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Major Article

Risk factors for *Staphylococcus aureus* colonization in a presurgical orthopedic population

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Background: Preoperative colonization with *Staphylococcus aureus* (SA) increases risk of surgical site infection. Screening for SA followed by skin and nasal decolonization can help to reduce the risk of postoperative infections. Risk factors for colonization are, however, not completely understood.

Methods: A case-control study using questionnaires and patient demographics specifically designed to observe SA colonization risk factors in a presurgical orthopedic population. A total of 115 subjects with a positive preoperative screen for SA nasal colonization prior to orthopedic surgery completed a questionnaire to assess for SA risk factors: these subjects served as our cases. An additional 476 controls completed similar questionnaires. Data collected included demographic, health, and lifestyle information. Multivariable logistic regression was used to generate odds ratios (OR) for risk of SA colonization.

Results: Several risk factors were identified. Male sex (OR 2.3; 95% confidence interval [CI], [1.4-3.8]) and diabetes (OR 3.8 [1.8-7.8]) significantly increased the risk of SA colonization. Older age, visiting public places (OR 0.2 [0.1-0.3]), recent antibiotic use (OR 0.2 [0.1-0.6]), and the presence of facial hair (OR 0.3 [0.1-0.6]) significantly lowered the risk of SA colonization.

Conclusions: By identifying patients who may be at greater risk of SA colonization, we can better streamline our presurgical techniques to help reduce risk of surgical site infections and improve patient outcomes.

Staphylococcus aureus (SA) is a common bacterium that can be isolated in the nares of healthy individuals.[1] Although prevalence of nasal carriage of SA differs in different populations, a mean carriage rate is estimated at 37.2% in the general population.[2] The human nares serve as a major reservoir of SA colonization for the rest of the body. As a result, testing for nasal SA colonization is a good proxy for colonization in other locations of the body and correlates well with risk of infection.[2] Several studies have identified nasal carriage as being an important independent risk factor for surgical site infections.[3,4] Bode et al[5] performed a large randomized control trial that demonstrated the efficacy of rapid hospital screening and decolonization in reducing the number of hospital-acquired infections. Orthopedic practices, in particular, have implemented protocols to decolonize positive carriers prior to surgery, resulting in the reduction of postoperative methicillin-sensitive and methicillin-resistant SA infections.[6-8]

Better knowledge of modifiable risk factors for SA colonization might enable more targeted screening or more targeted approaches to eliminating colonization. Price et al[9] examined an outpatient orthopedic preoperative population and found no associations between demographics or procedure and nasal carriage status. Another study observing a preoperative orthopedic population found obesity and younger age to be significant risk factors for SA nasal carriage.[10] Herwaldt et al[11] also concluded that obesity and male sex were significant risk factors of presurgical SA nasal colonization.

We performed a case-control study using questionnaires specifically designed to observe SA colonization risk factors in a presurgical orthopedic population.

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METHODS

All study procedures were approved by the hospital's institutional review board. Cases of SA colonization were identified during a prior study at the same hospital. A total of 115 persons with a positive preoperative screen for SA nasal colonization 0-3 weeks prior to orthopedic surgery were identified from June 2014 until August 2014. All subjects completed a questionnaire to assess environmental risk factors of SA colonization. These subjects served as our cases.[12]

To identify risk factors for SA colonization, we recruited additional controls undergoing orthopedic surgery between November 2015 and October 2016. Both cases and controls were a smaller subset of our overall surgical population selected at random. Eligibility requirements were designed to mimic those in the original case population. We included anyone between ages 18 and 89 years who were to undergo any orthopedic procedure. Potential subjects were approached at preoperative screening appointments and classes by trained research assistants. After obtaining written informed consent, the subjects completed a similar questionnaire assessing environmental risk factors for SA colonization. Questionnaires were completed in preoperative areas of the hospital. Controls were recruited regardless of their presurgical SA colonization status, as this sampling method better reflects the distribution of risk factors in the population[13] and results in odds ratios (ORs) that better reflect the risk ratio. We recruited 4 times as many controls as cases, to sufficiently maximize power.

Both questionnaires were similar in format and included questions about potential risk factors for SA colonization. These questions included race, living situation (home or institutions), pets (type and kind), public places visited, how often subjects bathed, presence of household pests, comorbidities (diabetes, obesity, skin conditions), use of medications that could suppress the immune system (eg, prednisone, biologics), antibiotics used around the time of screening, presence of facial hair, and whether the subject reported routinely putting anything in the nose. Examples of public places included gyms or health clubs, hospitals or health care facilities, prisons or jails, or other homes with children or pets. Household pests included bedbugs, scabies, lice, or other infestations by insects or rodents.

