Otitis Media with Effusion (OME) and Sensorineural Hearing Loss (SNHL): “Ungluing a Sound Foundation”

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OME & SNHL: A Persistent Topic of Concern

“Conductive hearing losses due to serous otitis media in children who suffer from sensorineural hearing loss are at once more difficult to identify and may perhaps be more devastating in terms of auditory deprivation than in children without sensorineural hearing loss.”

OME & SNHL: A Persistent Topic of Concern

• 1970’s – with advent of tympanometry, reports of:
  – Frequency of previously undetected OME in schools for the deaf (e.g., Porter 1974; Rubin 1978; Mehta & Erlich 1978; Findlay et al. 1978; Morgenstern & Jones-Crymes 1979)
  – Missed identification of underlying mild and moderate PHL due to OME overlay (e.g., Hutchings 1978; Ruben & Math 1978)
  – Problems in audiologic confirmation of PHL with audiometry & evoked response methods (e.g., Mair et al. 1979)
OME & SNHL: A Persistent Topic of Concern

• 1980’s – papers on audiologic confirmation & management of child with OME & SNHL:
  – High prevalence of OME in children with SNHL particularly when other developmental delays present (e.g., Das 1990)
  – Audiologic misdiagnosis (e.g., Toner & Kerr 1987)
  – Impact on amplification use (e.g., Milner et al 1985)
  – Need for aggressive treatment (e.g., Milner et al. 1985; Bluestone 1988)
OME & SNHL: A Persistent Topic of Concern

• Brookhouser, Worthington & Kelly 1993: “Middle ear disease in young children with sensorineural hearing loss”
  – Studied 437 consecutive cases of children with bilateral SNHL (moderate or >; before 5 years of age) at BTNRH
  – Described threshold shift associated with OME
  – Percentage (35%) which required tympanostomy tubes (TT) because of persistence of OME & impact on auditory function
Brookhouser et al. 1993:
Observations

Before the advent of newborn hearing screening, these authors warned:

“…serious diagnostic errors can occur, particularly as to the degree and configuration of the SNHL, leading to inappropriate conclusions regarding expected benefit from conventional amplification and rehabilitative recommendations”
The “Glue”: OME

- Presence of fluid (effusion) in middle ear without signs & symptoms of acute infection
- 90% of children (80% of individual ears) have OME before school age: 6 mo – 4 yr
  - 1\(^{st}\) yr: > 50% of children experience OME
  - By 2\(^{nd}\) yr: > 60%

OME

• Many episodes resolve spontaneously within 3 mo

• However,
  – ~ 30-40% children have recurrent OME
  – 5-10% of children have episodes that last ≥ 1 yr

OME

- TT before 1 year of age – increased risk of additional tube insertions
- Social class, day care, exposure to other children & respiratory infections
- Breast feeding & passive smoke exposure
- Genetic susceptibility

Daly et al., (2005). Epidemiology, Natural History, & Risk Factors Annals Otol Rhinol Laryngol (Suppl)
Effect of OME on Threshold Sensitivity: Cross-sectional Studies in Children

- 50%: AC Ave = 20 dB HL
- 20%: AC Ave ≥ 35 dB HL
- 5-10%: AC Ave = 40-50 dB HL

Kokko 1974; Fria et al. 1985; Hunter et al. 1994
Degree of Hearing Loss
Average (.5, 2 & 4 kHz) Thresholds (sound field)
in dB HL for Bilateral OME

<table>
<thead>
<tr>
<th>Age in mo.</th>
<th>Method</th>
<th>Site</th>
<th>Mean dB HL (sd)</th>
<th>Range in dB HL</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-16</td>
<td>VRA</td>
<td>NC</td>
<td>30.4 (8.9)</td>
<td>13 - 47</td>
</tr>
<tr>
<td>18-26</td>
<td>VRA</td>
<td>NC</td>
<td>27.4 (8.6)</td>
<td>13 - 43</td>
</tr>
<tr>
<td>28-36</td>
<td>Play</td>
<td>NC</td>
<td>24.1 (10.8)</td>
<td>8 - 41</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NY</td>
<td>23.3 (7.1)</td>
<td>13 - 38</td>
</tr>
</tbody>
</table>

Gravel, Roberts et al., 2002
### Air Conduction Threshold Shifts at Time of OME in Children with Sensorineural Hearing Loss
(Brookhouser, Worthington & Kelly 1993)

