The Relationship Between Acute Mastoiditis and Antibiotic Use for Acute Otitis Media in Children

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Objective: To determine the relationship between prior antibiotic use and the development of acute mastoiditis (AM) in children.

Design: Retrospective review.

Setting: Tertiary pediatric center.

Patients: We identified 129 patients with AM who were admitted to our center between 1996 and 2005.

Main Outcome Measure: Proportion of children who developed AM.

Results: A total of only 67 patients (51.9%) had undergone any antimicrobial treatment prior to hospital admission. In 1996, 64% of patients with AM had received antibiotics for acute otitis media (AOM) prior to admission (n=7 of 11), but this percentage had steadily decreased to 27% by 2005 (n=4 of 15). The yearly number of cases of AM treated in our institution has remained stable over this period. A subperiosteal abscess was identified in 45 patients (34.9%), while the remainder (n=84) had postauricular inflammation only (65.1%). Nineteen patients with a subperiosteal abscess (42%) and 48 patients without a subperiosteal abscess (57%) had undergone prehospitalization antimicrobial therapy for suppurative AOM. There was no significant difference in antibiotic use between the numbers of patients with or without a subperiosteal abscess. Regarding the sensitivity of bacteria isolated from patients with a subperiosteal abscess, only 1 patient was infected with an organism that was not sensitive to the prehospitalization antibiotic prescribed.

Conclusion: Use of antibiotics to treat suppurative AOM in children might not influence the subsequent development of AM.


T HE DIAGNOSIS OF ACUTE MAS- 
T OIDITIS (AM) is based on the 
presence of acute otitis me-
dia (AOM), an acutely pro-
truding ear with postauricu-
lar inflammation or subperiosteal abscess, 
and systemic symptoms. Current publica-
tions have noted that prior to the advent of 
antibiotics, greater than 50% of AOM cases 
progressed to AM, with or without more 
severe intracranial problems, and most of 
these required surgical intervention.1 However, with the advent of antibiotic use, AOM became for the most part a medical disease rather than a surgical one.2 Surgery tended to be reserved for treatment of the compi-
lications of the disease, and the overall inci-
dence of mastoiditis as a complication of AOM dropped to less than 1%.1,3

Recent clinical evidence indicates that 
60% to 80% of uncomplicated AOM cases resolve within 24 to 48 hours without an-
tibiotic therapy.4 Correspondingly, anti-
biotic prescription guidelines emerged to 
recommend that antibiotic treatment of 
AOM be reserved for cases in children 
younger than 6 months, unresolving cases, 
or otherwise complicated cases. All other 
AOM cases should be treated initially with 
supportive therapy with discretionary cli-
nical follow-up.5 The intent of these guide-
lines is generally to reduce the use of un-
necessary antibiotics, which contributes to 
development of microbial antibiotic re-

See Invited Commentary at end of article

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patients in our study developed either meningitis or a brain abscess prior to admission.

A total of 129 patients (81 boys, 48 girls) were identified, mean age, 2.5 years (age range 0.5-12). Each year, different numbers of cases were identified without evidence of a trend toward either increased or decreased incidence (Figure 1).

The relative proportions of patients treated with antibiotics for AOM prior to hospital admission vs the proportions of untreated patients, grouped by year of discharge, are shown in Figure 2. Over the study period, a trend is noted toward a steady decrease in the relative proportions of untreated patients, grouped by year of discharge. The Fisher exact test was used to assess differences between 2×2 data points when the data were categorical. The t test was used to assess differences between the means of equally variable groups. Significance was established at P<.05.

