Audiological Diagnosis after Newborn Screening

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

0–1 month

3 months

6 months

UNHS
Diagnosis
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
**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)
Principles of Behavioral Audiometry

- Building a circular path between the clinician and the child
- 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

P1 = 0 atm

Otitis with middle ear effusion

Adapted from Van Den Abbeele et al.
# Effect of ear canal volume

<table>
<thead>
<tr>
<th>Age Group</th>
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<tbody>
<tr>
<td>Newborns and Infants (&lt;6 months)</td>
</tr>
<tr>
<td>6-18 months - (226 Hz probe)</td>
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<tr>
<td>&gt;18 months to 10 years (226 Hz probe)</td>
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<tr>
<td>&gt;10 years and Adults (226 Hz probe)</td>
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</tbody>
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<thead>
<tr>
<th>Equivalent ear canal volume (V&lt;sub&gt;ec&lt;/sub&gt;)</th>
<th>Static compensated admittance (Y&lt;sub&gt;tm&lt;/sub&gt;)</th>
<th>Tympanometric width (TW)</th>
<th>Tympanometric peak pressure (TPP)</th>
</tr>
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</table>
| 0.2 - 0.8 cc | </ul=

## 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 0toacoustic emissions

Objective Audiometry: DPOAEs are back!
Distortion Products

[Graph showing frequency peaks: 2f1-f2, f1, f2]

[Diagram showing neural activity with arrows indicating neural pathways]
Distorsion Products
Distorsion Products

Graph showing f2 amplitude (dB SLP) against f2 (Hz) with two lines: one representing DPOAE (2f1-f2) and the other the noise floor.

Diagram of the cochlea with the terms 'Haute fréquence' and 'Basse fréquence'.
TARGETTING...

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

Click, Chirp, Tone Burst

Why « brainstem »?

Early activity (< 20 ms) > 80 Hz

ABR

Auditory Brainstem Response

fs = 7 à 50 kHz
3000 trials
> 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
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)
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-Burst ABRs

Original Article

International Journal of Audiology 2007; 00:1–9

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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
Auditory steady state response (ASSR)
Auditory steady state response (ASSR)

Carrier: e.g. 2000 Hz

Modulation 90 Hz

FM +/-AM signal
- Carrier Frequencies (FP): 500, 1000, 2000, 4000 Hz
- Modulation Frequencies (FM): 40 Hz (awake adult, sleep-sensitive) vs 90 Hz (children)

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
PTA vs ASSR threshold

Rance & Rickards, 2002- JAAA vol.13(5), 236-245.
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 during follow-up
Thank you!