Audiological Diagnostic and On-Going Assessment for Infants

Webcast
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2:00-4:00pm Eastern

Moderator:

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Electrophysiologic Diagnosis of Hearing Loss in Infants in the Era of Universal Newborn Hearing Screening

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Pediatric ABR: The basics

- Stimulus parameters
  - Insert earphones (many advantages)
  - Click and tone burst signals
  - Air- and bone-conduction stimulation
  - Masking generally not important

- Acquisition parameters
  - Fz (vs. Cz) non-inverting electrode
  - 30 Hz (HP) to 1500 or 3000 Hz (LP) filter settings
  - No notch filter
  - Number of stimuli (repetitions or sweep) = to produce adequate SNR

ABR: Advantages of Insert (ER-3A) Earphones

- General
  - increased interaural attenuation
  - increased ambient noise attenuation
  - elimination of ear canal collapse
  - increased patient comfort
  - improved aural hygiene
  - more precise placement (increased reliability)

- ABR specifically
  - reduced transducer ringing
  - reduced stimulus artifact (with separation of transducer from inverting electrode)

Pediatric ABR: Analysis principles

- Waveform analysis of click ABR
  - Delayed wave I (> 2 msec) = conductive component
  - Small or no wave I = sensory hearing loss
  - Delayed inter-wave latencies (e.g., I-V) = neural)
  - Lowest intensity level producing repeatable wave V = 10 dB above estimated behavioral threshold
  - Always take into account age
    - ABR immature at birth (incomplete myelinization)
    - use age-corrected normative data until 18 months after birth

Frequency-Specific ABR Test Protocol: Stimulus Parameters

Parameter	Selection	Rationale
Transducer	ER-3A inserts	numerous infant advantages
Type	tone bursts	available on all systems
Frequencies	1, .5, 4, 2 K Hz	sequence varies clinically
Duration	2-0-2 cycles	abrupt frequencies 0 plateau < specral splatter

Frequency-Specific ABR Test Protocol: Stimulus Parameters

Parameter	Selection	Rationale
Polarity	alternating	minimize stimulus artifact
Rate	27.1/sec	rapid data collection with adequate response integrity with longer analysis time
Intensity	dB nHL	RE: adult behavioral data, but variable unknown increases in effective intensity for infants are likely

Frequency-Specific ABR Test Protocol: Acquisition Parameters

Parameter	Selection	Rationale
Artifact reject	on	minimize muscle artifact
Analysis time	20 msec	encompass delayed wave Vs and SN10 after wave V
Sweeps	> 2000	whatever is needed for SNR for poor morphology ABRs
Reliability	2 or 3 runs	"if it doesn't replicate, you must investigate"

Frequency-Specific ABR Test Protocol: Acquisition Parameters

Parameter	Selection	Rationale
Electrode type	disc & earclip	ease of application
Electrode location	Fz - Nape or Ai Fpz ground	optimal infant response good for BC stimulus permits ipsi/contra meas't
Filter settings	30 - 3000 Hz no notch filter	encompass infant spectrum
Artifact reject	on	minimize muscle artifact

ABR: Frequency-specific stimuli

- How accurate is estimation of pure tone thresholds with tone burst ABR?
  - High correlation (> .94) between ABRs elicited with tone bursts in quiet or in notched noise vs. pure tone thresholds for infants and older children *(e.g., Stapells et al, 1995)*
  - >90% of ABR thresholds were within 20 dB of PT thresholds, and majority were within 10 dB
  - audiometric configuration of the hearing loss does not affect accuracy (Oates & Stapells, 1998)

Tone-Burst ABR Stimulus Intensity: Steps in Calibration

- Develop tone burst protocol (s)
- Obtain average normal behavioral thresholds (from adults) for each tone burst signal (e.g., 35 dB dial = 0 dB nHL)
- Practice recording ABRs for tone burst signals from normal adults and children
- Remember, ABR thresholds are not equal to pure tone hearing thresholds (subtract approx.. 10 dB)
- Plot estimated auditory thresholds on "tone burst ABR audiogram"

A New ABR Motto in the Era of Universal Newborn Hearing Screening

"Don't stick with the click …
Be the first with a burst!"

