If you are viewing this course as a recorded course after the live webinar, you can use the scroll bar at the bottom of the player window to pause and navigate the course.

This handout is for reference only. It may not include content identical to the powerpoint. Any links included in the handout are current at the time of the live webinar, but are subject to change and may not be current at a later date.
Diagnostic ABR: Tips From the Trenches – Difficult to Test Populations in Difficult Test Environments, presented in partnership with Cincinnati Children’s

Kelly Baroch, AuD  Gayle Riemer, MA
Audiologists at Cincinnati Children’s Hospital
March 1, 2017

Objectives

• Describe the relationship between obtaining complete test results at the initial ABR appointment and reducing loss to follow-up rates.
• List diagnostic ABR protocols which may help reduce test time and new types of technology which may allow for more effective/efficient ABR evaluations.
• Describe developmentally supportive positioning and touch to help infants achieve an optimal sleep state.
• Explain the importance of developing relationships with other care providers.
• Describe techniques to complete ABR evaluations on older patient populations which are difficult-to-test.
• Discuss case studies from environments and patient populations which are difficult to test
Introductions

Statistics: Medically Complex Infants – Inpatient Environment

- 1 out of every 8 babies in the US born prematurely
- Prematurity leading cause of long-term neurological disabilities in children
  CDC 2013
- 1 baby born every hour addicted to opiates in the US
- Number of babies with neonatal abstinence syndrome tripled from 2000 to 2009
  Patrick et al 2012
- 9% of infants in the US receive NICU care
Statistics: Medically Complex Infants – Inpatient Environment

- 75% of 500-749g infants survive
- 25% of <500g infants survive

Hernandez 2009

- As technology improves and we keep more infants alive, the length of stay in the NICU also increases.

March of Dimes 2013

Long Term Hospitalizations

AudiologyOnline
Inpatient Diagnosis and Intervention

“If the newborn doesn’t pass the initial screening, explore the possibility of using audiologists already in the facility to do a definitive ABR before the baby leaves the hospital.”

Communicating the Need For Follow-up to Improve Outcomes of Newborn Hearing Screening, Workgroup, July 2001

<table>
<thead>
<tr>
<th>Action Steps</th>
<th>Responsible Actors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop protocol for diagnostic testing in NICU</td>
<td>AAP, AAA</td>
</tr>
<tr>
<td>Develop intervention protocols for use in the NICU with infants identified with hearing loss</td>
<td>AAP, ASHA, EI Agencies</td>
</tr>
<tr>
<td>Survey centers that perform diagnostic testing and hearing aid fitting in the NICU and develop a workgroup to provide technical assistance to other hospitals to replicate this model</td>
<td>NCHAM, state EHDI coordinators</td>
</tr>
</tbody>
</table>

Russ et al Pediatrics 2010

AudiologyOnline
Critical Components: Evaluating Medically Complex Infants

Experience of Audiologists

Counseling of Parents/Caregivers

Collaboration with Medical Team

Manipulation of the Environment

Understanding the Population

Appropriate Equipment and Protocols

Tips from the Trenches: The Audiologists

- Small team of audiologists dedicated to the population
- Extensive ABR experience
- Strong medical knowledge
- Personal characteristics
  - Flexible
  - “Thick skinned” 😊
  - Adrenaline “junkies” with a calm demeanor
Tips from the Trenches:
Collaboration with Medical Team

• Knowledge
  • Do your homework
    • Know the medical history
    • Risk factors
    • Read care plans
    • Ask what calms/stresses infant and know how to manage – Developmental care!!!

• Take every teaching opportunity
  • Nursing orientation
  • Residents/APNs/Attendings

• “Team member” vs “tech”/consultant
  • What does the audiologist bring to the table?
  • Team player – help out where you can
  • Leave patient the way you found them
  • Silo vs big picture

• Why do we care?
  • Gatekeeper to the patient
  • Earlier access for testing
  • Assistance with choosing ideal test time
  • Advocates in reinforcing message - reducing LTF

Tips from the Trenches:
Understanding the Population

• NICUS and Neonatal Pain
  • Average for all NICU admissions:
    • 60 to 100 painful procedures
  • Premature infants 27-31 weeks:
    • 134 painful procedures
  • <27 weeks
    • 300 painful procedures
  • <25 weeks
    • Over 450 painful procedures

  Hernandez 2009
Tips from the Trenches: Developmentally Supportive Touch and Positioning

