Impact of a New Practice Guideline on Antibiotic Use With Pediatric Tonsillectomy

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IMPACT
More than 500,000 children undergo tonsillectomy each year in the United States. Although prior studies suggest that most patients received perioperative antibiotics, practice varies across centers. In 2011, the American Academy of Otolaryngology-Head and Neck Surgery (AAO-HNS) published a practice guideline recommending against perioperative antibiotic use for pediatric tonsillectomy. The impact of this recommendation has not been thoroughly examined.

OBJECTIVE
To determine the impact of the AAO-HNS guideline on the use of perioperative antibiotics and patient outcomes for pediatric tonsillectomy.

DESIGN, SETTING, AND PARTICIPANTS
This was a quasi-experimental study including 9265 children who underwent routine tonsillectomy from January 2009 through August 2012 within a large pediatric health care network containing hospital-based and ambulatory surgical facilities. Data were collected from a shared electronic health record and validated through manual medical record review. We used an interrupted time series analysis with segmented logistic regression and a nonequivalent dependent variable (tymanoplasty) to assess acute changes and differences in trends over time relative to guideline publication.

INTERVENTIONS
Publication of the AAO-HNS clinical practice guideline.

MAIN OUTCOMES AND MEASURES
The primary outcome was antibiotic administration on the day of surgery. Secondary outcomes included otolaryngology clinic encounters, emergency department encounters, hospital admissions, and surgical procedures for bleeding in the 30 days following tonsillectomy.

RESULTS
Of 9265 tonsillectomies during the study period, 5359 met inclusion criteria. Immediately after guideline publication, perioperative antibiotic use dropped by 86.5% (P < .001) and was sustained throughout the postintervention period. Rates of otolaryngology clinic encounters, emergency department encounters, and hospital admissions did not change significantly over time. There was a small but statistically significant increase in surgical procedures for bleeding following the intervention from 1.35% (95% CI, 0.57%-2.14%) to 3.48% (95% CI, 1.85%-5.10%).

CONCLUSIONS AND RELEVANCE
AAO-HNS guideline publication decreased perioperative antibiotic use for pediatric tonsillectomy across a large pediatric health care network. Although there were no changes in otolaryngology clinic visits, emergency department visits, or admissions, we found a small but significant increase in surgery for bleeding following guideline publication. Additional studies are necessary to verify this unexpected association.
veruse of antimicrobial agents can lead to the emergence of antimicrobial resistance, adverse drug events, and unnecessary costs. Surgical patients account for approximately 40% of antibiotic use in children's hospitals, and tonsillectomy is the second most common pediatric surgery, with more than 500,000 performed annually in the United States. A survey of otolaryngologists in the United States showed that 79% reported routine prescribing of antibiotics following tonsillectomy, and a recent retrospective review of 34 US children's hospitals showed that the rate of antibiotic use ranged from 2.7% to 92.6%. In contrast, only 10% of otolaryngologists in the United Kingdom reported using antibiotics for pediatric tonsillectomy. Although early studies reported that use of perioperative antibiotics for tonsillectomy was associated with improved outcomes, more recent studies have not been able to demonstrate a significant benefit on posttonsillectomy morbidity, and a 2010 Cochrane Review concluded that there was no evidence to support a clinically important impact of antibiotics on morbidity following tonsillectomy. In January 2011, the American Academy of Otolaryngology–Head and Neck Surgery (AAO-HNS) published a treatment guideline for pediatric tonsillectomy that included a recommendation that “clinicians should not routinely administer or prescribe perioperative antibiotics to children undergoing tonsillectomy.” Because adherence to national prescribing guidelines has been shown to vary, we examined the effect of this guideline on antibiotic use with tonsillectomy and measures of postoperative morbidity across a large, pediatric health care network.

Methods

Study Design
We performed a quasi-experimental study of 9265 children undergoing routine, ambulatory tonsillectomy before and after publication of the AAO-HNS guideline. Tympanoplasty was selected as a nonequivalent dependent variable because, like tonsillectomy, it involves open surgery to the upper respiratory tract mucosa and is performed by the same surgeons in the same operating rooms, but was not addressed in the guideline being studied. This study was approved by the institutional review boards of the Children’s Hospital of Philadelphia and the University of Pennsylvania. Because this was a retrospective review of data already collected, informed consent was not required and participants received no compensation.

