.6–1.8]) and receipt of perioperative antibiotic prophylaxis active against MRSA (OR, 0.8 [95% CI, 0.4–1.6]) had no measurable effect.

In the multivariable model (area under the receiver operating characteristic curve [AUC], 0.79), we identified 5 independent risk factors for MRSA SSI: duration of surgery longer than the 75th percentile (OR, 3.0 [95% CI, 1.7–5.1]), wound contamination class of “contaminated” surgery (OR, 1.7 [95% CI, 1.3–2.2]), receipt of immunosuppressive therapy (OR, 2.7 [95% CI, 1.2–6.5]), receipt of emergency surgery (OR, 2.2 [95% CI, 1.2–4.0]) and the presence of at least 1 comorbidity (OR, 2.3 [95% CI, 1.2–4.7]). Of note, MRSA carriage on admission and receipt of topical decolonization treatment were not correlated with MRSA SSI.

DISCUSSION

We examined 46 risk factors for MRSA SSI in 670 patients with MRSA carriage included in a large clinical trial. The probability of MRSA SSI was 2–3 times greater among patients who had emergency surgery, a “clean” or “clean-contaminated” wound, prolonged surgery, comorbidities, and/or immunosuppressive therapy. The majority of patients with MRSA SSI were free of MRSA on admission. This finding might explain, at least in part, why in our study a commonly accepted risk factor for MRSA SSI (carriage on admission) did not predict which patients would develop infection.

Only a few studies have reported detailed rates of MRSA SSI. In the study by Manian et al.,³ 75 (0.32%) of 23,671 surgical procedures were associated with MRSA SSI. Anderson et al.⁶ reported from 26 US community hospitals a rate of 0.23 MRSA SSIs per 100 surgical procedures; however, superficial SSIs were not included. In the United Kingdom, these rates seem to be considerably higher (0.78 MRSA SSIs per 100 surgical procedures; J. Wilson, written communication December 2007). Interestingly, our study reports a length of stay until MRSA detection almost identical to the number reported by Engemann et al.⁷ (8 days [IQR, 5–14 days]).

This study extends previous evidence about risk factors for MRSA SSI, most of them not easily modifiable.^{2,8} However, our finding that MRSA carriage on admission is not an independent risk factor for MRSA SSI stands in contrast to previous studies claiming that preoperative carriage of MRSA has an independent effect on the risk of MRSA SSI.⁹ Our data indicate that postoperative acquisition may play an important role in the causation of

MRSA infection.³ Probably, an undetected reservoir of MRSA among colonized surgical patients or healthcare workers may contribute to ongoing cross-transmission and postoperative MRSA acquisition. In support of this finding, Spanish colleagues have recently observed that of 8 cases of MRSA mediastinitis, none had previous nasal MRSA colonization detected on admission.¹⁰

Several limitations of our study need to be discussed. As in the case of any observational study, one cannot infer causality from the associations we describe. We studied exclusively patients from a single surgical department; hence, our results may not be applicable to patients hospitalized elsewhere. Since we did not collect data on all 10,193 patients who underwent MRSA screening, we were not able to perform a population-based risk factor analysis for MRSA infection in the entire cohort. Finally, antibiotic prophylaxis against MRSA was suboptimal for several reasons.⁴ It remains to be shown if use of a more rapid screening test or use of a better antimicrobial agent than vancomycin can decrease MRSA SSI rates.

The presented risk factor analysis offers important information about the probability of MRSA SSI in surgical patients, extending earlier findings. Our data will help explain some of the disparities in reported success rates of topical eradication treatment and perioperative prophylaxis directed against MRSA, and these insights may lead to the development of more effective postoperative MRSA control strategies.

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Potential conflicts of interest. All authors report no conflicts of interest relevant to this study.

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