- Hand Containment
  - Touch alters oxytocin, provides relaxation and lowers stress hormone levels (Field 2003)
- Talking prior to infant prior to testing
- Gentle touch
- Avoid sudden changes in posture
- “Tune in” and read infant cues
- Ensure infant is in a calm, regulated state prior to testing
- Pacing
- Support recovery and back to sleep

Tips from the Trenches: Positioning Considerations

- Swaddling
  - Arouse less and sleep longer
  - Reduces level of motor activity
    - Van Steven 2007
- Parent involvement
- Midline Position

AudiologyOnline
Tips from the Trenches: Positioning Considerations

- Fractures
- Critical tubes
- Skin conditions
- Tracheostomies
- Wound dehiscence – VAC dressing
- VP shunts/reservoirs
- Omphalocele
- Sternal closure

Tips from the Trenches: Equipment and Environment

AudiologyOnline
Right Technology for the Environment

Considerations for Technology

- Signal processing
  - Averaging vs weighted processing
- Residual noise levels
- A and B buffers for replication
- Chirps
- Statistical Analysis
  - Correlation Coefficient
  - Fsp
- Equipment utilized in outpatient clinic may not be effective in inpatient environment
- Familiarity vs Outcomes???
Tips from the Trenches: Establishing Protocols

• What information do you need to answer the question or establish a baseline for monitoring?
• Detection of hearing loss, degree and type, as quickly and as early as possible.

Initial Newborn ABR

• Suprathreshold Click at 60 dBnHL
  – Important to assess integrity of neural pathways
  – Gives quick information about middle ear based on wave I latency
  – Robust response as baseline
• 4000 Hz toneburst near threshold
  – Most sensitive frequency for detecting SNHL
  – Ototoxic meds, mechanical ventilation etc.
  – More similar to click latency
  – Often still get a I/III/V
• 1000 Hz toneburst near threshold
  – Weeds out some of the transient CHL
  – Maturational effects at 500 Hz
Tips from the Trenches:
ABR Analysis and Medically Complex Infants

CNS Maturity

- Immature auditory system characterized by increased interpeak latencies and increased thresholds
- Auditory maturation can be delayed in preterm compared to term infants
- The maturation effect of the response threshold is relatively small and matures sooner than the maturation of the I-V interval
- Combination of normal response threshold and prolonged I-V interval is common in cases of delayed auditory maturation.
- Severe neural pathology is unlikely with normal ABR threshold
Hydrocephalus

- More CSF produced than absorbed
- Associated with
  - Myelomeningocele
  - IVH
  - Aqueductal stenosis
- Causes distortion and displacement of the brainstem and ABR generators
- Increased ventriculomegaly
- Increased intracranial pressure

Hydrocephalus

- Studies have shown pre-op ABR abnormalities in up to 95% of infants
  - Prolonged wave V
  - Increased I-V interval
  - Total absence of ABR responses most common in communicating hydrocephalus (4th ventricle enlargement)
  - Bilateral
- Post shunt ABR
  - 50% resolve
  - 20% significantly improve
  - 10% have continued abnormalities

AudiologyOnline
Hydrocephalus

• Slowed Click Rate
Brainstem Dysfunction

- Infant Boy
- Born at 33 weeks GA
- Dandy Walker Malformation
- Severe brainstem and cerebellar hypoplasia
- Lissencephaly
  - “Smooth brain”
- Neurosurgery requested a brainstem study
- Infant intubated and on bili lights
- No gag reflex or purposeful movement

AudiologyOnline

AudiologyOnline
Myelomeningocele

- Infant Boy born at 36 weeks GA
- Myelomeningocele repaired in utero
- Severe lateral ventriculomegaly with VP shunt placement

ABR completed 1 week post VP shunt placement
Follow-up ABR completed 8 weeks later

Neurologic Overlay

- Always assess neural transmission in NICU infants. Especially infants with myelomeningocele, hydrocephalus, IVH and VP shunts!!!
- Don’t waste time chasing tone burst thresholds on infants with brainstem dysfunction!!!
- Don’t forget to slow down the click rate
- OAEs will be critical in these cases
- If neural component is going to resolve, will typically see normalized ABR about 8 weeks post shunt.
Bone Conduction ABR

- Infant Girl
- Born at 36 weeks GA
- Treacher Collins Syndrome
- Micrognathia
- Bilateral aural atresia
- Tested at 37 weeks GA
Because the latencies and amplitudes are the same, you can be sure that both are ipsilateral recordings.
Bone Conduction ABR

