**BACTERIAL MENINGITIS AND PEDIATRIC SENSORINEURAL HEARING LOSS IN THE POST-PCV13 ERA.**

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The authors do not have any relevant financial conflicts to disclose.

**ABSTRACT**

INTRODUCTION: Bacterial meningitis is the most common cause of postnatally-acquired sensorineural hearing loss (SNHL). Prognostic associations are lacking for pediatric SNHL due to Streptococcus pneumoniae bacterial meningitis after the introduction of updated pneumococcal vaccine (PCV13) in 2010. OBJECTIVES: 1) To assess clinical presentation of meningitis based on bacterial etiology in children and identify associations with post-menignitic SNHL in children after 2010. 2) To describe rates of S. pneumoniae-associated post-menignitic SNHL based on three time periods: pre-PCV, post-PCV7 and post-PCV13. METHODS: A retrospective review was performed for patients 18 years and younger diagnosed with meningitis after January 1, 2010. Patients were identified by history of positive CSF bacterial culture or FilmArray Meningitis/Encephalitis Panel (MEP) assay. Clinical data were stratified by bacterial etiology, analyzed for clinically relevant characteristics, and compared with previously reported rates of post-menignitic SNHL. RESULTS: In a cohort of 147 patients with positive CSF cultures, 91 (61.9%) met inclusion criteria. Seventy-one (mean age 21 months; 56% male) had audiograms after diagnosis and were divided into four subgroups based on bacterial etiology: S. pneumoniae (n=20), Group B streptococcus (GBS, n=25), Haemophilus influenzae (n=10), and Other (n=16). Of those with hearing evaluations, SNHL was reported in 15 patients (21%), most frequently in the S. pneumoniae group (n=10, 47%, 20% for GBS). Children in the PCV13 vaccination era had a similar rate of post-menignitic SNHL (42%) as historical pediatric cohorts in the pre-PCV vaccination time period (23.8%), and the PCV7 vaccination time period (35%) (Fishier’s exact, p=0.19). CONCLUSION: Despite advances in vaccine development for S. pneumoniae, SNHL remains a common long-term complication of this disease. Further research into predicting and preventing this outcome is necessary.

**BACKGROUND**

- Bacterial meningitis (BM) accounts for 60-90% of all pediatric sensorineural hearing loss (SNHL) cases and is associated with significant morbidity and mortality in children.
- The two most common causes of postnatally acquired SNHL cases are H. influenzae type B (HiB) and S. pneumoniae.
- Vaccines against HiB and S. pneumoniae have dramatically reduced incidence of bacterial meningitis.
- However, the incidence of pediatric SNHL due to pneumococcal meningitis has remained stable at 28-33% between the years of 2007-2013.
- Hearing loss has significant effects on childhood development, contributing to delays in language development and academic performance.
- No prior studies have compared bacterial meningitis and hearing outcomes from children in the pre-PCV, post-PCV7 and post-PCV13 eras.

**OBJECTIVES**

- To present a pediatric cohort of patients with bacterial meningitis and SNHL in the post-PCV13 era.
- To compare historical data about bacterial meningitis and SNHL from the pre-PCV and post-PCV era with a post-PCV13 pediatric cohort.

**METHODS AND MATERIALS**

- Institutional review board approval was obtained.
- Chart review of patients with spontaneous bacterial meningitis from 2010-2020.
- Inclusion criteria: CHCO patients diagnosed with spontaneous bacterial meningitis on or after January 1, 2010. Age 18 years or younger at time of diagnosis. Diagnosis must be made by positive CSF cultures.
- Exclusion criteria: Patients with known underlying immunodeficiencies, on biologic agents such as monoclonal antibodies or with bacterial meningitis related to trauma, a shunt infection or a neurological procedure. Patients without culture or PCR-confirmed meningitis due to bacterial etiology.
- Data was compared with previously reported rates of post-menignitic SNHL.

**RESULTS**

Demographics and Clinical Characteristics stratified by Bacterial Etiology

<table>
<thead>
<tr>
<th>Bacterial Etiology</th>
<th>Hi. flu (n=10)</th>
<th>Other (n=16)</th>
<th>GBS (n=25)</th>
<th>S. pneumoniae (n=20)</th>
<th>Total (N=71)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>5 (50%)</td>
<td>4 (25%)</td>
<td>21 (84%)</td>
<td>15 (75%)</td>
<td>52 (74%)</td>
</tr>
<tr>
<td>Black/African American</td>
<td>3 (30%)</td>
<td>3 (19%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>6 (9%)</td>
</tr>
<tr>
<td>Asian</td>
<td>0 (0%)</td>
<td>1 (6%)</td>
<td>1 (4%)</td>
<td>1 (5%)</td>
<td>3 (5%)</td>
</tr>
<tr>
<td>More than one race</td>
<td>2 (20%)</td>
<td>1 (6%)</td>
<td>1 (4%)</td>
<td>1 (5%)</td>
<td>5 (7%)</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>0 (0%)</td>
<td>1 (6%)</td>
<td>5 (20%)</td>
<td>3 (15%)</td>
<td>9 (13%)</td>
</tr>
</tbody>
</table>

**Table 1. Demographics and Clinical Characteristics stratified by Bacterial Etiology**

<table>
<thead>
<tr>
<th>Hi. flu</th>
<th>Other</th>
<th>GBS</th>
<th>S. pneumoniae</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No (%)</td>
<td>62%</td>
<td>56%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>Deceased %</td>
<td>4%</td>
<td>6%</td>
<td>10%</td>
<td>10%</td>
</tr>
</tbody>
</table>

**Table 2. Outcomes for patients with bacterial meningitis stratified by bacterial etiology**

<table>
<thead>
<tr>
<th>Bacterial Etiology</th>
<th>Hi. flu (n=10)</th>
<th>Other (n=16)</th>
<th>GBS (n=25)</th>
<th>S. pneumoniae (n=20)</th>
<th>Total (N=71)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hearing Loss?</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes (%)</td>
<td>6 (60%)</td>
<td>10 (62%)</td>
<td>19 (76%)</td>
<td>9 (45%)</td>
<td>44 (62%)</td>
</tr>
<tr>
<td>No (%)</td>
<td>4 (40%)</td>
<td>6 (38%)</td>
<td>6 (24%)</td>
<td>11 (55%)</td>
<td>27 (39%)</td>
</tr>
<tr>
<td>Deceased (%)</td>
<td>1 (10%)</td>
<td>2 (12%)</td>
<td>4 (16%)</td>
<td>10 (50%)</td>
<td>17 (24%)</td>
</tr>
</tbody>
</table>

**DISCUSSION**

- We present a novel analysis of post-menignant SNHL in a pediatric cohort after the introduction of the PCV13 vaccine in 2010.
- Prior studies from the pre-PCV7 and PCV7-vaccinated era have reported similar rates of post-menignant SNHL as our pediatric cohort.
- Our results indicate a need for further exploration of predictive markers in the pathogenesis of post-menignant SNHL, particularly in pediatric pneumococcal populations.

**CONCLUSION**

- Advances in vaccine development have helped reduce incidence of bacterial meningitis in the US due to H. influenzae and S. pneumoniae.
- Rates of SNHL within post-pneumococcal meningitis populations remain constant in pediatric cohorts since the introduction of PCV7 and PCV13.
- Future directions include univariate testing and potential multivariate analysis if more patients are added that meet inclusion criteria.

**References**


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