A retrospective review was conducted of all patients aged 6 months to 18 years admitted with AM between January 1996 and December 2005 to the Royal Children’s Hospital, Melbourne, Australia. The criteria for diagnosis of AM required the simultaneous presence of AOM, an outwardly protruding ear associated with postauricular swelling and/or abscess, and systemic symptoms. Excluded were immunocompromised patients, those with tympanostomy tubes in situ, and those who had undergone prior ear operations other than tympanostomy tube insertion. Our management algorithm for AM in children has been described previously. Patients are taken to the operating room if a subperiosteal abscess is detected clinically or in the presence of significant systemic symptoms. Otherwise, they are initially treated with intravenous flucloxacillin and ceftriaxone for 24 hours but then undergo surgery if there is no improvement after 24 hours. Surgery involves tympanostomy tube insertion and needle aspiration of the postauricular swelling, with incision and drainage if pus is present. Computed tomographic scans are not routinely obtained unless clinically indicated. These indications include suspicion of a cholesteatoma, infection spread beyond the temporal bone, preparation for planned mastoidectomy, and uncertainty regarding diagnosis. A cortical mastoidectomy is performed as a primary surgical treatment in the presence of additional suppurative complications or when there is a high clinical suspicion of an underlying cholesteatoma. For the present study, patients who received a cortical mastoidectomy as part of their surgical treatment remained included. However, they were subsequently excluded from further analysis if a cholesteatoma was discovered.

Patients were grouped according to whether or not they had received antimicrobial therapy for AOM in the 2 weeks immediately prior to hospitalization for AM. Among those patients who had received treatment, the organism cultured from a subperiosteal abscess was compared with the prehospitalization antibiotic administered. A comparison was not made when the only available culture was obtained from a middle ear aspirate because, the study being retrospective, we could not be sure that the external ear in question had been adequately antisep-

tically prepared to ensure against potential contamination of the culture results by commensal external ear organisms.

Statistics were calculated using Microsoft Excel version 11.8 software (Redmond, Washington). Trend lines of best fit were used to highlight points of interest on the graphs. The Fisher exact test was used to assess differences between 2×2 data points when the data were categorical. The t test was used to assess differences between the means of equally variable groups. Significance was established at P<.05.

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Figure 2. Number of acute mastoiditis cases based on year of presentation. The dotted line (trend line) shows a stable average incidence of cases over time.

Figure 2. The relative proportions over 10 years of patients treated with antibiotics for acute suppurative otitis media immediately prior to hospital admission for acute mastoiditis.

RESULTS

A total of 129 patients (81 boys, 48 girls) were identified, mean age, 2.5 years (age range 0.5-12). Each year, different numbers of cases were identified without evidence of a trend toward either increased or decreased incidence (Figure 1).

The relative proportions of patients treated with antibiotics for AOM prior to hospital admission vs the proportions of untreated patients, grouped by year of disease presentation, are shown in Figure 2. Over the study period, a trend is noted toward a steady decrease in the proportion of patients undergoing antibiotic therapy for AOM prior to hospital admission for AM.

Overall, slightly more than half of the study population underwent antimicrobial therapy prior to hospital admission (n=67; 51.9%). The most commonly prescribed prehospitalization antibiotic was amoxicillin (n=24; 42%), followed by amoxicillin–clavulanic acid (n=14; 25%) and cefaclor (n=12; 21%). The mean duration of prehospitalization treatment was 5.6 days. Three patients developed complications prior to admission: 2, facial nerve weakness; 1, sigmoid sinus thrombosis. No patients in our study developed either meningitis or a brain abscess prior to admission.

The in-hospital treatment details of the patient population are summarized in Table 1. Typically, a double-coverage antibiotic regimen was applied, most commonly flucloxacillin (n=96; 74.4%) and cefotaxime (n=77;
59.7%). Tympanostomy tubes were placed through surgical incisions for all patients who required them; no patients had preexisting eardrum perforations.

Forty-five patients had a subperiosteal abscess identified (34.9%), whereas the remainder had postauricular inflammation only (n=84; 65.1%). Of the 45 patients with subperiosteal abscesses, 19 had undergone prehospitalization antimicrobial therapy (42%). Among the 84 in whom no subperiosteal abscess was present, 48 had received prehospitalization antibiotics (57%). There was no significant difference in antibiotic use between the patients with and without a subperiosteal abscess (Fisher exact test, 2-tailed distribution, P=.14).