- Earlier is better!!
- Testing at less than 12 weeks and less than 15dBeHL should not require masking

Stapells 2007
Outpatient Infant Assessments

The Effects of Inconclusive ABR Results on Loss To Follow Up

- ABRs at six outpatient centers (n=764)
- 9% did not achieve adequate sleep state (standard signal averaging) (n=71)
- 63% of those were lost to follow up (n=45)
- 17% (n=129) had suspected fluid with incomplete ABR due to inability to complete BC ABR
- 45% of these were lost to follow up (n=58)
- For all abnormal ABRs 64% had incomplete BC data
- For infants needing more than one, ABR average age of ID for PHL was 4.3 months
Take Home Message: Part 1

- The number of medically complex infants is growing. We need audiologists who are comfortable doing diagnostic testing in the inpatient environment.
- A sleeping baby is always best. The inpatient audiologist must have a strong working knowledge of infant sleep state and how to provide developmentally supportive strategies to help an infant achieve an optimal state for testing.
- Utilize all available tools for cross check of thresholds
- Audiologists don’t like change, but we must utilize technology that provides the best data and outcomes for the patient population.

Difficult Test Environments:
- No sedation opportunities exist (at the bedside)
  - Care plan components
  - Timing
  - Family
  - Ambient noise
  - Electrical noise
  - Skin conditions
  - Interruptions and interferences
  - Touch sensitivities
Difficult Test Environments:
- No sedation opportunities exist (at the bedside)
  • Care plan components
    • Is there an urgent need to complete the ABR?
    • Is there a particular order in which the ABR must be done (pre-chemo, post-shunt, etc.)
    • Is ear surgery or other treatment pending your ABR outcome?
    • Are there family concerns about the child’s hearing?
    • Are there other providers (speech pathology, OT, etc.?) who question the hearing?
    • **Who needs these test results and why?**

Difficult Test Environments:
- No sedation opportunities exist (at the bedside)
  • Timing
    • Does the child have a nap time?
    • Does the child take medications that make him drowsy?
    • Is it better to have a parent present for the ABR?
    • Are there other providers available to help?
      • Audiologists or interns
      • Child life specialists
      • Speech pathologists
      • Audiology aides
      • Patient Care Assistants
Difficult Test Environments:
- No sedation opportunities exist (at the bedside)

  • Family
    • What outcomes does the family seek?
    • What are the needs of the family at the bedside?
    • Will the family be able to help with the awake/non-sedated ABR by providing quiet distractions to engage the child?
    • Will the family provide significant interferences instead and how will these be dealt with?

Difficult Test Environments:
- No sedation opportunities exist (at the bedside)

  • Ambient Noise*
    • HVAC
    • Pumps and monitors
    • Talking
    • Music/Toys
    • Keyboard typing
    • Hallway noises

  *Most of these are more likely to affect the child’s sleep state than the ABR data collection. Continuous sounds, however (like HVAC or nearby conversations), are more detrimental to the collection.
Difficult Test Environments:
- No sedation opportunities exist (at the bedside)

• Electrical Noise
  • Recognize 60Hz interference in the averaged ABR waveforms.
  • Eliminate/reduce interference by setting the low filter to eliminate low frequency data in the average (set at 70 Hz or higher will significantly reduce electrical noise).
  • Isolate the electrode wires from metal rails or other cables.
  • Kinked or worn electrodes will act as antennas.
  • Consider lowering the sensitivity (gain) setting to eliminate more of the high amplitude interference.
  • If available, choose alternate evoked potential equipment that uses a wireless connection between the pre-amplifier and the computer.

Difficult Test Environments:
- No sedation opportunities exist (at the bedside)

• Interruptions and Interferences
  • Rounds – wait til group is at a distance
  • Family – engage and reinforce
  • Monitors and alarms – engage help of nurse
  • Fire alarms
  • Care providers – engage and reinforce
  • Child awakens from sleep – try to calm & engage
  • Loss of child cooperation – try again at another time
Difficult Test Environments:
- No sedation opportunities exist (at the bedside)

  • Skin conditions
    • Might not be able to abrade the skin (epidermolysis bullosa, chemotherapy side effects, etc.)
    • Might need to adjust ABR collection parameters (change sensitivity or filter settings) or use equipment that is less demanding of low impedance

  • Touch sensitivity
    • Child might waken easily to touch (when does he sleep most deeply?) Skin prep may not be feasible.
    • Children who can tolerate the application of electrodes and earphones may be able to cooperate for non-sedated ABR, even if awake.
    • No tolerance for electrodes & earphones when awake – but what if you have to get some audiologic information asap!