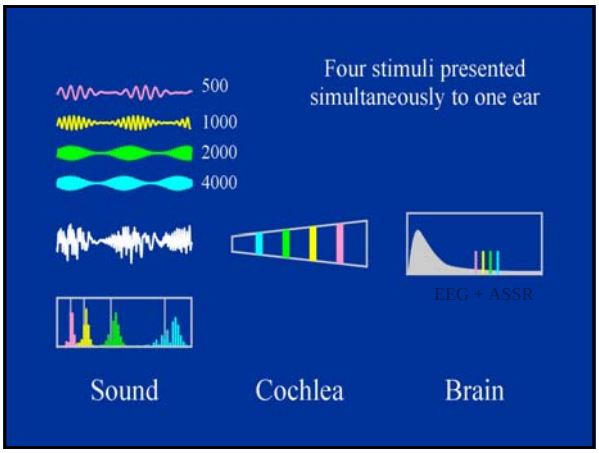
ABR: Protocol for bone conduction

- B-70 vibrator
- Mastoid placement
- Earlobe inverting electrodes (distance from transducer)
- Alternating click stimuli (or tone burst stimulation) to minimize stimulus artifact
- Slower rate (e.g., 11.1/sec) to enhance wave I
- 30 to 3000 Hz (need low frequencies)
- Begin near maximum intensity level (about 50 dB nHL)
- Identify wave I in ipsilateral array to verify test ear
- Plot latency/intensity function for wave V (vs. AC)

AUDITORY STEADY STATE RESPONSE (ASSR): Wave of the Future

ASSR: General Principles

- An electrophysiologic response, similar to ABR.
- Instrumentation includes:
  - Insert earphones
  - Surface electrodes
  - Averaging computer
- Stimuli are pure tones (frequency specific, steady state signals) activating cochlea and CNS
- ASSR is generated by rapid modulation of "carrier" pure tone amplitude (AM) or frequency (FM).
- Signal intensity can be as high as 120 dB HL
- ASSR phase or frequency is detected automatically (vs. visual detection)



JAAA ASSR special issues, 2002: Summary (1)

- Click ABR and tonal ASSR may offer a powerful diagnostic combination in diagnosis of hearing loss in children.
- ASSR estimations of auditory thresholds in young or difficult-to-test infants may be better (lower) than behavioral MRLs.
- The ASSR is a composite response from multiple generators, depending on the modulation rate.
- Differences between behavioral vs. ASSR estimated auditory thresholds are greater for low frequencies and mild hearing loss.

- These differences are dependent on factors such as:
  - Strategy used for behavioral threshold measurement.
  - Patient-related noise (sedated vs. awake)
  - Intensity increment (e.g., 5 or 10 dB).
  - Criteria used for response presence vs. absence.

JAAA ASSR special issues, 2002: Summary (2)

- ASSR can be recorded in infants and young children.
- "Pass" rates with ASSR are higher for full-term versus premature infants.
- "Pass" rates in full-term infants are higher for higher frequencies (e.g., 2000 Hz) than lower frequencies (e.g., 500 Hz).
- Strong correlation between auditory thresholds estimated with ABR and ASSR for mild through moderate hearing loss.

- ASSRs differ slightly (smaller response) for single frequency versus simultaneous multiple frequency stimulation (e.g., MASTER approach).
- In normal hearing and mild hearing loss, ASSR may overestimate auditory thresholds.
- The clinical feasibility of bone conduction ASSR remains uncertain.

ASSR, ABR, and Pure Tone Audiometry: Asking the clinically relevant question

Not:

Which frequency-specific electrophysiologic technique is best … tone burst ABR or ASSR?

But:

How does the ASSR technique complement click and tone burst ABR techniques in the infant test battery?

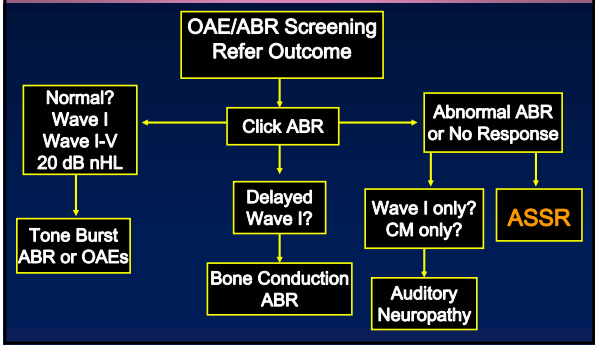
ABR (Click and Tone Burst) versus ASSR: Clinical Application

