Screening and Treatment of Methicillin-Resistant Staphylococcus aureus in Children Undergoing Open Airway Surgery

Melissa McCarty Statham, MD; Alessandro de Alarcon, MD, MPH; Janet N. Germann, MSN, CNP; Meredith E. Tabangin, MPH; Aliza P. Cohen, MA; Michael J. Rutter, FRACS

Objectives: (1) To determine the prevalence of methicillin-resistant Staphylococcus aureus (MRSA) colonization in children undergoing open airway surgery using a screening protocol; (2) to examine the rates of postoperative infection in this cohort; and (3) to determine adherence to a MRSA antibiotic protocol.

Design: Retrospective cohort study.

Setting: Tertiary pediatric referral center.

Patients: The study population comprised 180 children undergoing 197 open airway operations from January 2007 to March 2009 at the Cincinnati Children’s Hospital Medical Center.

Intervention: Methicillin-resistant Staphylococcus aureus screening and treatment protocol.

Main Outcome Measures: Prevalence of MRSA colonization, postoperative infection rates, colonization rates by site, and adherence to antibiotic protocol.

Results: A total of 180 patients who underwent 197 operations were included in the study. The overall prevalence of MRSA was 32.5%. There were no significant differences between MRSA-colonized and noncolonized patients regarding age at surgery, sex, gestational age at birth, or comorbidities. Postoperative infection rates were similar between the 2 groups (16% MRSA colonized; 17% MRSA noncolonized). Three patients who developed postoperative MRSA infections were MRSA negative on preoperative screening. Intraoperative adherence was high in both groups.

Conclusions: We describe a MRSA screening and treatment protocol for children undergoing open airway surgery. We found a high prevalence (32.5%) of MRSA colonization in these patients. Treatment of MRSA-colonized patients resulted in postoperative infection rates similar to those in MRSA-noncolonized patients. Treatment of MRSA-colonized patients resulted in no MRSA-associated postoperative infections, graft loss, or dehiscence. MRSA screening and treatment protocols may be helpful in minimizing MRSA-associated postoperative infections in these patients.

advised that an antibiotic prophylactic protocol for airway reconstruction should include intraoperative as well as postoperative antibiotic therapy and should be carried out on all patients known to be colonized with MRSA.

In our experience, MRSA infection in open airway procedures can be a devastating complication, resulting in dehiscence, graft loss, and weakening of the cartilaginous structure of the laryngotracheal complex. Given the high index of suspicion for MRSA in patients undergoing open airway surgery, the development and institution of a screening and treatment antibiotic protocol was essential in proactively managing care of this vulnerable population. The overall aim of the present study was to retrospectively examine the effect of the protocol in this group of patients. Our specific objectives were 3-fold: (1) to determine the prevalence of MRSA colonization; (2) to examine the rate of postoperative infection in this cohort; and (3) to determine adherence to our antibiotic protocol.

METHODS

We identified all patients who underwent open airway surgery at Cincinnati Children’s Hospital Medical Center from January 2007 to March 2009. We reviewed the medical records of these patients to obtain demographic data and information pertaining to operative procedures, comorbidities, adherence to MRSA protocol, antibiotic use, postoperative infections, and graft failure. Patients without documented evidence of MRSA screening were excluded from the study. We received approval for this study from our institutional review board.

MRSA SCREENING PROTOCOL

Prior to the present study, a MRSA screening and treatment protocol was developed and implemented by two of the authors (J.N.G. and M.J.R.) in consultation with the director of the infection control program at our institution. This protocol is summarized in the Figure. All candidates for open airway procedures underwent initial MRSA screening according to the protocol.

Preoperative Protocol

Patients known to be colonized with MRSA or with a history of MRSA without evidence of negative culture status were considered to be colonized. Surveillance cultures of MRSA were obtained from the nares, perianal area, axilla, gastrostomy tube site (if present), and tracheotomy tube aspirate (if present). These cultures were obtained on initial airway evaluation in patients deemed appropriate candidates for open airway procedures. If MRSA screening was carried out within 3 to 6 months of surgery, it was not repeated preoperatively.

Based on sensitivities of MRSA in both nosocomial and community-acquired organisms, the decision to use double-strength trimethoprim-sulfamethoxazole (DSTS) as an empirical preoperative antibiotic to decrease the risk of MRSA-associated infection was made. Patients colonized with MRSA received 6 to 12-mg/kg DSTS, divided twice daily, for 72 hours prior to surgery. In patients with an allergy to sulfa drugs or in those who were resistant to these drugs on initial screening, clindamycin was chosen as the alternate antibiotic. Patients who had positive nasal cultures also received intranasal mupirocin twice daily for 72 hours before surgery.

