Suppurative Complications of Acute Otitis Media in the Era of Antibiotic Resistance

Jeffrey S. Zapalac, MD; Kathleen R. Billings, MD; Nathan D. Schwade, PhD; Peter S. Roland, MD

Objective: To review our experience with suppurative complications of acute otitis media (AOM) in the era of antibiotic resistance, given a perceived increase in the number of such cases in recent years requiring surgical intervention.

Design: Retrospective review of pediatric patients presenting with suppurative complications of AOM from January 1993 to June 2000.

Setting: Academic tertiary care children’s medical center.

Patients: A total of 90 pediatric patients, ranging in age from 3 months to 16 years (mean age, 45 months).

Results: A total of 104 suppurative complications of AOM occurred in 90 patients over the 7.5-year study period. The incidence of noncoalescent, coalescent, and total cases of mastoiditis and total number of suppurative complications all increased over the study period, with coalescent outpacing noncoalescent disease during the last 3 years of the study. A trend toward an increasing number of cases requiring surgical intervention was noted during the study period, corresponding to an increasing number of resistant Streptococcus pneumoniae isolates. Ten of 16 S pneumoniae isolates were resistant, primarily collected from younger children ranging in age from 4 to 24 months (mean age, 11.9 months).

Conclusion: The rising incidence of resistant S pneumoniae corresponded to the increasing number of suppurative complications of AOM during the study period and seemed to contribute to more aggressive infectious processes requiring surgical intervention.


THE INCIDENCE of suppurative complications of acute otitis media (AOM) has declined dramatically in the postantibiotic era. Antibiotic therapy has not only decreased morbidity and mortality, but has concomitantly decreased the need for mastoid surgery.1 The emergence of antibiotic-resistant middle ear microorganisms, however, has prompted a reevaluation of the approach to both uncomplicated otitis media and its suppurative sequelae.2,3

In 1997, Thornsberry et al4 evaluated more than 11,300 respiratory isolates from 434 institutions in 45 states and the District of Columbia and demonstrated resistance in 30% to 40% of Haemophilus influenzae and Streptococcus pneumoniae isolates and 90% of Moraxella catarrhalis isolates.4 Resistance patterns of S pneumoniae vary widely and are geographically and seasonally dependent. Furthermore, S pneumoniae is a more virulent organism than H influenzae or M catarrhalis, which are rarely implicated in suppurative complications of AOM.5 The rising incidence of resistant S pneumoniae is alarming, prompting establishment of guidelines for management of AOM when resistant organisms are suspected.2,3

Suppurative complications of AOM might be expected to increase in incidence with the escalation of antibiotic resistance.6 Various reports in the recent literature have noted an apparent increase in mastoiditis, although this was not definitively linked to the rising incidence of S pneumoniae resistance.7,8 In recent years at our institution, a perceived increase in both the incidence of suppurative complications and the need for acute mastoid surgery was noted. To analyze this apparent trend, we undertook a review of patients with suppurative complications of AOM, paying particular attention to cases involving resistant S pneumoniae and those requiring surgical intervention.

RESULTS

DEMOGRAPHIC DATA

Over the 7.5-year study period, 90 patients with a total of 104 suppurative complications of AOM were treated. Age at pre-
PATIENTS AND METHODS

A retrospective chart review was performed for patients with suppurrative complications of AOM admitted to the Children’s Medical Center of Dallas from January 1993 to June 2000. Medical records were obtained by searching databases for the International Classification of Diseases, Ninth Revision codes corresponding to inpatient diagnoses of acute mastoiditis, subperiosteal abscess, facial nerve paralysis, labyrinthitis, petrositis, otitic hydrocephaus, sigmoid sinus thrombosis, or intracranial abscess. All cases of chronic suppurrative otitis media or known cholesteatoma were excluded.

Standardized data forms were used to extract information on patient demographics, prior therapy, culture results including antimicrobial susceptibilities, medical treatment, surgical intervention, and outcome. Operative reports were used to confirm diagnoses and elucidate extent of intervention. Minimal audiometric and follow-up data were available for review and were not included.

Statistical analysis of age at presentation within the subset of children with S pneumoniae–related complications was performed using JMP Statistical Discovery Software, version 4.01 for Microsoft Windows (SAS Institute Inc, Cary, NC). A t test was run, and statistical significance was reported with a P value less than .01, with 102 df. To evaluate trends in the incidence of suppurrative complications of AOM over the 7.5-year study period, 3 equal periods of 2.5 years (30 months) were established. Patients presenting from January 1993 to June 1995 were designated group 1; those presenting from July 1995 to December 1997, group 2; and those presenting from January 1998 to June 2000, group 3. An exact test for directional (1-tailed) linear trend in ordered binomial proportions, available in the StatXact statistical software package (CyTel, Cambridge, Mass), was used to estimate whether rates of total suppurrative complications, surgical intervention, and S pneumoniae resistance expressed as proportions of total otolaryngology admissions increased linearly over the given time intervals.