Study Site and Population
The study was conducted within the Children’s Hospital of Philadelphia Care Network, which includes a 520-bed inpatient facility with 30 operating rooms as well as 3 ambulatory surgical facilities (ASFs) located in southeastern Pennsylvania and Southern New Jersey. More than 27,000 procedures are performed at these sites each year, including approximately 2500 tonsillectomies and 250 tympanoplasties. The hospital, ASFs, otolaryngology outpatient clinics, and emergency department all share a common electronic health record (EHR).

Study Participants
Study participants were drawn from all patients who underwent tonsillectomy (with or without adenoidectomy) or tympanoplasty from January 1, 2009, through August 31, 2012. To mirror the population described in the practice guideline, patients were excluded if they were younger than 1 year, older than 18 years, admitted to the hospital on the day of surgery, or had a second surgical procedure performed on the same day (Figure 1). Monopolar electrocautery was the sole modality used for tonsillectomy throughout the study period.

Data Collection
Data were abstracted from the patient EHR (EpicCare, Epic Systems Inc) and operating room electronic databases, both of which were common across all patients in all settings. Age, sex, and race were recorded as demographics to assess stability of the patient population across the study period. Other variables included primary surgeon, surgery location (hospital operating room or ASF), procedure name, and antibiotic orders. Outpatient otolaryngology encounters, emergency department encounters, hospital admissions, and repeated surgical procedures within the 30 days following surgery were recorded. A manual medical record review of 750 of the 9265 patients (10%) was undertaken to validate the accuracy of electronically extracted demographic, antibiotic prescribing, and follow-up care data, including the indication for repeated encounter or surgical procedure.

Outcome Measures
The primary outcome was administration of at least 1 dose of an antibiotic in the operating room. Secondary outcome measures included ambulatory encounters to the otolaryngology clinic (there was no routine scheduled follow-up after tonsillectomy throughout the study period) or emergency department as well as hospital admissions or surgical procedures. A patient was considered to have the specific outcome if he or she had experienced at least 1 of these events occurring within 30 days from the day of surgery. We chose to study a 30-day window because most morbidity events typically occur within 14 days of surgery, and recent studies have used 14- or 30-day windows to capture similar outcomes.

Statistical Analysis
The proportion of patients prescribed perioperative antibiotics or receiving postoperative medical care in each month was calculated and plotted. Segmented logistic regression was then performed using patient level binary indicators of antibiotic prescribing or morbidity measure as the dependent variable. The regression model included (1) an indicator of the postintervention period; (2) a variable for continuous time in months, with January 2011 identified as the month following guideline publication; and (3) a variable for time (in months) after the intervention, which equaled 0 during the preintervention period. Output from this model provides information on the slope of the preintervention regression line; the change in slope between the preintervention and postintervention regression lines; and the change in the y-intercept at the time of the intervention. Predicted probabilities were es-

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Estimated by taking the inverse logit function of model parameters or parameter contrasts. Autoregressive integrated moving average (ARIMA) models were also considered as a secondary approach to account for serial dependence of observations over time.

Results

Between January 1, 2009, and August 31, 2012, 9265 tonsillectomies were performed across the network. After applying the exclusion criteria 5359 remained for analysis. Of the 543 children who underwent tympanoplasty (the nonequivalent dependent variable), 494 were available for analysis (Figure 1).

Patients from the preintervention and postintervention periods were compared and found to be similar with respect to age, sex, race, and type of surgery performed (Table). The surgeons, surgery locations (hospital or ASF), and surgical technique were similar across the 2 time periods.

Antibiotic Prescribing

Following guideline publication, the average rate of perioperative antibiotic prescribing for tonsillectomy dropped acutely from 97% (95% CI, 96%-98%) to 6% (95% CI, 4%-8%) (Figure 2). This acute reduction in perioperative antibiotic use was statistically significant (P = .001). Trends in antibiotic prescribing in the preintervention and postintervention periods were stable. However, the rate of reoperation for bleeding increased from 1.35% (95% CI, 0.57%-2.14%) in December 2010 to 3.48% (95% CI, 1.85%-5.10%) in the month following guideline publication (February 2011) (P = .008) (Figure 3). Because the rates of surgery for bleeding were highly variable from month to month, secondary analysis using an ARIMA model was performed. This analysis confirmed that the increase in bleeding following publication of the guideline was significant (P = .009).

