Audiological Diagnosis after Newborn Screening

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Universal Newborn Hearing Screening (UNHS): What’s next?

- **0 – 1 month**: UNHS
- **3 months**: Diagnosis
- **6 months**: Intervention
Behavioral Audiometry: when and how

- Objective measures: what is children-specific?
- Diagnostic strategy
Principles of Behavioral Audiometry

- Building a circular path between the clinician and the child

  *Deliver stimuli*  
  *Take reactions*

  *Take stimuli*  
  *Deliver reactions*

- Adapt your testing to the child age (neurodevelopmental, not chronological)

- Always use the parents as partners when testing
Before 6 months: Behavioral Observation Audiometry (BOA)

- Take your time and look for the infant reflexive behaviors to auditory stimuli: i.e., eye blink/widening, modification of cardiac rhythm, startle responses (Moro reflex)...
- **Bias 1**: can be elicited by a wide range of intensity levels
- **Bias 2**: babies can get bored very quickly
- **Bias 3**: observer experience-dependent
Behavioral Audiometry: when and how

Objective measures: what is child specific?

Diagnostic strategy
TARGETTING…

- Middle Ear
- Inner Ear
- Afferent pathway & beyond
Otitis with middle ear effusion

Impedance: type B

P1 = 0 atm

Adapted from Van Den Abbeele et al.

Tympanometry

(Otto Metz, 1946; Jerger, 1970)
# Effect of ear canal volume

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Equivalent ear canal volume ($V_{ec}$)</th>
<th>Static compensated admittance ($Y_{tm}$)</th>
<th>Tympanometric width (TW)</th>
<th>Tympanometric peak pressure (TPP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborns and Infants &lt;6 months (1000 Hz probe)</td>
<td>0.2 – 0.8 cc</td>
<td>$\geq 0.6$ mmho for negative compensation</td>
<td>$&lt;150$ daPa</td>
<td>NA</td>
</tr>
<tr>
<td>6-18 months - (226 Hz probe)</td>
<td>0.5 – 1.0 cc</td>
<td>$\geq 0.2$ mmho</td>
<td>$&lt;250$ daPa</td>
<td>+25 to -75 daPa</td>
</tr>
<tr>
<td>&gt;18 months to 10 years (226 Hz probe)</td>
<td>0.6 – 1.2 cc</td>
<td>$\geq 0.3$ mmho</td>
<td>$&lt;200$ daPa</td>
<td>+25 to -75 daPa</td>
</tr>
<tr>
<td>&gt;10 years and Adults (226 Hz probe)</td>
<td>1.0 – 2.2 cc (males)</td>
<td>$\geq 0.3$ mmho</td>
<td>$&lt;125$ daPa</td>
<td>+5 to -105 daPa</td>
</tr>
<tr>
<td></td>
<td>0.8-1.9 cc (females)</td>
<td></td>
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<td></td>
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</tbody>
</table>

Consensus statement: Eriksholm workshop on wideband absorbance measures of the middle ear. Feeney MP et al., Ear Hear. 2013
3D wideband tympanometry
TARGETTING...

- Middle Ear
- Inner Ear
- Afferent pathway & beyond
Transient evoked otoacoustic emissions
Transient evoked otoacoustic emissions

Assessing OHCs in vivo

Otoacoustic emissions
Distorsion Product Otoacoustic emissions

Objective Audiometry: DPOAEs are back!
Distorsion Products
Distorsion Products
Distorsion Products

![Graph showing f2 amplitude (dB SLP) vs. f2 (Hz) with DPOAE (2f1-f2) and noise floor lines]

![Diagram of a cochlea with high and low frequency sections]
TARGETTING…

- Middle Ear
- Inner Ear
- **Afferent pathway & beyond**
AUDITORY BRAINSTEM RESPONSES

Click, Chirp, Tone Burst

Why « brainstem »?
Early activity (< 20 ms) > 80 Hz

ground

fs = 7 à 50 kHz
3000 trials
> 80 Hz

ABR
Auditory Brainstem Response
Auditory Evoked Potentials (AEP)

I) CLICK ABRs
II) FREQUENCY-SPECIFIC DIAGNOSIS
III) HOW TO GET RID OF CONDUCTIVE HL
ABR RECIPE
IN YOUNG CHILDREN
Looking for objective hearing threshold

Start at 70 dB then diminish stim level (10-20 dB steps)

Normal ABRs (20 dB-threshold)
ABR information

What does it tell you?

- Well-defined waveforms
- CNS maturity
- Topodiagnosis in conjunction with TEOAEs
- Auditory neuropathy diagnosis
TOAEs are present

ABRs are absent

Cochlear microphonic potential (CMP) must be looked for
Cochlear Microphonic Potential (CMP)

- Low amplitude response just a few msec after the click
- Latency does not change with intensity level
- Receptor potential of hair cells
- Follow stimulus polarity (either rarefaction or condensation click)

*(Starr et al., 1996; Starr et al., 2001; Buchman et al., 2006; Berlin et al., 2010)*

From Hood, 2015
Case Report – 2 month-old preterm birth (36 weeks)

OEA present

OEA absent
Case Report – 2 month-old preterm birth (36 weeks)

ABR present
Alternating Polarity click

ABR absent
Alternating Polarity click
Case Report – 2 month-old preterm birth (36 weeks)

CMP present
Rarefaction / Condensation clicks
Auditory Evoked Potentials (AEP)

I) CLICK ABRs
II) FREQUENCY-SPECIFIC DIAGNOSIS
III) HOW TO GET RID OF CONDUCTIVE HL
Tone-evoked ABR in full-term and preterm neonates with normal hearing
Tone-Burst ABR

Ribeiro, 2003
Global neurodevelopment delay
✓ No collaboration at behavioral audiometry
✓ Need for frequency specific diagnosis
Auditory steady state response (ASSR)

Carrier: e.g. 2000 Hz

Modulation 90 Hz

FM +/- AM signal
Auditory steady state response (ASSR)

- Carrier Frequencies (FP) : 500, 1000, 2000, 4000 Hz
- Modulation Frequencies (FM) : 90 Hz

To optimize session strategy decisions as test progresses, the response confidence is tracked over time for each test frequency.
Testing 4 frequencies in both ears at a time!
ASSR provide objective audiogram
Click-ABR vs ASSR threshold
Auditory Evoked Potentials (AEP)

I) CLICK ABR
II) FREQUENCY-SPECIFIC DIAGNOSIS
III) HOW TO GET RID OF CONDUCTIVE HL
With permission from Ribeiro & Chapchap, Hospital Sao Luiz - Sao Paulo
Behavioral Audiometry: when and how

Objective measures: what is child specific?

Diagnostic strategy
TAKE HOME MESSAGES

- Combine otoscopic, endocochlear and afferent auditory pathway examination
- It’s always nice to see the ABR traces
- If you can’t get a precise idea of middle ear status, go for Bone conduction testing
- Frequency-specific diagnosis can be done at follow-up
Thank you!

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