We developed multivariable logistic regression models to examine risk factors for SA colonization. Rather than use an arbitrary selection procedure based on *P* values, we included in our models factors specifically of interest to us or that we thought might be important predictors. We mutually adjusted for all variables. Due to small reported numbers for a few of the risk factors (eg, infestations and visiting public places) we were unable to fully subcategorize responses for some variables (eg, visiting a gym). All analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

We did not attempt to impute missing data; our final models included only subjects in which data were complete. However, we did perform sensitivity analyses in which we included missing data in each variable as a separate response, and the estimates for all variables were not substantially changed.

RESULTS

We analyzed data from 115 cases and 476 controls. After finding our controls, we realized that 4 of our original cases identified by polymerase chain reaction (Cepheid; Sunnyvale, CA) failed to grow SA when cultured; we therefore excluded them from the analysis, however, we chose to retain their controls. Demographic information is presented in Table 1. In general, the control population was older and roughly equally split between men and women. The mean age in the control group was 65.9 (SD 8.4) years and the mean age in the colonized group was 60.4 (SD 12.0) years. A total of 63% of the control group were women and 46.1% of the colonized group were women. Our sample population was overwhelmingly white (96%), reflecting the hospital's patient population. Body mass index did not differ between the control (30.1 SD 6.10) and the colonized (31.4 SD 6.8) groups.

Questionnaire responses can be seen in Table 1. Most of our samples lived in private homes, and we were therefore unable to examine the effect of living in an institution on colonization status. Having pets, frequency of bathing, taking immunosuppressant medications, and the presence of infestations (eg, lice or scabies) did not differ between the groups.

Multivariable logistic regression was used to generate ORs (Table 1) for SA colonization after adjustment for all other variables. Men were 2.3 (95% confidence interval [CI] [1.4, 3.8]) times more likely to be colonized than women. Patients with diabetes were 3.8 (1.8, 7.8) times more likely to be colonized. Increasing age decreased risk of colonization (Table 1). Visiting public places such as a gym, hospital, or another home with children or pets was protective against SA colonization (OR 0.2 [0.1-0.3]). Patients who reported having facial hair were significantly less likely to be colonized (OR 0.3 [0.1-0.6]). Also, patients who took antibiotics were significantly less likely to be colonized (OR 0.2 [0.1-0.6]).

DISCUSSION

This case-control study reveals several potential risk factors for SA colonization in a presurgical orthopedic population. Male sex and diabetes significantly increase risk of SA colonization. Older age, visiting public places, taking antibiotics around the time of surgery, and having facial hair significantly decrease the risk of SA colonization.

Table 1
Demographic and multivariable regression analysis results

	Colonized (n = 115) n (%)	Controls (n = 476) n (%)	Odds ratio (95% CI)
Sex (male)	62 (53.9)	176 (37.0)	2.3 (1.4, 3.8)
Age (years)			
8-49.9	20 (17.4)	14 (3.0)	Reference
50-59.9	27 (23.5)	87 (18.3)	0.2 (0.07, 0.5)
60-69.9	47 (40.9)	213 (44.8)	0.1 (0.04, 0.2)
70-79.9	17 (14.8)	146 (30.7)	0.04 (0.02, 0.1)
≥80	4 (3.5)	15 (3.2)	0.2 (0.04, 0.6)
			P for trend <.001
Race (self-reported)			
White	111 (96.5)	454 (95.9)	reference
Black	3 (2.6)	11 (2.3)	0.8 (0.2, 3.9)
Other	1 (0.9)	8 (1.7)	0.4 (0.04, 4.3)
BMI			
<25	23 (20.0)	107 (22.6)	reference
25-29.9	32 (27.8)	152 (32.1)	0.7 (0.3, 1.5)
30-34.9	25 (21.7)	133 (28.1)	0.8 (0.4, 1.8)
35-39.9	21 (18.3)	46 (9.7)	1.7 (0.7, 4.0)
≥40	14 (12.2)	35 (7.4)	0.7 (0.2, 1.9)
			P for trend = .7
Pets in the house	65 (56.5)	224 (47.4)	1.2 (0.7, 2.0)
Visits to public places	74 (64.4)	437 (91.8)	0.2 (0.1, 0.3)
Household pests (scabies, bedbugs, lice, other)	7 (6.1)	32 (6.7)	1.1 (0.3, 3.7)
Diabetes	20 (18.2)	32 (7.2)	3.8 (1.8, 7.8)
Skin conditions (psoriasis, eczema, other)	12 (10.9)	57 (12.9)	0.8 (0.3, 1.7)
Immunosuppressant medication use	10 (8.7)	30 (6.4)	1.2 (0.4, 3.0)
Antibiotic use	7 (6.3)	97 (21.1)	0.2 (0.1, 0.6)
Presence of facial hair	14 (12.4)	109 (23.8)	0.3 (0.1, 0.6)
Insertion of items into nose	49 (42.6)	234 (49.2)	1.0 (0.6, 1.7)