<table>
<thead>
<tr>
<th></th>
<th>.25 kHz</th>
<th>.5 kHz</th>
<th>1 kHz</th>
<th>2 kHz</th>
<th>4 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>% ears &lt; 20 dB</td>
<td>33%</td>
<td>10%</td>
<td>21%</td>
<td>33%</td>
<td>30%</td>
</tr>
<tr>
<td>% ears 20-30 dB</td>
<td>33%</td>
<td>59%</td>
<td>46%</td>
<td>39%</td>
<td>30%</td>
</tr>
<tr>
<td>% ears &gt; 30 dB</td>
<td>33%</td>
<td>31%</td>
<td>33%</td>
<td>28%</td>
<td>40%</td>
</tr>
<tr>
<td>% ears ≥ 40 dB</td>
<td>15%</td>
<td>20%</td>
<td>23%</td>
<td>23%</td>
<td>27%</td>
</tr>
</tbody>
</table>
Chronic OME and Extended High-Frequency Hearing Loss

kHz

- EHF HL increased with frequency in children with OME histories –
  - Suggest basal cochlear damage
- EHF HL in OME directly related to # of tubes and frequency of OME episodes during follow-up.

e.g., Hunter et al., 1996, e.g., Hunter et al., 1996, Gravel et al. 2005
Impact on Audiologic Practice: Detection of Permanent Hearing Loss when MEE is present

Early Identification through Newborn Screening
A-ABR and OAE Pass Rate for Ears and Outcome of Otoscopic Inspection

Doyle et al., 1997

% Ears Passing

AABR

OAE

93.6

87.6

50

37.5

*p < 0.001
Prevalence of Abnormal TM Mobility/MEE in Neonates

<table>
<thead>
<tr>
<th>Well Baby</th>
<th>NICU</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 9.0% Doyle et al., 1997</td>
<td>• 20% Sutton et al., 1996</td>
</tr>
<tr>
<td>• 7.3% Smurzynski et al., 1993</td>
<td>• 21% Pestalozza, 1984</td>
</tr>
<tr>
<td>• 9.0% Chang et al., 1993</td>
<td>• 30% Balkany et al., 1978</td>
</tr>
<tr>
<td>• 11.0% Poulsen &amp; Tos, 1978</td>
<td>• 3% Warren &amp; Stool, 1971</td>
</tr>
<tr>
<td>• 0% Balkany et al., 1978</td>
<td></td>
</tr>
</tbody>
</table>
Risk Factor for MEE:
Length of Stay in NICU

Sutton, Gleadle & Rowe, 1996

- Infants staying > 30 days: relative risk = 4.3
  (95% confidence interval 2.0 - 9.1)
- Infants staying > 50 days: relative risk = 5.3
  (95% confidence interval 1.9 - 14.6)

Our challenge: Prevalence of PHL is 10x greater in the NICU Population
Neonatal Middle Ear Effusion Predicts Chronic Otitis Media


- Majority of infants (58%) with neonatal MEE at 30 to 48 hrs of age will develop COME during 1st year of life
- COME common in all infants: 20% (control subjects)
- Average # of OME episodes in Year 1:
  - Neonatal effusion = 4.14
  - No neonatal effusion = 1.27
Tympanometry in Infants > 4m

- Abnormal 220-Hz tympanograms associated with OME
- Normative values available for infants and young children 6-36 months of age (Roush et al., 1995)
But…

Infants < 4 months (CA)

• Normal 220-Hz tympanograms in ears with OME (Paradise et al. 1976, Shurin et al., 1976, Meyer et al. 1997)

• Abnormal 220-Hz tympanograms in normal ears (Keefe et al., 1996)
Higher-Frequency Probe Tone: Infants < 4 months (CA)

• Good agreement between 660-Hz probe-tone and presence of OME (Shurin et al 1977, Marchant et al 1984)

• Good agreement between 660-Hz & 1000-Hz tympanograms & ABR (Baldwin 2000) and 1000-Hz & OAE presence (Margolis et al. 2003)
Margolis et al. 2003

7-week-old; velar cleft; subsequently OME; PE tubes
Problems in using OAEs: Audiologic Diagnosis of Infants

- Middle ear effusion/OME = absent OAE
- Inappropriate probe frequency during tympanometry in young infants:
  - normal tympanogram and absent OAE interpreted as SNHL
  - Abnormal tympanogram and absent OAE interpreted as conductive HL
Across infants & young children (1 wk - 8 yrs) with NL and HL, correlations between ABR & Behavioral thresholds ≥ 0.94.

- 80% of thresholds within 15 dB; 93% within 20 dB.