AudiologyOnline

Difficult Test Environments:
- No sedation opportunities exist (at the bedside)

Case #1:
• Patient with newly-diagnosed neuroblastoma
• ABR ordered after all scans and procedures with anesthesia were already completed
• Scheduled to start chemotherapy immediately
• Passed newborn hearing screening
• No other ear history or parental concern

AudiologyOnline
Difficult Test Environments:
- No sedation opportunities exist (at the bedside).

DPOAE's present 2000-8000 Hz, normal tympanometry

Change filter settings (doesn’t really help with myogenic artifact):

Filter settings: 30-1500 Hz

Filter settings: 70-1500 Hz

Neither setting is effective in confirming normal hearing.
Bedside, non-sedate
(different equipment)

This ABR inspires more confidence!

Difficult Test Environments
- ABR with Sedation or Anesthesia

The Piggyback Game

- Search appointments and provider recommendations for upcoming procedures with sedation/anesthesia.
- Flag the medical record that an ABR with sedation or anesthesia needs to be coordinated if possible.
- Coordinate scheduling with other departments who will allow for ABR evaluations before, during, or after other procedures under sedation/anesthesia.
- OR, Radiology, ECHO, Cardiac Cath, Dentistry, Hem/Onc, ICU
Difficult Test Environments
- ABR with Sedation or Anesthesia

Stand-alone ABR evaluations
- Work with your institution to provide sedation/anesthesia in environments that already provide this service for other procedures.
- Set up discussions with anesthesiologists re: what is possible, what is preferable.
- If necessary, find physician advocates who can help defend the importance of having this opportunity to thoroughly evaluate hearing in difficult-to-test patients. “How can we appropriately fit amplification if we don’t know hearing thresholds?”

What’s the difference between sedation and anesthesia?
- Sedation: Sedation is administered and monitored by a registered nurse and overseen by our anesthesiologists. It is considered a “lighter sleep,” meaning your child is asleep, but can still be stimulated by touch, light, or sound. This form of medication is used for procedures that take an hour or less and for children weighing 60 pounds or less. Generally this option is only utilized for children without complex medical histories and for non-invasive procedures. Sedation can be administered orally, nasally, or through the placement of an IV. The anesthesiologist determines the appropriate method (oral or IV) after the initial assessment of your child.

- General Anesthesia (GA): GA is administered by a certified registered nurse anesthetist or an anesthesiologist. It is considered to be a “deeper sleep,” meaning it is more difficult to stimulate your child, allowing us to do longer, more invasive procedures without waking them. Typically we use this method for older patients who weigh more than 60 pounds and patients with more complex medical histories. GA can be administered through mask inhalation from an anesthesia machine and/or IV medication. Ultimately, the anesthesiologist decides which method will be used based on his or her medical opinion and your child’s needs.
Difficult Test Environments
- ABR with Sedation or Anesthesia

Barriers to obtaining “Good ABR’s”

• Same as non-sedated (ambient noise, electrical noise, interruptions, etc.)
• But going into other departments to complete an ABR can result in some sticky situations
  • Machine noises (anesthesia administration, MRI scanners, bed warmers, suction machines, pulse oximetry, etc.)
  • Staff courtesy (or not)
  • Where to stand/sit, what to touch/don’t touch
  • Space or time constraints
• Effects of anesthetic gasses and medications
• Can you save time by combining procedures (ex: an ABR can be completed at the same time as an echocardiogram)?

Tips for managing these relationships:

• Learn which machines can be turned off or run at reduced volumes (or how they affect your data)
• Ask where you should sit or stand, what areas or objects you should avoid
• Be polite when discussing the conversational noise in the room
• Determine at the outset if there are time constraints
• Know who’s the boss (assigned and/or evolved)
• Learn the personalities: who are the friendlies and who are the challengers?

AudiologyOnline

CONTINUED™
Difficult Test Environments
- ABR with Sedation or Anesthesia

**Electrical Artifact**

#1 CULPRIT = ELECTRODES
(worn, cracked, kinked, touching electrical source, high impedance, or one fell off!)

Normal ABR done with sed/anes

Click stimuli
eHL = 10 dB
ABR with SN hearing loss done with sedation/anesthesia

Click stimuli:
eHL = 20 dB

4000 Hz stimuli:
eHL = 40 dB

Conductive Hearing Loss
TIP: Seek good placement of bone oscillator!