Perioperative Protocol

During the perioperative phase of care, patients received intravenous vancomycin. To achieve peak serum levels, administration of this drug was completed approximately 1 hour prior to skin incision. It was then administered every 6 to 8 hours until the surgical site drains were removed. Patients with an allergy to vancomycin received clindamycin. Patients who tested MRSA negative, and those with a history of MRSA in whom 3 subsequent cultures were negative, received perioperative intravenous cefazolin.

Postoperative Protocol

MRSA–colonized patients were treated for 14 days postoperatively with the same antibiotic regimen that was used preoperatively.

CRITERIA FOR TRANSITION FROM MRSA COLONIZED TO MRSA NONCOLONIZED

For MRSA-colonized patients to be considered MRSA noncolonized, 3 negative cultures were required, commencing at least 2 weeks after the cessation of systemic antibiotics.

DATA ANALYSIS

We examined the baseline characteristics (including demographics, procedure type, tracheotomy placement, and comorbidities) for differences between MRSA-colonized and MRSA-noncolonized patients to determine possible confounders within our study population. Differences in continuous variables were tested using the Wilcoxon rank sum test. Differences in categorical variables were tested using χ² or the Fisher exact test. Analyses were conducted at the procedural or event level.

We defined postoperative infection as any infection documented and treated during the postoperative period. Infections were categorized as follows: MRSA vs non-MRSA, deep wound (neck abscess), graft failure associated with infection, ventilator-associated pneumonia, urinary tract infection, and parotitis. We then compared infection rates between the MRSA-colored and noncolonized patients using the Fisher exact test. Adherence to the complete protocol as well as to the preoperative, intraoperative, perioperative, and postoperative components of the complete protocol was determined. Patients were
considered to be adherent to the complete protocol when there was no discrepancy between the protocol and the antibiotic actually administered. Patients were considered partially adherent in the perioperative period when they received at least 1 of the protocol antibiotics. These proportions were then compared between the MRSA-colonized and the MRSA-noncolonized groups using the Fisher exact test for individual period comparisons and the \( \chi^2 \) test over all periods, adjusting for multiple tests using the Bonferroni method.

A 2-tailed \( P \) value of .05 was considered statistically significant. For comparisons of adherence by operative period, a \( P \) value less than .008 was considered statistically significant. All analyses were performed using SAS version 9.2 (SAS Institute Inc).

RESULTS

A total of 180 patients underwent 202 open airway operations. Of these, 5 patients were excluded owing to unclear documentation of screening; the remaining 197 operations were included in this study. Demographic data and baseline characteristics of this study population are presented in Table 1. As shown, there were no significant differences between MRSA-positive patients and MRSA-negative patients with regard to age at surgery, sex, gestational age at birth, or comorbidities. In addition, there were no significant differences between these 2 groups with regard to the percentage of patients who underwent 2-stage vs single-stage procedures or the percentage of those with a history of tracheotomy placement.

COLONIZATION AND MRSA PREVALENCE

The overall prevalence of MRSA in the study was 32.5%. Site-specific colonization for the MRSA-colonized patients is described in Table 2. The prevalence of MRSA in patients with a tracheotomy at the time of surgery was not significantly different from the prevalence in patients without a tracheotomy (\( P = .35 \)).

MRSA TREATMENT AND POSTOPERATIVE INFECTION

Postoperative infection in the MRSA-colonized and MRSA-noncolonized patients is presented in Table 3. As shown, postoperative infection rates were similar between the 2 groups. However, the 3 patients who developed postoperative MRSA infections were MRSA negative on preoperative screening. One MRSA-colonized patient underwent a laryngotracheal separation but was not treated according to protocol. This patient developed a surgical site MRSA abscess that resolved after incision, drainage, and a course of intravenous vancomycin.