Stapells, Gravel & Martin, 1995
Clinical Pitfall: ABR and OME

- In some infants, ABR may overestimate the degree of hearing loss when OME+
- ‘Assumption’ of type of HL based on ABR thresholds when OME+ unwise.
- Tympanometry and BC-ABR are critical in audiologic assessment
- Delaying ABR because of OME+ = late ID of underlying SNHL

Stapells, 1989
OME & PHL: Impact on Audiologic Practice

Timely & Accurate Confirmation
(Comprehensive Audiologic Assessment)
Case 1: Logan
Case: Logan

- Male: now 3 years; developmental delay
- 30 wk premie; 1 mo stay in NICU at another facility; transferred to CHOP: 2 mo. NICU stay; ventilated
- Failed first ABR screening in NICU:
  - left ear fail; right ear pass
  - CNT tympanogram on screening day
  - MEE suspected
  - ENT consult
  - Rec: ABR following ENT clearance
Case: Logan

- Failed 3 total screenings during NICU stay; same pattern of results:
  - right ear: pass; left ear: fail

- Following discharge seen for outpatient screening:
  - DPOAE: present right; absent left
  - Scheduled for complete ABR one month later
Case: Logan

- Returned for sedated ABR; CN sedate- child had taken juice that morning; rescheduled; next sedated ABR slot 4 months later
- Showed up for 8:30 am appointment at 10:45; ABR rescheduled two months later; family ‘no-showed’ for ABR
- One month later, child had CAE
  - Tympanometry: normal R; flat L
  - SF responses to NBN at 70 dB HL at .5 and 1 kHz; SF to speech @ 65 dB HL ‘Fair reliability’
  - Recommendation: ABR
Case: Logan

- One month later, ‘no show’ for ABR; mother when contacted said he had “still not had fluid drained from ear”
- One year later, CAE
  - Flat tympanograms bilaterally consistent with OME
  - BC: 15 dB at .5 and 2 kHz
  - SF: FM tones at 60 dB HL
- 6 months later: CAE prior to ventilating tube insertion: 70 dB HL SAT in sound field
# Case: Logan Audiogram

<table>
<thead>
<tr>
<th></th>
<th>.5 kHz</th>
<th>1 kHz</th>
<th>2 kHz</th>
<th>4 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Right</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15dB</td>
<td>70dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Left</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40 dB</td>
<td>100 dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sound Field</strong></td>
<td>40 dB</td>
<td>30 dB</td>
<td>30 dB</td>
<td>&gt;80 dB</td>
</tr>
</tbody>
</table>

Tympanograms: Large volumes bilaterally indicating patent ventilating tubes
Case: Logan

to be continued......
Factors Impacting Logan’s Case: The OME Loop

• Policy of not performing diagnostic ABRs in NICU if fluid is present in at least one ear: postponed tests for otologic clearance

• Mother in need of increased support for follow-up; missed appointments, misunderstood instructions regarding sedation and reversed ABR test policy with regard to OME, long waitlist for ABR testing

• Presence of MEE may have affected the ‘urgency message’ mother received (thinking the issue was fluid and not the possibility of permanent hearing loss)
Case 2: Harrison
Case: Harrison

Age: One Week
Diagnostic ABR following A-ABR screening fail

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Wave V Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
</tr>
<tr>
<td>Click</td>
<td>90 dB nHL</td>
</tr>
<tr>
<td>0.5 kHz tone</td>
<td>DNT</td>
</tr>
<tr>
<td>BC</td>
<td>DNT</td>
</tr>
<tr>
<td>Tymp (1 kHz)</td>
<td>CNT</td>
</tr>
</tbody>
</table>

Recommendation: ENT evaluation; Repeat ABR; Refer to Early Intervention; Ophthalmology
Case: Harrison

Age: 4 weeks
2\textsuperscript{nd} Diagnostic ABR

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Wave V Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>Left</td>
</tr>
<tr>
<td>Click</td>
<td>70 dB nHL</td>
</tr>
<tr>
<td>.5 kHz tone</td>
<td>DNT</td>
</tr>
<tr>
<td>BC</td>
<td>DNT</td>
</tr>
<tr>
<td>Tymp (1 kHz)</td>
<td>flat</td>
</tr>
</tbody>
</table>

Recommendation: ENT evaluation
Impression: conductive HL
Case: Harrison

Age: 11 weeks
3rd Diagnostic ABR: Status post-tubes

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Wave V Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
</tr>
<tr>
<td>Click</td>
<td>60 dB nHL</td>
</tr>
<tr>
<td>.5 kHz tone</td>
<td>60 dB nHL</td>
</tr>
<tr>
<td>BC</td>
<td>30 dB nHL</td>
</tr>
<tr>
<td>Tymp (1 kHz)</td>
<td>Flat-nl vol.</td>
</tr>
</tbody>
</table>