Acute noncoalescent mastoiditis occurred in 51 patients (49%), while acute coalescent mastoiditis occurred in 24 (23%). All but 4 cases of coalescent mastoiditis demonstrated a subperiosteal abscess. Facial nerve paralysis occurred in 14 patients (13%), 7 each of complete and incomplete paralysis. Epidural abscess occurred in 7 patients (7%), sigmoid sinus thrombosis in 5 (5%), petrositis in 2 (2%), suppurrative labyrinthitis in 1 (1%), and otitic hydrocephaus in 1 (1%). The total number of complications (N=104) exceeds the number of patients (N=90) because some patients manifested concurrent complications.

MICROBIOLOGY

Microbiologic results of specimens taken from the middle ear or mastoid are given in Table 1. Streptococcus pneumoniae was isolated in 16 cases, while resistant S pneumoniae was isolated in 10 cases. For the entire study group, antibiotics were taken within 1 month of presentation by 53 patients (59%). Within the subset of S pneumoniae isolates, 10 patients (63%) had taken antibiotics within the last month while 8 (80%) had done so in the subset of resistant S pneumoniae isolates.

In 11 cases of noncoalescent mastoiditis (22%), no culture material was obtained. In these cases, intravenous antibiotics were given and no myringotomy performed. The microbiologic profile of the remaining cases of noncoalescent mastoiditis revealed 5 S pneumoniae isolates (13%). Gram-positive cocci accounted for 24 isolates (60%). There were no cases of either H influenzae or M catarrhalis. Resistant strains were recovered in 3 of 5 isolates of S pneumoniae, for a resistance rate of 60%.

In the coalescent mastoiditis subset, the microbiologic profile revealed 10 S pneumoniae isolates (42%) while gram-positive cocci accounted for 16 (67%). There was only 1 case of H influenzae, which was β-lactamase negative. Resistant strains of S pneumoniae were recovered in 6 of 10 cases, yielding a resistance rate of 60%. In cases of facial nerve paralysis, 7 cultures revealed no growth (50%). There was 1 case of resistant S pneumoniae. Gram-positive cocci accounted for 4 (29%). The case of suppurrative labyrinthitis resulted from Staphylococcus aureus. Patients with petrositis, epidural abscess, or sigmoid sinus thrombosis tended to have multiple complications. In 2 cases, no organism was isolated. The remaining 9 cases were due to gram-positive cocci, and resistant S pneumoniae was recovered in 1 case.

TREATMENT

Noncoalescent mastoiditis was treated with intravenous antibiotics alone or in combination with myrin-

Table 1. Microbiologic Profile of Noncoalescent, Coalescent, and Total Cases of Mastoiditis*

<table>
<thead>
<tr>
<th>Mastoiditis Type</th>
<th>Noncoalescent</th>
<th>Coalescent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streptococcus pneumoniae†</td>
<td>5 (13)</td>
<td>10 (42)</td>
<td>15 (23)</td>
</tr>
<tr>
<td>Group A streptococcus</td>
<td>6 (15)</td>
<td>4 (17)</td>
<td>10 (16)</td>
</tr>
<tr>
<td>Coagulase-staphylococcus</td>
<td>10 (25)</td>
<td>2 (8)</td>
<td>12 (19)</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>3 (8)</td>
<td>0</td>
<td>3 (5)</td>
</tr>
<tr>
<td>Haemophilus influenzae</td>
<td>0</td>
<td>1 (4)</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Moraxella catarrhalis</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other‡</td>
<td>7 (18)</td>
<td>3 (13)</td>
<td>10 (16)</td>
</tr>
<tr>
<td>No growth</td>
<td>9 (23)</td>
<td>4 (17)</td>
<td>13 (20)</td>
</tr>
<tr>
<td>Total</td>
<td>40 (100)</td>
<td>24 (100)</td>
<td>64 (100)</td>
</tr>
</tbody>
</table>

*All data are number (percentage) of cases.
†S pneumoniae resistance was observed in 9 (60%) of 15.
‡Pseudomonas, Prevotella, and Bacillus species.
The incidence of noncoalescent and coalescent mastoiditis increased over the study period. The proportion of mastoiditis manifesting as coalescent disease increased steadily over the study period from 29% of patients in group 1 (n=5) to 31% in group 2 (n=8) and 34% in group 3 (n=11). The incidence of S pneumoniae and resistant S pneumoniae increased during the study period. All but 2 cases in group 3 of pneumococcal-related disease resulted from resistant strains. This yielded a resistance rate of 75% in the final 2.5 years of the study (Table 3).