BMI, body mass index; *CI*, confidence interval.

Several previous studies have assessed demographic risk factors for SA including age, sex, and race. Herwaldt et al[11] performed one of the first studies comparing SA nasal carriers to noncarriers in a preoperative population. As in our study, they found male sex to be a risk factor. Other studies concluded male sex to be a significant risk factor for nasal colonization in the community and healthy adults.[14,15] In addition, younger persons are at increased risk of SA colonization in our study, as is also supported by other studies.[10,14]

Previous studies have also investigated comorbidities such as obesity and diabetes. Herwaldt et al[11] identified obesity as a risk factor for colonization, which was not observed in our study. The Herwaldt study, like ours, identified perioperative antibiotic use to be protective. In addition, Kluytmans et al[2] identified several additional comorbidities including diabetes, kidney failure, intravenous drug addiction, and HIV infection to significantly increase risk factor of nasal carriage. Except for diabetes, these risk factors were present in only a small minority of the elective orthopedic population in this study, which did not allow sufficient power to assess for these variables as risk factors for SA colonization.

Interestingly, patients who reported having facial hair were less likely to be colonized. The presence of facial hair may help keep bacteria from colonizing the nares; or perhaps shaving perpetuates the re-inoculation of bacteria into the skin. The second hypothesis seems more likely, especially given that surgical sites are no longer routinely shaved prior to surgery as it has been demonstrated that micro trauma from shaving increases bacterial colonization.[8,16] Wakeam et al[17] studied a population of hospital workers and also discovered that those with facial hair were less likely to be colonized with SA. However, another study found that the presence of a moustache had no effect on nasal colonization.[18] Further research could explore the interaction between shaving and SA colonization. If shaving impacts colonization, as it does for surgical site infection risk, then this may explain why men were more likely to be SA colonized than women, as most men in our study did not report facial hair and therefore presumably shave.

Because our study used patient-reported outcomes, the data are subject to recall bias. For example, some patients may not be inclined to report if they put things in their nose or if they have had a lice infestation. However, it is difficult to imagine that this effect would be different between those who are and are not colonized, and we therefore do not expect differential confounding. Furthermore, because of the small number of some responses, we were not able to analyze some responses adequately. For example, our questionnaire asked what patients put in their nose and response included fingers, tissue, nasal spray, or other. Previous literature suggests that use of nasal sprays is protective against SA colonization,[14] whereas another found that nose picking was significantly associated with SA nasal carriage.[19] However, because of the small number of persons who used nasal sprays, we could not differentiate between this and inserting other items into the nose and had to group these responses together, although they could have had different effects.

Our cases and controls are a small subset of the overall surgical population of our hospital selected at random. As available, research coordinators would contact patients for enrollment in preoperative areas of the hospital. Because of this sampling method, we must include the possibility of selection bias as a limitation in our study. Our sampling assumes that the subjects contacted and enrolled are representative of our entire surgical population. Study staff support limitations also account for the timeline variation for our study. Future studies could examine larger sample populations, particularly in a simultaneous fashion to further assess the relationships between risk factors and SA colonization.

CONCLUSIONS

SA colonization is known to be a dynamic process, as risk changes over time and by different geographic locations. Our study helps to better identify and understand risk factors for SA colonization in patients preparing for orthopedic surgery. Although we believe that we have captured several important components to SA nasal colonization, our questionnaire did not assess every possible factor, and future works could review topics including, but not limited to, socioeconomic status and various occupations. Future studies also need to be undertaken to identify risk factors in other presurgical populations, and to investigate whether some of these risks may be modifiable to further reduce infection risk. By better identifying specific factors that put patients at greater risk of SA colonization, we may be able to further reduce the risk of surgical site infections and improve patient outcomes.

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