Table 1. Study Population Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Study Population (197 Procedures)</th>
<th>MRSA Positive (64 Procedures)</th>
<th>MRSA Negative (133 Procedures)</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at surgery, median (IQR), y</td>
<td>4.1 (2.3-9.0)</td>
<td>4.1 (2.4-6.8)</td>
<td>4.2 (2.3-9.7)</td>
<td>.50</td>
</tr>
<tr>
<td>Male, No (%)</td>
<td>113 (57.4)</td>
<td>32 (50.0)</td>
<td>53 (39.1)</td>
<td>.15</td>
</tr>
<tr>
<td>Gestational age, median (IQR), wk</td>
<td>33 (26-40)</td>
<td>34 (26-40)</td>
<td>32 (26-40)</td>
<td>.36</td>
</tr>
<tr>
<td>Gestational age &lt;36 wk, No (%)</td>
<td>122 (61.9)</td>
<td>39 (60.9)</td>
<td>83 (62.4)</td>
<td>.84</td>
</tr>
<tr>
<td>Gestational age &lt;32 wk, No (%)</td>
<td>100 (50.8)</td>
<td>29 (45.3)</td>
<td>71 (53.4)</td>
<td>.29</td>
</tr>
<tr>
<td>Double-stage procedure, No (%)</td>
<td>123 (62.4)</td>
<td>37 (57.8)</td>
<td>86 (64.7)</td>
<td>.35</td>
</tr>
<tr>
<td>Procedure type, No (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LTR and grafts</td>
<td>149 (75.6)</td>
<td>46 (71.9)</td>
<td>103 (77.4)</td>
<td></td>
</tr>
<tr>
<td>Resection of stenosis</td>
<td>31 (15.7)</td>
<td>11 (17.2)</td>
<td>20 (15.0)</td>
<td>.20</td>
</tr>
<tr>
<td>LTR cleft</td>
<td>6 (4.1)</td>
<td>2 (3.1)</td>
<td>6 (4.5)</td>
<td></td>
</tr>
<tr>
<td>TEF repair</td>
<td>7 (3.6)</td>
<td>5 (7.8)</td>
<td>2 (1.5)</td>
<td></td>
</tr>
<tr>
<td>LT separation</td>
<td>2 (1.0)</td>
<td>0</td>
<td>2 (1.5)</td>
<td></td>
</tr>
<tr>
<td>History of tracheotomy</td>
<td>173 (87.8)</td>
<td>56 (87.5)</td>
<td>117 (88.0)</td>
<td>.92</td>
</tr>
<tr>
<td>Indwelling tracheotomy at surgery</td>
<td>136 (69.0)</td>
<td>47 (73.4)</td>
<td>89 (66.9)</td>
<td>.35</td>
</tr>
</tbody>
</table>

Comorbidities:
- Pulmonary disease
- Gastrointestinal disease
- Cardiac disease
- Endocrine disease

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>( P ) Value</th>
</tr>
</thead>
</table>

Abbreviations: IQR, interquartile range; LTR, laryngotracheal; LTE, laryngotracheoesophageal; LTR, laryngotracheal reconstruction; MRSA, methicillin-resistant Staphylococcus aureus; TEF, tracheoesophageal fistula.

Table 2. Colonization Sites in 54 MRSA-Positive Procedures

<table>
<thead>
<tr>
<th>Site</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nares</td>
<td>43 (79.6)</td>
</tr>
<tr>
<td>Axilla</td>
<td>11 (20.4)</td>
</tr>
<tr>
<td>Perianal</td>
<td>19 (35.2)</td>
</tr>
<tr>
<td>BAL/tracheotomy aspirate</td>
<td>27 (50.0)</td>
</tr>
<tr>
<td>Gastrostomy tube</td>
<td>4 (7.4)</td>
</tr>
</tbody>
</table>

Abbreviations: BAL, bronchoalveolar lavage; MRSA, methicillin-resistant Staphylococcus aureus.
cin. Nineteen of the 23 postoperative infections in MRSA-noncolonized patients and all 10 infections in MRSA-colonized patients were caused by nosocomial non-MRSA organisms.

Two laryngotracheal reconstruction cartilage graft failures and 1 dehiscence occurred. None of these events occurred in MRSA-colonized patients. One graft failure was attributed to corticosteroid administration and impaired wound healing. Another was attributed to *Hemolytic Streptococcus*. The dehiscence was attributed to *Haemophilus influenzae*.

**ADHERENCE TO PROTOCOL**

Adherence to the complete protocol and to perioperative components of the protocol is presented in Table 4. Adherence was especially problematic (complete, 63.9%, vs partial, 91.8%) in patients who had nasal colonzation and did not receive the nasal mupirocin. Intraoperative adherence was high both in the MRSA-colonized and MRSA-noncolonized groups.