Cases of suppurative complications, surgical intervention, and resistant S pneumoniae might be expected to rise as the population served by a given hospital increases. To relate these increases to a measure of the population as a whole, total otolaryngology admissions for the corresponding time periods were obtained (group 1, 540 admissions; group 2, 420; and group 3, 636). To facilitate statistical analysis, rates of suppurative complications, surgical intervention, and S pneumoniae resistance (as proportions of total otolaryngology admissions) were established for the given time intervals. A linear trend approaching statistical significance was noted for increases in the rate of suppurative complications (P=.11), surgical intervention (P=.17), and S pneumoniae resistance (P=.15).

Otitis media is one of the most commonly diagnosed pediatric illnesses. Before modern antibiotics, the sequelae of AOM contributed to significant morbidity and mortality. In the antibiotic era, however, suppurative complications of AOM have declined dramatically. The emergence of resistant bacteria has generated concern over the past 20 years. Some have predicted a concomitant rise of suppurative complications and requisite need for surgical intervention as a consequence of antimicrobial resistance.

The breakdown of suppurative complications in this study revealed a preponderance of acute mastoiditis, followed by facial paralysis, epidural abscess, sigmoid sinus thrombosis, petrositis, suppurative labyrinthitis, and otitic hydrocephalus. Epidural abscess, sigmoid sinus thrombosis, and petrositis occurred in patients with multiple concurrent complications.

Acute mastoiditis is classified as either noncoalescent or coalescent, representing a continuum of the disease process. Coalescent mastoiditis is considered a more virulent process, manifesting as destruction of mastoid trabeculae and/or cortex, and typically portends a worse prognosis. Cortical mastoidectomy is regarded as the standard of care for coalescent mastoiditis. In this study, coalescent mastoiditis was diagnosed in patients with bony erosion of the mastoid, which was demonstrated radiographically by computed tomography and confirmed in all cases during mastoidectomy.

In 46 patients with noncoalescent mastoiditis (90%), intravenous antibiotics alone or in combination with myringotomy and tubes were effective. Five patients required acute surgical intervention for subperiosteal abscess or failure to improve under treatment with intravenous antibiotics. All cases of coalescent mastoiditis underwent mastoid surgery. In total, 29 patients with acute mastoiditis (39%) required surgery. In 1998, Goldstein et al documented that intervention was more prevalent during the later years. Consequently, the proportion of cases requiring surgical intervention increased over the study period from 31% of patients in group 1 (n=7) to 34% in group 2 (n=11) and 38% in group 3 (n=14). The incidence of S pneumoniae and resistant S pneumoniae increased during the study period. All but 2 cases in group 3 of pneumococcal-related disease resulted from resistant strains. This yielded a resistance rate of 75% in the final 2.5 years of the study (Table 3).

### Table 2. Rising Incidence of Coalescent and Noncoalescent Mastoiditis During the Study Period*

<table>
<thead>
<tr>
<th>Disease Process</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coalescent mastoiditis</td>
<td>5</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Noncoalescent mastoiditis</td>
<td>12</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>Total mastoiditis</td>
<td>17</td>
<td>26</td>
<td>32</td>
</tr>
</tbody>
</table>

*Unless otherwise indicated, all data are number of cases. Groups are defined in the “Patients and Methods” section.

### Table 3. Rising Incidence of Total Suppurative Complications, Surgical Therapy, and Streptococcus pneumoniae Resistance*

<table>
<thead>
<tr>
<th>Factor Evaluated</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suppurative complication</td>
<td>21</td>
<td>32</td>
<td>37</td>
<td>.11</td>
</tr>
<tr>
<td>Surgical intervention</td>
<td>7</td>
<td>11</td>
<td>14</td>
<td>.17</td>
</tr>
<tr>
<td>Percentage requiring surgery</td>
<td>31</td>
<td>34</td>
<td>38</td>
<td>...</td>
</tr>
<tr>
<td>S pneumoniae isolates</td>
<td>3</td>
<td>5</td>
<td>8</td>
<td>...</td>
</tr>
<tr>
<td>Resistance S pneumoniae isolates</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>.15</td>
</tr>
<tr>
<td>Percentage resistance</td>
<td>67</td>
<td>40</td>
<td>75</td>
<td>...</td>
</tr>
</tbody>
</table>

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### Statistical Analysis

The incidence of noncoalescent and coalescent mastoiditis increased over the study period. The proportion of mastoiditis manifesting as coalescent disease increased steadily over the study period from 29% of patients in group 1 (n=5) to 31% in group 2 (n=8) and 34% in group 3 (n=11). The incidence of coalescent disease increased to a greater extent than that of noncoalescent disease toward the latter years of the study (Table 2).