The organisms grown from the cultures of the 45 patients with a subperiosteal abscess and their resultant sensitivities are detailed in Table 2. No growth was found in 21 of these patients (47%). The most common organism cultured overall and within each subgroup was *Streptococcus pneumoniae* (n=19; 42%). There were no differences in the organisms cultured between the 2 subgroups. Of the 19 patients undergoing prehospitalization antibiotic therapy, only 1 tested positive for an organism (*Pseudomonas aeruginosa*) that was not sensitive to its prehospitalization antibiotic (amoxicillin–clavulanic acid).

The mean duration of hospital stay was 5.0 days. There was no statistical difference between patients with prior antibiotic therapy (4.3 days) and those without (5.1 days) (P=.43). Two complications occurred: a wound infection, which resolved with medical therapy; and abscess reaccumulation, which necessitated a repeated postauricular drainage procedure.

### Table 1. In-Hospital Treatment Details of Patients With Acute Mastoiditis

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Patients, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=129)</td>
</tr>
<tr>
<td>Intravenous antibiotics alone</td>
<td>33 (25.6)</td>
</tr>
<tr>
<td>Intravenous antibiotics + tympanostomy tube</td>
<td>51 (39.5)</td>
</tr>
<tr>
<td>Intravenous antibiotics + tympanostomy tube + abscess drainage</td>
<td>38 (29.5)</td>
</tr>
<tr>
<td>Intravenous antibiotics + tympanostomy tube + abscess drainage + mastoidectomy</td>
<td>7 (5.4)</td>
</tr>
</tbody>
</table>

### Table 2. Subperiosteal Abscess Microbiologic Culture Results

<table>
<thead>
<tr>
<th>Culture Finding</th>
<th>Total (n=45)</th>
<th>Prehospitalization Antibiotics (n=19)</th>
<th>No Prehospitalization Antibiotics (n=26)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No growth</td>
<td>21 (47)</td>
<td>8 (42)</td>
<td>13 (50)</td>
</tr>
<tr>
<td><em>Streptococcus species</em></td>
<td>19 (42)</td>
<td>8 (42)</td>
<td>11 (42)</td>
</tr>
<tr>
<td><em>S pneumoniae</em></td>
<td>16 (36)</td>
<td>7 (37)</td>
<td>7 (27)</td>
</tr>
<tr>
<td><em>S pyogenes</em></td>
<td>2 (4)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>S milleri</em></td>
<td>1 (2)</td>
<td>1 (5)</td>
<td>1 (4)</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>3 (7)</td>
<td>1 (5)</td>
<td>2 (8)</td>
</tr>
<tr>
<td><em>Haemophilus influenza</em></td>
<td>1 (2)</td>
<td>1 (5)</td>
<td>0</td>
</tr>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td>1 (2)</td>
<td>1 (5)</td>
<td>0</td>
</tr>
</tbody>
</table>

aAll subtypes sensitive to penicillin and erythromycin.
bSensitive to flucloxacillin and cephalexin.
cSensitive to amoxicillin.
dSensitive to pipercillin and ticarcillin.

In this study, we assessed the use of antibiotics for treatment of AOM in a group of children who subsequently developed AM. Over the past 10 years, we have noted a trend at our institution toward a decreasing proportion of children with AM who had been pre-treated with antibiotics for AOM, yet this has not translated into a corresponding rise in the number of cases of AM. Of the 129 patients with AM in our study, only 67 patients had been prescribed antibiotics for AOM prior to hospitalization (51.9%). In 1996, 64% of patients with AM (n=7 of 11) had received antibiotics for AOM prior to admission, which then steadily decreased to 27% in 2005 (n=4 of 15). There was no significant difference in antibiotic use between the patients with and without a subperiosteal abscess. Although not conclusive, these data suggest that within our study population, the use of antibiotics to treat AOM in the prehospitalization setting did not influence the subsequent development or presentation of AM.