**COMMENT**

To our knowledge, this is the first study to describe a screening and treatment MRSA protocol for pediatric patients undergoing open airway surgery. Based on prior experience, we considered these patients to be at high risk for colonization and the development of MRSA-associated surgical site infections. As anticipated, the prevalence of MRSA was high (32.5%). It was considerably higher than prevalence rates reported in patients undergoing other types of surgery.\(^6,13\) Moreover, it was higher than reported prevalence rates for other nonairway patients considered to be at high risk.\(^14\) We attribute this largely to the characteristics of our study population. Specifically, 61.9% of the children were premature; 87.8% had been tracheotomized; and many had serious comorbidities such as pulmonary, gastrointestinal, and cardiac disease (Table 1). We consider these factors to be proxies for frequent hospitalization and exposure to antibiotics. This is consistent with reports that MRSA colonization may be greater in patients who have previously spent more than 5 days in an institutional setting and who have had frequent exposure to antibiotics.\(^4,15,16\)

During the study period, there were no MRSA-associated postoperative infections in patients treated according to our antibiotic protocol, which is consistent with reported findings in other studies.\(^17,18\) Also, there were no graft losses or dehiscences in patients who were MRSA-colonized. The 3 cases of postoperative MRSA infection occurred in patients who were previously MRSA negative, suggesting that MRSA was acquired during hospitalization. Two patients treated according to protocol experienced graft loss or dehiscence associated with non-MRSA infection. This suggests that despite a screening and treatment protocol, there is an inherent risk of graft loss and dehiscence in all patients who undergo airway surgery. Infections other than MRSA may be causative factors.
Although complete adherence to all aspects of the protocol was lower than anticipated (66.0%), this can primarily be attributed to the particularly low adherence preoperatively (Table 4). Unlike preoperative adherence, intraoperative, perioperative, and postoperative adherence was high (93.9%, 88.9%, 92.8%, respectively).

Our study has several limitations. Because it is a retrospective analysis of our protocol, it is subject to the inherent limitations associated with all retrospective studies. Missing data, such as infections or complications, may have occurred but may not have been documented. As well, a historical control group for direct comparison before institution of the protocol was not available. Prior to this time, screening of patients was not performed. The protocol was instituted only after multiple catastrophic airway reconstruction failures concomitantly occurred with an associated MRSA infection. In view of this, clinicians believed that the risk of catastrophic airway failure merited the introduction of a standardized MRSA treatment protocol.

Despite the described limitations, our data demonstrate a high prevalence of MRSA in this patient population, suggesting a high risk of postoperative MRSA infection and the need for a MRSA protocol. Future prospective studies in this patient population should further examine postoperative infection rates and specific treatment protocols.

In conclusion, our study describes a screening and treatment MRSA protocol for pediatric patients undergoing airway surgery. We found a high prevalence (32.5%) of MRSA colonization in these patients. Treatment of MRSA-colonized patients resulted in postoperative infection rates that were similar to those in MRSA-noncolonized patients. Furthermore, treatment of MRSA-colonized patients resulted in no MRSA-associated postoperative infections, graft loss, or dehiscence. In view of our results, we advise instituting MRSA screening and treatment protocols in patients undergoing airway surgery.

Submitted for Publication: June 25, 2011; final revision received September 21, 2011; accepted November 16, 2011.

Correspondence: Alessandro de Alarcon, MD, MPH, Cincinnati Children’s Hospital Medical Center, 3333 Burnet Ave, MLC 2018, Cincinnati, OH 45229-30309 (alessandro.dealarcon@chmc.org).

Author Contributions: Drs Statham, de Alarcon, and Tabangin had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: McCarty Statham, de Alarcon, Germann, and Rutter. Acquisition of data: McCarty Statham. Analysis and interpretation of data: McCarty Statham, de Alarcon, Tabangin, Cohen, and Rutter. Drafting of the manuscript: McCarty Statham, de Alarcon, Germann, Cohen, and Rutter. Critical revision of the manuscript for important intellectual content: de Alarcon, Tabangin, and Rutter. Statistical analysis: de Alarcon and Tabangin. Administrative, technical, and material support: McCarty Statham, de Alarcon, and Germann. Study supervision: de Alarcon and Rutter.

Financial Disclosure: Dr Rutter has the following relationships to disclose: Acclarent (scientific advisory board), Gyrus/Olympus (consultant), Boston Medical Products (consultant), Hood Laboratories (consultant), Bryan Medical (consultant), and Karl Storz (consultant).

Previous Presentation: This study was presented at the annual meeting of the American Society of Pediatric Otolaryngology; May 2, 2010; Las Vegas, Nevada.

Online-Only Material: Visit http://www.archotolaryngol.com to listen to an author podcast about this article.

Additional Contributions: Beverly Connelly, MD, director of the infection control program, assisted in the development of our antibiotic protocol.

REFERENCES