Both the total number of patients presenting with suppurative complications and those requiring surgical intervention increased over the study period. Surgical intervention was more prevalent during the later years. Consequently, the proportion of cases requiring surgical intervention increased over the study period from 31% of patients in group 1 (n=7) to 34% in group 2 (n=11) and 38% in group 3 (n=14). The incidence of S pneumoniae and resistant S pneumoniae increased during the study period. All but 2 cases in group 3 of pneumococcal-related disease resulted from resistant strains. This yielded a resistance rate of 75% in the final 2.5 years of the study (Table 3).

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### Comment

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mented their 15-year experience with intratemporal complications of AOM in the Pittsburgh, Pa, area. Twenty-five percent of patients with acute mastoiditis required surgery. Antonelli et al reported that 34% of patients with mastoiditis required mastoidectomy for coalescence, development of additional complications, or failure to improve under treatment with intravenous antibiotics. The present study is notable for the higher rate of surgical intervention for patients presenting with acute mastoiditis.

Isolated facial nerve paralysis resulting from AOM responded well to intravenous antibiotics and myringotomy with or without tubes in most patients. Despite poor long-term follow-up, all patients displayed significant improvement prior to hospital discharge and, ultimately, most experienced excellent recovery of facial function. Similar to other studies, mastoidectomy with facial nerve decompression was performed infrequently, primarily in those with multiple concurrent suppurative complications or those failing to improve after treatment with parenteral antibiotics and myringotomy.10

All patients with multiple suppurative complications required mastoid surgery. In the present series, factors dictating the need for mastoid surgery were coalescent disease, multiple suppurative complications, and failure to improve under treatment with intravenous antibiotics.

The incidence of acute mastoiditis and total suppurative complications increased over the study period. The rise in coalescent mastoiditis outpaced a similar rise in noncoalescent mastoiditis. Additionally, the percentage of cases requiring surgical intervention increased over the study period. This particular trend has not been documented in the literature.

Resistant *S. pneumoniae* was isolated more frequently over the last years of the study. All but 2 cases of pneumococcal-related suppurative complications were attributable to resistant strains during the final 2.5 years. For this group, resistant organisms were isolated in 75% of patients. Local rates of *S. pneumoniae* resistance have been established at 50% to 60%.11 Our study population was composed of patients with severe and sometimes refractory sequelae of AOM; therefore, a higher prevalence of more virulent organisms than found in general inpatients or outpatients was expected. The mean age of the *S. pneumoniae* population was significantly younger than that observed for the total study group. Factors such as young age, day care attendance, and antibiotic exposure are known risk factors for pneumococcal disease.12,13

Gathering microbiologic data was hindered by several factors. First, culture material was not obtained in a large number of patients with noncoalescent mastoiditis. This occurred typically in those patients whose condition improved rapidly under treatment with intravenous antibiotics. Therefore, myringotomy and culture were not performed. Second, 90% of the specimens exhibiting no growth occurred in those patients who received oral antibiotics just prior to admission. Culture material yields diagnostic information vital to therapeutic decision making in this time of high antibiotic resistance. Given that antibiotics suppress bacterial growth, obtaining a specimen prior to implementing intravenous antibiotic treatment is preferable and improves the diagnostic yield of the laboratory tests. Because myringotomy with aspiration and subsequent culture of middle ear contents is both diagnostic and therapeutic, all patients with suppurative complications should benefit from this intervention.

Gram-positive organisms such as *S. pneumoniae*, *Staphylococcus* species, and group A *Streptococcus* constituted most of the bacteria cultured from isolates in this study. All cases manifesting multiple suppurative complications occurred as a result of these organisms. The increased virulence of gram-positive cocci compared with *H. influenzae* and *M. catarrhalis* is substantiated by the prevalence of these organisms in suppurative complications of AOM.

In conclusion, the increasing incidence of resistant *S. pneumoniae* seems to parallel the rising number of cases of acute mastoiditis and other suppurative complications of AOM at our institution. Mastoidectomy is necessary in the management of many of these infections, possibly because of the increased virulence of the infectious process. Early acquisition of middle ear cultures for laboratory evaluation is recommended to assist in management decisions. Coalescence, concomitant suppurative complications, and clinical regression dictate the need for timely surgical intervention.

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Corresponding author: Peter S. Roland, MD, Department of Otolaryngology—Head and Neck Surgery, The University of Texas Southwestern Medical Center, 5323 Harry Hines Blvd, Dallas, TX (e-mail: peter.roland@mednet.swmed.edu).

### REFERENCES