	Advantages	Disadvantages
ABR	* estimates normal hearing thresholds	* can't estimate profound HL
	* ear-specific BC findings	* skilled analysis required
	* diagnosis of AN	* limited BC intensity levels
ASSR	* estimates severe-to-profound HL	* no ear-specific BC findings * requires sleep or sedation

Tone Burst ABR versus Auditory Steady State Response (ASSR): Clinical Experience

Auditory dysfunction	ABR	ASSR
Normal hearing	~ accurate estimation	~over-estimates thresholds
Conductive HL	~ear-specific findings without masking	~tone-burst measures but masking is required
Sensory HL	~ accurate to moderate degree of HL	~accurate from moderate to profound HL
Neural / Auditory Neuropathy	~ identified with wave I or CM	~difficult to distinguish profound sensory vs neural HL

Role of ASSR in Frequency-Specific Estimation of Hearing Sensitivity in Infancy



Auditory Steady State Responses (ASSRs): CONCLUSIONS

- Advantages
  - Highly frequency specific
  - Can be used for electrophysiologic assessment of severe to profound degree of hearing loss in infants and young children
  - Clinical devices now available
- Potential disadvantages
  - require *very* quiet state of arousal
  - less accurate in normal hearing
  - limited site specificity
  - analysis difficult with bone conduction stimulation

ASSR: Clinical questions

- Are there maturational effects on ASSR from premature infants through childhood?
- Is test time equivalent for ASSR vs. tone burst ABR?
- Can ASSR be recorded from non-sedated patients?
- What is the effect of sedation and anesthesia on ASSR?
- How closely correlated are ASSR and pure tone hearing thresholds?
- Can ASSR be used in estimation of *bone conduction* auditory thresholds?

Pediatric Audiology: AEP's

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University of Virginia
&
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The One Thing You Need

Membership in the :

International Peak Pickers Association IPPA

The One Thing You Need (continued)

Develop Pattern Recognition Skills for reviewing Waveforms

ABR Response Parameters

- **Electrode placement (Cz, A1, A2)**
- **Averaging window (15-23 msec)**
- **Stimulus delay (2-3 msec)**
- **Filter (30-3000 Hz)**
- **Artifact rejection**
- **Notch Filter (No - Never)**
- **Display Gain (feel free to change)**

ABR Stimulus Parameters

- Type – click vs. TB
- Duration (2-0-2 cycle rise/fall)
- Envelope (Blackman/Nonlinear)
- Intensity (as needed)
- Polarity (Rarefaction)
- Rate (39.3/sec)

AC ABR

- Recommended that all scrubbing and electrode placement occur prior to feeding the infant.
- Using the right inserts can make all the difference…..

Is it neural?

- Wave V is present?
- Reverse polarity at the same high intensity to make sure that the response repeats (one acquisition with rarefaction; one with condensation).
- This r/o that you are looking at CM.
- This confirms the response is truly neural.

Clear Wave V Established

- Wave V is now clear…..
- Reduce intensity in 10 dB steps until wave
  V is no longer seen.
- As intensity decreases, latency increases, and amplitude decreases….make sure you increase your display gain if wave V is hard to see at lower intensity levels.

Finding Threshold

- Keep an eye on the latency-intensity function.
- Your wave V latency will increase as the intensity decreases.
- Use the negative trough following wave V to identify it at low intensities (peak broadens).
- Repeat threshold to confirm. The trough may be the component that repeats., not the peak.
- Decrease intensity below threshold (sometimes an absent response is clearer to see).
- CHECK YOUR DISPLAY GAIN!

When to mask AC ABR

- If there is a difference in AC thresholds between ears, masking may be necessary.
- Try to test the better ear first if possible.
- Mask the opposite ear with 20 dB below the test stimulus:
  - ✓ testing LE at 60 dB
  - ✓ RE masking at 40 dB

Finished with AC ABR?

- Normal hearing thresholds of 20 dBnHL established, bilaterally? YES
- AC abnormal results? MAYBE
  - You need to establish BC responses to determine nature of loss

When to do bone conduction ABR?

- Whenever there is an abnormal AC result, bone conduction ABR is recommended.

Reasons not to wait….

- The parents…….when we have the capability of providing parents with a full and accurate picture of their child's hearing loss….why wait?
- The child……early identification leads to early intervention.

What now?

- Established AC thresholds…
- Established BC thresholds….
- Do I need to do toneburst testing?

When to do TB testing….