Impression: Right tube blocked (ENT); Rx: drops
Recommendation: ENT management; F/U ABR
Case: Harrison

Age: 3 months
4th Diagnostic ABR: (with sedation) ENT cleared

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Wave IV Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
</tr>
<tr>
<td>Click</td>
<td>60/50 dB nHL</td>
</tr>
<tr>
<td>.5 kHz tone</td>
<td>60 dB nHL</td>
</tr>
<tr>
<td>BC</td>
<td>45 dB nHL</td>
</tr>
<tr>
<td>Tymp (1 kHz)</td>
<td>Large vol.</td>
</tr>
</tbody>
</table>

Impression: Sensorineural HL; patent tubes
Recommendation: Binaural hearing aids; Loaners fit
Factors Impacting Harrison’s Case

• Diagnostic ABR despite MEE presence
• Repeated ABRs yielded findings that were variable from original impression of conductive hearing loss
• Early intervention achieved by 3 months of age due to persistence of audiologic testing and otologic follow-up
OME & PHL: Impact on Audiologic Practice

Hearing Aid Selection, Fitting & Verification
Factors to consider in Hearing Aid Fitting: PHL and OME

- **RECD measures:** Martin, Westwood & Bamford (1996)
  - Mean RECD’s in 0.2 – 3 kHz up to 3.5 dB greater for children with OME than those without
  - Good test-retest reliability 4 kHz and below
  - Large inter-subject variability
Factors to consider in Hearing Aid Fitting: PHL and OME

• Adult listeners with mixed hearing loss
  – Higher LDLs
  – Prefer more gain than listeners with only PHL (Berger 1980; Walker 1997; Carlin & Browning 1990; Lieu & Chen, 2000)

• Various methods for accounting for effects of conductive overlay have been suggested
Factors to consider in Hearing Aid Fitting: PHL and OME

• New DSL v5.0:
  – Targets never exceed 140 dB SPL in the ear canal regardless of presence of conductive hearing loss
  – Predictions of LDL increased by 25% of air-bone gap from .5 – 4 kHz

Scollie et al. (in press)
OME & PHL: Impact on Audiologic Practice

Development of Auditory-Based Communication and Cochlear Implant Candidacy
Case 3: Emily

- Severe sensorineural hearing loss identified by newborn hearing screening
- Fit at 3 months with digital hearing aids
- Developed recurrent OME
- At CHOP, aids determined to be inappropriate (speech essentially inaudible)
Case: Emily

• Made no progression in achieving auditory/language milestones
• Considered to receive no benefit from conventional amplification
• At 12 months, decision to proceed with cochlear implantation
Factors Impacting Emily’s Case

• Recurrent OME: severe loss often was profound impairment
• Inappropriate early hearing aid fitting even without OME, although advanced technology used
Factors Impacting Emily’s Case

• Questionable whether infant received any ‘trial period’ with appropriate amplification or whether auditory skills had an opportunity to develop: auditory deprivation

• Parents and CI team decided to move ahead with implantation shortly after infant’s first birthday.
Clinical Practice Guidelines: OME
Rosenfeld, et al. 2004
Otolaryngol Head Neck Surg, 130(5), S95-S118

AAP, AAFP, AAO-HNS
Liaisons: ASHA, AAA, NAPNP
Child At Risk Recommendation
Clinical Practice Guidelines: OME
Rosenfeld, et al. 2004
Otolaryngol Head Neck Surg, 130(5), S95-S118

- **Risk factors (sensory, physical, cognitive or behavioral) for Developmental Difficulties:**
  - Permanent HL independent of OME
    - Suspected or Diagnosed Speech-Language Delay or Disorder
    - Autism-spectrum disorder & other PDD
    - Syndromes (e.g., Down) or craniofacial disorders that include cognitive, speech & language delays
    - Blindness or uncorrectable visual impairment
    - Cleft palate, with or without associated syndrome
    - Developmental delay
Research Needs

- impact of MEE on speech perception in children with SNHL and with and without OME
- chronic OME leading to increase in existing SNHL
- effect of unilateral SNHL and chronic OME bilaterally
- validity of conductive correction to prescriptive gain
- simple, quick & reliable method to detect OME in children with sensorineural hearing loss who use amplification
OME and Sensory Hearing Loss: Ungluing a Sound Foundation

Thanks for Listening!!

And special thanks to:
Fran Batson, Amy Flamenbaum, Amy White,
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