Morbidity Measures

Following guideline publication, rates of ambulatory surgical encounters (P = .83), emergency department encounters (P = .42), and hospitalization (P = .14) within 30 days of tonsillectomy showed no significant acute change, and trends in all outcome measures in the preintervention and postintervention periods were stable. However, the rate of reoperation for bleeding increased from 1.35% (95% CI, 0.57%-2.14%) in December 2010 to 3.48% (95% CI, 1.85%-5.10%) in the month following guideline publication (February 2011) (P = .008) (Figure 3). Because the rates of surgery for bleeding were highly variable from month to month, secondary analysis using an ARIMA model was performed. This analysis confirmed that the increase in bleeding following publication of the guideline was significant (P = .009).

Tymanoplasty Patients

Tymanoplasty patients had a high rate of antibiotic prescribing and low rates of secondary morbidities over the entire study period. There was no noted effect related to the publication of the guideline (Figure 4). Otolaryngology clinic visits are not included in this figure because some clinicians routinely saw tymanoplasty patients after surgery.

Medical Record Review

Our review of 750 randomly sampled medical records revealed 100% accuracy for surgery type, surgery date, surgeon and other patient demographics, and a 98% match for antibiotics administered in the operating room. Furthermore, the presence or absence of intravenous antibiotic administration in the operating room almost always predicted the presence or absence of an oral antibiotic prescription for 3 to 5 days following the surgical procedure (a 96% match).

Discussion

We examined the effect of implementation of a practice guideline on (1) perioperative antibiotic use and (2) patient outcomes after tonsillectomy surgery across a large pediatric health care network. Following publication of the 2010 AAO-
In the HNS guideline, we found a dramatic decrease in perioperative antibiotic use in concordance with the guideline's recommendation. Stopping the routine use of perioperative antibiotics did not change the rate of follow-up ambulatory encounters or hospitalizations within 30 days from tonsillectomy. However, we found a small but statistically significant increase in the rate of follow-up procedures for postoperative bleeding in the month following guideline publication.

Following guideline publication, the reduction in perioperative antibiotic use for tonsillectomy surgery was large and abrupt. This likely relates to efforts within this particular otolaryngology group to standardize tonsillectomy practices according to the new guidelines, reflecting a successful quality improvement initiative. The 91% decrease in perioperative antibiotic use meant that 2106 patients in the postguideline study period avoided antibiotic exposure. Furthermore, our medical record review revealed that patients receiving antibiotics in the operating room almost invariably received a prescription of oral antibiotics. Home antibiotic prescriptions were typically for 3 to 5 days of amoxicillin, which would equate to up to 10,000 additional patient-days of antibiotic use during the study period. If deemed to be safe, avoidance of perioperative antibiotic use would serve as a potentially high-impact target for antimicrobial stewardship efforts.

Clinical complications following tonsillectomy were uncommon both before and after the change in perioperative antibiotic use. We found no significant changes in rates of otolaryngology clinic visits, emergency department visits, or hospital admissions.