Late Wave I, overall delayed latencies, elevated thresholds – looks conductive.

Normal hearing: BC looks like AC, latencies a bit longer, correction factor a bit greater.
Difficult to Interpret Cases:
Neurologic abnormality vs anesthetic effect

What can you do to evaluate whether or not this is a true asymmetry vs. effects of longer anesthesia?
Answer: Repeat the ear with the shorter I-V and compare again.

Difficult to Interpret Cases:
ANSD vs. brainstem pathology

Classic cochlear microphonic "ring" associated with ANSD.
Difficult to Interpret Cases:
ANSD vs. brainstem pathology

- Large amplitude Wave I & II, without cochlear microphonic, associated with known brainstem abnormalities.

Difficult to interpret cases:
Or errors in data collection?

- Electrode montage is upside down
- Earphone in
- Earphone fell out
- Contralateral recording
Difficult to interpret cases:
Sloping sensorineural loss

Case #2

- 6 year old with PNET brain tumor
- VP shunt
- Post-chemotherapy (including carboplatin and cisplatin) and proton beam radiation
- Typically can do behavioral audiologic evaluations (since age 3 yrs)
- Known high frequency sensorineural hearing loss
- Currently ill and less likely to cooperate
- Opportunity to complete ABR under anesthesia following her MRI

Nice morphology on suprathreshold clicks.

Definite 4000 Hz responses down to 25 dBnHL on right, 20 dBnHL on left.
Difficult to interpret cases: Sloping sensorineural loss

Different equipment: still see 4K responses at 35 dBlHL bilaterally.

But 6000 and 8000 Hz are only showing responses down to 70 dBlHL.

TIP: Frequency-specific ABR isn’t always accurate with steeply sloping SNHL. 6000 and 8000 Hz are helpful!

(Yes, her DPOAE results are consistent with the behavioral audiogram.)
Difficult to interpret cases: Mixed hearing loss

**Case # 3**
- 7 month old
- Down Syndrome
- Failed UNHS in both ears
- ABR at 4 months = normal right, slight to moderate conductive left
- ABR at 5 months = left ear now with mild to moderately severe conductive (25 dB by bone conduction for 4000 Hz suggests possible SNHL component)
- Under anesthesia for non-ear related procedures

Air conduction ABR is consistent with conductive pathology (middle ear effusion on exam): slight on right and mild to moderately severe on left.
Difficult to interpret cases: Mixed hearing loss

Even though masked, the bone conduction responses on left ear at 4000 Hz are potentially crossover responses. The latency of Wave V on the contralateral response is earlier than the ipsilateral. The same is not true for 1000 and 2000 Hz.

Difficult to interpret cases: Mixed hearing loss

<table>
<thead>
<tr>
<th>Predicted Hearing Thresholds (dB eHL)</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>Clicks</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right AIR</td>
<td>did not test</td>
<td>20 dB</td>
<td>25 dB</td>
<td>15 dB</td>
<td>25 dB</td>
</tr>
<tr>
<td>Right BONE</td>
<td>40 dB</td>
<td>40 dB</td>
<td>50 dB</td>
<td>70 dB</td>
<td></td>
</tr>
<tr>
<td>Left AIR</td>
<td>20 dB</td>
<td>10 dB</td>
<td>15 dB</td>
<td>20 dB</td>
<td></td>
</tr>
<tr>
<td>Left BONE</td>
<td>30 dB</td>
<td>20 dB</td>
<td>15 dB</td>
<td>20 dB</td>
<td></td>
</tr>
</tbody>
</table>

"These test results are consistent with a very slight hearing loss in the right ear (consistent with middle ear effusion). The left ear has a mild to moderate conductive hearing loss 500-2000 Hz and a moderately severe hearing loss at 4000 Hz that appears to be predominantly conduction. The possibility of a small high frequency sensorineural component cannot be ruled out for the left ear."
Take Home Message: Part 2

- The #1 source of electrical interference is the electrodes.
- Don’t be afraid to attempt non-sedated ABR’s on older children who can accept wearing the electrodes and earphones. Having the right equipment might be the key.
- When practicing audiology in other environments, make the effort to build relationships. Find champions!
- Do bone conduction testing often and well.
- Use caution when interpreting sloping SNHL.

AudiologyOnline

Diagnostic ABR: Tips From the Trenches – Difficult to Test Populations in Difficult Test Environments

Questions?

AudiologyOnline