Several recent publications have attested to a rise in the number of AM cases in children. Bahadori et al8 found that the overall annual incidence of AM in 22 patients had increased between 1986 and 1999. A similar study by Spratley et al also demonstrated a rising trend among 43 patients between 1993 and 1998. Hoppe et al performed a retrospective review of 57 AM cases from 1975 to 1992 and also showed an increased number of admissions each year. In these studies, the increased rate of AM cases was attributed in part to decreased rates of antibiotic prescriptions in the community for AOM. A larger study by Nussinovitch et al compared 2 nonconsecutive time periods (1983-1985 and 1993-1995) and showed an overall increased rate of AM cases between the 2 periods. In contrast, our study found no increase in the rate of admission with AM, and our patient population was substantially larger than the populations of the earlier studies and was assessed over a longer continuous period.

The retrospective nature of the present study makes it difficult to draw definitive conclusions regarding the relationship between incidence of AM in children and declining rates of antibiotics use for the treatment of AOM. Our patient population was larger than that of many other studies on this subject, but our study still carries the limitations of a retrospective review. Also, while our institution is the major pediatric tertiary center in the state, our experience may not be representative of the broader community. Furthermore, to assess the rate of development of AM in children only as a complication of AOM (rather than simply the absolute number of AM cases) would require information...
regarding the total number of AOM cases in the community. This information was not readily available during the period of the present study. Factors such as improved public health measures, including antistreptococcal vaccinations, may have led to an overall decrease in the number of cases of AOM.

A case-control study is needed to properly assess the effects of antibiotic treatment for AOM as a means of preventing the development of AM. A group of patients with AOM complicated by AM would serve as the cases, while patients with AOM who did not develop AM would serve as controls. The ideal study would be a prospective randomized controlled trial of antibiotic use in AOM to subsequently determine the rate of AM developing in each group. While a worthwhile endeavor, such a study would prove difficult to execute.

Studies have shown that the most common organism cultured from patients with AM is P aeruginosa, with proportions ranging from 24% to 34%. The authors of those studies indicated that the high numbers of Streptococcus grown were all from patients who had undergone antibiotic treatment prior to hospitalization. However, in all cases this result might reflect contaminated specimens taken from the middle ear rather than from the abscess cavity. We analyzed cultures grown on samples taken only from the subperiosteal abscess, thus precluding the possibility of commensal outer ear organisms contaminating the data set. Consequently, our most common organisms were streptococcal species (42%), with only 1 culture of 45 growing P aeruginosa (2%).

Antibiotic resistance did not seem to be a factor in our study because all organisms grown were sensitive to the antibiotic prescribed to kill them, if an appropriate antibiotic was chosen initially. None of the cultures showed any resistance to penicillin, a result that echoes the findings of other studies. This, along with our stable rate of AM cases, stands in contrast to recent findings of Antonelli et al., which demonstrated that antibiotic-resistant S pneumoniae may be responsible for an increasing rate of AM.

In conclusion, at our institution we have demonstrated a steady rate of admissions of children with AM over the last 10 years despite a decreased use of prehospitalization antibiotics for the treatment of AM in these children. Antibiotic administration for the treatment of AOM in the prehospitalization setting does not seem to influence the rate of development of AM in children.

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Author Contributions: Dr Berkowitz had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Ho, Rotenberg, and Berkowitz. Acquisition of data: Ho. Analysis and interpretation of data: Ho, Rotenberg, and Berkowitz. Drafting of the manuscript: Ho, Rotenberg, and Berkowitz. Critical revision of the manuscript for important intellectual content: Ho, Rotenberg, and Berkowitz. Statistical analysis: Rotenberg. Administrative, technical, and material support: Ho and Berkowitz. Study supervision: Rotenberg and Berkowitz.

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REFERENCES