### Table. Patient Demographics and Clinical Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. (%)</th>
<th>Total</th>
<th>Preintervention</th>
<th>Postintervention</th>
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<tr>
<td><strong>Patients, No.</strong></td>
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<td>Tonsillectomy patients</td>
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<tr>
<td>Age, mean (SD), y</td>
<td>7.28 (3.6)</td>
<td>7.23 (3.6)</td>
<td>7.34 (3.6)</td>
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<tr>
<td>Sex Male</td>
<td>2604 (48.6)</td>
<td>1484 (50.8)</td>
<td>1164 (47.8)</td>
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<td>Race White</td>
<td>3475 (64.8)</td>
<td>1962 (67.1)</td>
<td>1513 (62.6)</td>
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<tr>
<td>Black</td>
<td>960 (17.9)</td>
<td>519 (17.8)</td>
<td>441 (18.1)</td>
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<tr>
<td>Other</td>
<td>924 (17.3)</td>
<td>443 (15.2)</td>
<td>481 (19.8)</td>
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</tr>
<tr>
<td>Procedure Tonsillectomy alone</td>
<td>163 (3.0)</td>
<td>76 (2.6)</td>
<td>87 (3.6)</td>
<td></td>
</tr>
<tr>
<td>Tonsillectomy + adenoidectomy</td>
<td>5196 (97.0)</td>
<td>2848 (97.4)</td>
<td>2348 (96.4)</td>
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<tr>
<td>Perioperative antibiotics</td>
<td>3075 (57.4)</td>
<td>2797 (95.7)</td>
<td>223 (9.2)</td>
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<tr>
<td>Otolaryngology clinic encounter</td>
<td>52 (1.0)</td>
<td>35 (1.2)</td>
<td>17 (0.7)</td>
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<tr>
<td>Emergency department encounter</td>
<td>358 (6.7)</td>
<td>158 (5.4)</td>
<td>200 (8.2)</td>
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<tr>
<td>Hospital admission</td>
<td>199 (3.7)</td>
<td>91 (3.1)</td>
<td>108 (4.4)</td>
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<tr>
<td>Second procedure</td>
<td>125 (2.3)</td>
<td>54 (1.9)</td>
<td>71 (2.9)</td>
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<td>No. Tympanoplasty patients</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, mean (SD), y</td>
<td>9.96 (3.9)</td>
<td>9.97 (4.0)</td>
<td>9.95 (3.8)</td>
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<tr>
<td>Sex Male</td>
<td>279 (56.5)</td>
<td>151 (57.0)</td>
<td>128 (55.9)</td>
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<td>Race White</td>
<td>388 (78.5)</td>
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<td>179 (78.2)</td>
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<td>Black</td>
<td>31 (6.3)</td>
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<td>9 (3.9)</td>
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<tr>
<td>Other</td>
<td>75 (15.2)</td>
<td>34 (12.8)</td>
<td>41 (17.9)</td>
<td></td>
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<tr>
<td>Procedure Complex</td>
<td>28 (5.7)</td>
<td>6 (2.3)</td>
<td>22 (9.6)</td>
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<tr>
<td>Ear</td>
<td>349 (70.7)</td>
<td>199 (75.1)</td>
<td>150 (65.5)</td>
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<tr>
<td>Ear + canal</td>
<td>30 (6.1)</td>
<td>8 (3.0)</td>
<td>22 (9.6)</td>
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<tr>
<td>Ear + ossicle</td>
<td>79 (16.0)</td>
<td>47 (17.7)</td>
<td>32 (14.0)</td>
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<tr>
<td>With graft</td>
<td>8 (1.6)</td>
<td>5 (1.9)</td>
<td>3 (1.3)</td>
<td></td>
</tr>
<tr>
<td>Perioperative antibiotics</td>
<td>487 (98.6)</td>
<td>260 (98.1)</td>
<td>227 (99.1)</td>
<td></td>
</tr>
<tr>
<td>Otolaryngology clinic encounter</td>
<td>253 (51.2)</td>
<td>129 (48.7)</td>
<td>124 (54.2)</td>
<td></td>
</tr>
<tr>
<td>Emergency department encounter</td>
<td>7 (1.4)</td>
<td>5 (1.9)</td>
<td>2 (0.9)</td>
<td></td>
</tr>
<tr>
<td>Hospital admission</td>
<td>6 (1.2)</td>
<td>4 (1.5)</td>
<td>2 (0.9)</td>
<td></td>
</tr>
<tr>
<td>Second procedure</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

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HNS guideline, we found a dramatic decrease in perioperative antibiotic use in concordance with the guideline's recommendation. Stopping the routine use of perioperative antibiotics did not change the rate of follow-up ambulatory encounters or hospitalizations within 30 days from tonsillectomy. However, we found a small but statistically significant increase in the rate of follow-up procedures for postoperative bleeding in the month following guideline publication.

Antibiotic Use With Pediatric Tonsillectomy
Figure 2. Tonsillectomy Patients Prescribed Antibiotics

Percentage of tonsillectomy patients prescribed antibiotics in the operating room for each month during the study period. The red arrow indicates publication of the American Academy of Otolaryngology–Head and Neck Surgery Guideline in January 2011. The x-axis displays the bimonthly measuring points from January 2009 to September 2012.

Figure 3. Tonsillectomy Patients Prescribed Antibiotics and Having Clinical Outcomes During 30 Days From Surgery

Percentage of tonsillectomy patients prescribed antibiotics in the operating room, or being seen in otolaryngology clinic, visiting the emergency department, being admitted to the hospital, or having surgery for bleeding in the 30 days after surgery. Each outcome is shown as a separate line and is color-coded. The red arrow indicates publication of the American Academy of Otolaryngology-Head and Neck Surgery Guideline in January 2011. The x-axis displays the bimonthly measuring points from January 2009 to September 2012.