- Whenever possible….if child is still sleeping.
- If a sensorineural HL is present, in order to fit with hearing aids.
- Test low frequencies (.5-.75 kHz) first, to see if there may be a slope in hearing.

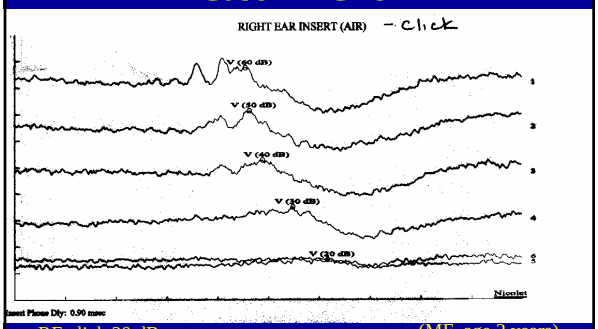
When to do TB testing…

- Even in the presence of normal click-evoked responses if there is a question or if the child is at risk:
  - Chemotherapy patient
  - Family history of congenital HL
  - Speech delay, with no other obvious delays
  - Behavioral results disagree

Why do tone burst testing?

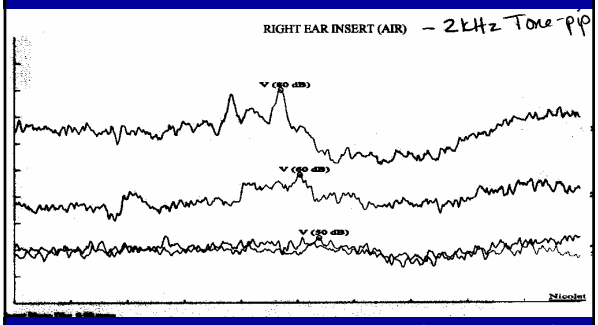
This is why we should do tone burst testing….

Case 2 - Click



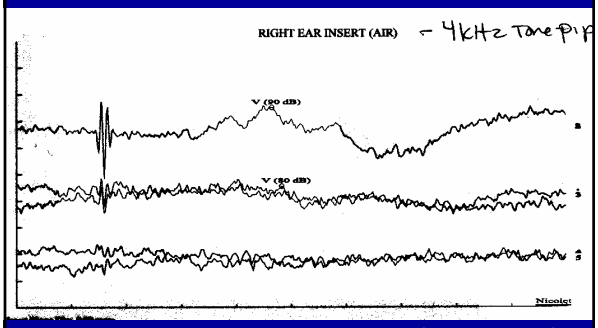
RE click 20 dB (MF, age 2 years)

Case 2 – 2.0 kHz TB



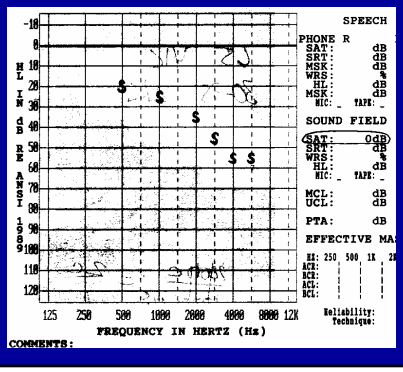
RE 2.0 kHz TB 50 dB (MF, age 2 years)

Case 2 – 4.0 kHz TB



RE 4.0 kHz TB 80 dB (MF, age 2 years)

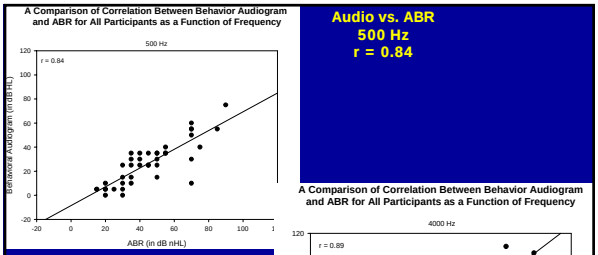
Case 2 – Sound field audiogram



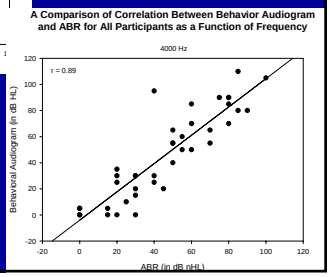
(MF, age 2 years)

Frequency Specific ABR Accuracy?

