Audiological Diagnosis after Newborn Screening

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Ifos World Course on Hearing Rehabilitation
Ho Chi Minh city, 24 November 2019
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
Tympanometry

(Otto Metz, 1946; Jerger, 1970)

Impedance: type B

\[ P = 0 \text{ atm} \]

Adapted from Van Den Abbeelee et al.
## 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>$\geq 0.6 \text{ mmho for negative compensation}$</td>
<td>$&lt;150 \text{ daPa}$</td>
<td>NA</td>
</tr>
<tr>
<td>6-18 months - (226 Hz probe)</td>
<td>0.5 – 1.0 cc</td>
<td>$\geq 0.2 \text{ mmho}$</td>
<td>$&lt;250 \text{ daPa}$</td>
<td>$+25 \text{ to } -75 \text{ daPa}$</td>
</tr>
<tr>
<td>&gt;18 months to 10 years (226 Hz probe)</td>
<td>0.6 – 1.2 cc</td>
<td>$\geq 0.3 \text{ mmho}$</td>
<td>$&lt;200 \text{ daPa}$</td>
<td>$+25 \text{ to } -75 \text{ daPa}$</td>
</tr>
<tr>
<td>&gt;10 years and Adults (226 Hz probe)</td>
<td>1.0 – 2.2 cc (males)</td>
<td>$\geq 0.3 \text{ mmho}$</td>
<td>$&lt;125 \text{ daPa}$</td>
<td>$+5 \text{ to } -105 \text{ daPa}$</td>
</tr>
<tr>
<td></td>
<td>0.8-1.9 cc (females)</td>
<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 DPOAE amplitude vs. f2 (Hz).]

- DPOAE (2f1-f2)
- Noise floor

![Diagram of the cochlea showing high and low frequency regions.]

- Haute fréquence
- Basse fréquence
TARGETTING…

- Middle Ear
- Inner Ear
- Afferent pathway & beyond
Click, Chirp, Tone Burst

AUDITORY BRAINSTEM RESPONSES

fs = 7 à 50 kHz
3000 trials
> 80 Hz

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

International Journal of Audiology 2007; 00:1–9

Tone-evoked ABR in full-term and preterm neonates with normal hearing
Tone-Burst ABR

Ribeiro, 2003
Tone-Burst ABR

Ribeiro FM, Carvallo, RM; 2007

✓ Global neurodevelopment delay
✓ No collaboration at behavioral audiometry
✓ Need for frequency specific diagnosis
Carrier: e.g. 2000 Hz

Modulation 90 Hz

FM +/- AM signal

Auditory steady state response (ASSR)
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
➢ 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!