Figure 4. Tympanoplasty Patients Prescribed Antibiotics and Having Clinical Outcomes During 30 Days From Surgery

Percentage of tympanoplasty patients prescribed antibiotics in the operating room, or visiting the emergency department, being admitted to the hospital or having surgery for bleeding in the 30 days from surgery. Each outcome is shown as a separate line, and is color-coded. The red arrow indicates publication of the American Academy of Otolaryngology-Head and Neck Surgery Guideline in January 2011. The x-axis displays the bimonthly measuring points from January 2009 to September 2012.
hospital significant increase in patients requiring surgery for bleeding in the month following guideline publication. This was unexpected owing to (1) the lack of a clear biological mechanism for systemic antibacterial prophylaxis to prevent postoperative bleeding and (2) its inconsistency with prior data, including the recent Cochrane Review used to inform the AAO-HNS guideline. Furthermore, it is somewhat surprising that an acute increase in surgery for bleeding after the publication of the guideline was the only significant difference found despite no significant differences in rates of clinic visits, ED visits, and admissions. Potential explanations for this discrepancy include the possibility that omission of perioperative antibiotic use did not increase the frequency of bleeding events but only the intensity of bleeding or that the small increase in surgery for bleeding was a spurious finding.

Other possible explanations for the rates of bleeding seen in our study were explored. Dexamethasone use has been associated with an increase in the risk of bleeding after tonsillectomy in a recent study, although the patients experiencing bleeding were more likely to have received antibiotics. In our study, however, dexamethasone use was stable at more than 95% throughout the entire study period. Nonsteroidal anti-inflammatory drugs (NSAIDs), which might increase the rate of postoperative bleeding, could also have been administered differentially across the study period. Although NSAIDs were rarely administered in the hospital, our data collection was unable to capture home use of NSAIDs. Despite these potential explanations, the increased rate of bleeding found warrants further study to determine if there are potential unintended consequences of a practice change to decrease antibiotic use. Our study was designed to look at antibiotic prescribing with tonsillectomy, and multicenter studies with comprehensive collection of patient exposure (eg, steroids, NSAIDs) and clinical outcome data (bleeding, adverse drug effects, Clostridium difficile infection) should be conducted to better delineate the risks and benefits of perioperative antibiotic use for pediatric tonsillectomy.

Our study had notable strengths, including (1) access to one of the largest pediatric health care networks in the United States that performs more than 2500 tonsillectomies annually across both hospital-based and ambulatory surgical centers; (2) a shared, comprehensive EHR with patient demographic, procedure, medication administration, and both ambulatory and hospital encounter data; and (3) the use of an interrupted time series analysis with a nonequivalent dependent variable. These factors allowed us to study more than 5000 patients over 44 months, facilitating the analysis of both the trends in antibiotic prescribing before and after the guideline publication, as well as the acute change that occurred immediately surrounding the intervention.

Our study had several potential limitations. This study included patients from a single health care network in the northeastern United States and, therefore, might not be generalizable to all children undergoing tonsillectomy. The use of procedure and diagnosis codes to extract data from an EHR can lead to information bias. To mitigate this, we performed an extensive manual medical record review to verify the accuracy of these data, revealing a 100% match for demographic data and a 98% match for antibiotic prescribing in the operating room. Follow-up care occurring outside of the network could have led to outcome misclassification. However, because the hospital-based and ambulatory surgical facilities shared a common EHR with the inpatient units, emergency department, and surgeon offices, our capture of return medical encounters is expected to be nearly comprehensive and, it is important to note, should not have changed over time relative to guideline publication. Finally, interrupted time series analyses are at risk of maturational bias, including seasonal bias. Our study sought to minimize this by including long periods of time both preintervention and postintervention.

Conclusions

Following the 2010 AAO-HNS guideline, perioperative antibiotic use for pediatric tonsillectomy was drastically reduced across a pediatric health care network. This change was not associated with changes in otolaryngology clinic visits, emergency department encounters, or hospital admissions, but was associated with a small increase in surgery for bleeding following publication of the guideline. Additional studies are necessary to verify this unexpected association and to inform the risks and benefits of perioperative antibiotic use for pediatric tonsillectomy.
Previous Presentation: This study was a podium presentation at ID (Infectious Diseases) Week 2014; October 11, 2014; Philadelphia, Pennsylvania.

REFERENCES