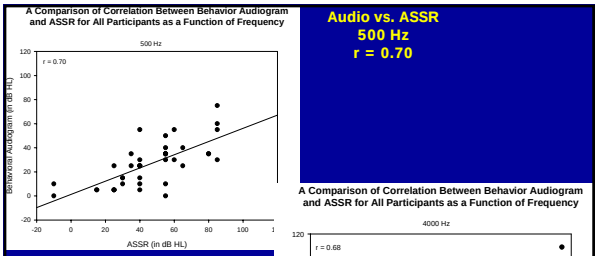
- High correlation (.94) between Tone Burst evoked ABR thresholds and pure tone thresholds for infants and older children
- Over 90% of ABR thresholds were within 20 dB of pure tone thresholds
- Most were within 10 dB
- Audiometric configuration did not affect accuracy of prediction
- *(Stapells et al, 1995; Oates & Stapells, 1998)*



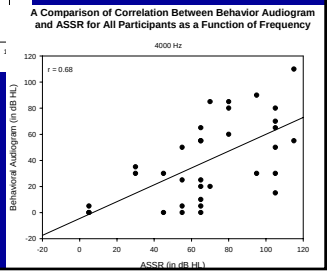
Audio vs. ABR
500 Hz
r = 0.84



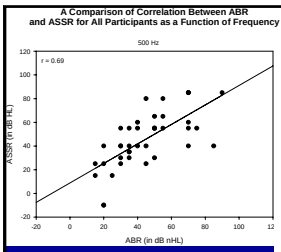
Audio vs. ABR
4000 Hz
r = 0.89



Audio vs. ASSR
500 Hz
r = 0.70

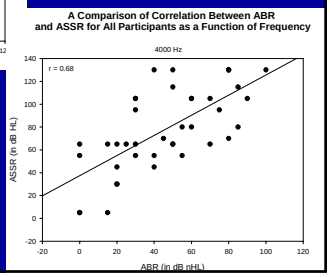


Audio vs. ASSR
4000 Hz
r = 0.68

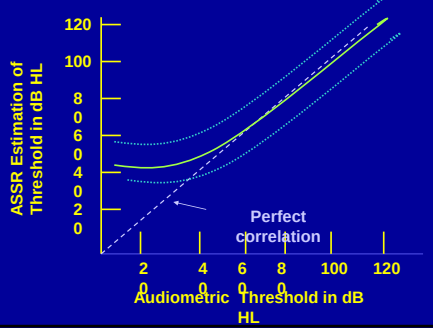


ABR vs. ASSR
500 Hz
r = 0.69

ABR vs. ASSR
4000 Hz
r = 0.68



Relationship Between ASSR and Pure Tone Thresholds



Can you test AEPs in infants without Sedation?

- **You bet!**
- **Every effort should be made to test infants under 6 months of age**
  - **Earliest possible identification of hear loss**
  - **More important – earlier intervention, if needed**
- **Under 6 months of age sedation is rarely required**
- **Under 3 months of age almost NEVER!!!**

JCAHO

Has Mandated that children who undergo sedation for procedures receive the same standard of care and monitoring as those who undergo general anesthesia.

Ideal Characteristics of Sedation

- ❑Rapid onset
- ❑Short duration of action
- ❑Lack of cumulative effects
- ❑Rapid recovery (short half-life)
- ❑Minimal side effects
- ❑Residual analgesia
- ❑Increased patient satisfaction

AEP Testing in Infants & Children at UVA

- ❑Performed in Pediatric Induction Room
- ❑Anesthesiologist or CRNA
- ❑Mild or low dose General Anesthetic
  - Sevoflurane/nitrous oxide
  - Propofol
  - Ketamine

Levels of Sedation

None	Conscious	Deep	General
alert	*easily aroused*	*not easily aroused*	*no response*

Successful ABR and OAE testing….

…..gives the parent the power to provide for their child.

Successful ABR and OAE testing….

- Results in an accurate picture of a child's hearing loss;
- Results in early identification;
- Which leads to early intervention….

Thank you!

Diane L Sabo

Children's Hospital of Pittsburgh
University of Pittsburgh

Hearing Aids

- Fitting Unilateral hearing losses
  - BTE
  - BAHA
  - FM

Hearing Aids

- MLRs and hearing aid fitting
  - Definitions
  - Confirmation of loss
- Coupling of hearing aid during S-REM

Hearing Aid

- Estimating hearing loss as an adult
- Use of vent for RECD

Essential Test Battery

- Children with autism
  - Physiologic measures
  - Behavioral measures