



UNC
SCHOOL OF MEDICINE

Comprehensive Audiologic Assessment for Infants and Children

5th Latin American Pediatric Conference
August 23-25, 2018
Mexico City

Patricia Roush, AuD
Professor, Department of Otolaryngology
Director of Pediatric Audiology
University of North Carolina
School of Medicine

Topics

- Overview of diagnostic hearing assessment for infants who refers from newborn hearing screen
 - » Electrophysiologic assessment
 - » Behavioral audiometric assessment
 - Visual reinforcement audiometry
 - Play audiometry



Joint Committee on Infant Hearing (JCIH 2000, 2007)

Purpose of audiologic test battery:

- Assess integrity of the auditory system
- Estimate hearing sensitivity
- Identify intervention options
- Describe the hearing loss
 - » Ear-specific estimates of type, degree, and configuration of hearing loss



AAA Guidelines 2012

Test Battery Approach

- When evaluating auditory function in infants and young children:
 - » A variety of techniques must be incorporated.
 - » Use of a test battery approach to determine a child's auditory profile is described as the cross-check principle (Jerger and Hayes, 1976).
- Behavioral, physiologic and electrophysiologic tests should be used.



AAA Guidelines 2012

Test Battery Approach

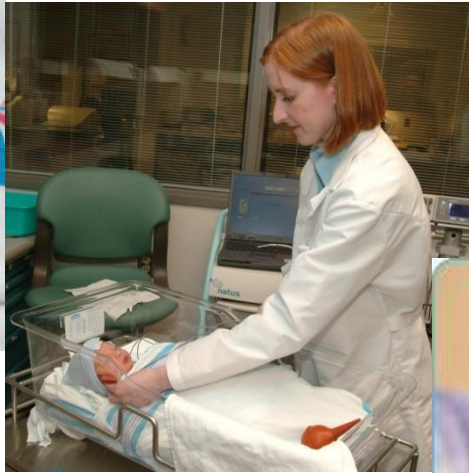
- Imperative that the diagnostic process be accomplished as quickly as possible.
- The 2007 Joint Committee on Infant Hearing 1-3-6 guidelines recommend diagnosis of hearing loss by 3 months of age and intervention by 6 months of age.
 - » ***Of course, earlier diagnosis and intervention would be acceptable and is preferred.***
- For any infant under the age of 3 years for whom hearing aids and/or cochlear implant(s) are to be fitted or recommended, at least one electrophysiological measure of threshold prediction should be completed (JCIH, 2007).



1



3



1-3-6 Goals Easy to Accomplish?

6



Joint Committee on Infant
Hearing (JCIH, 2007)
American Academy of
Pediatrics (AAP; 2010)

Images: Boys Town National Research Hospital .
University of North Carolina Hospitals, University
of South Carolina

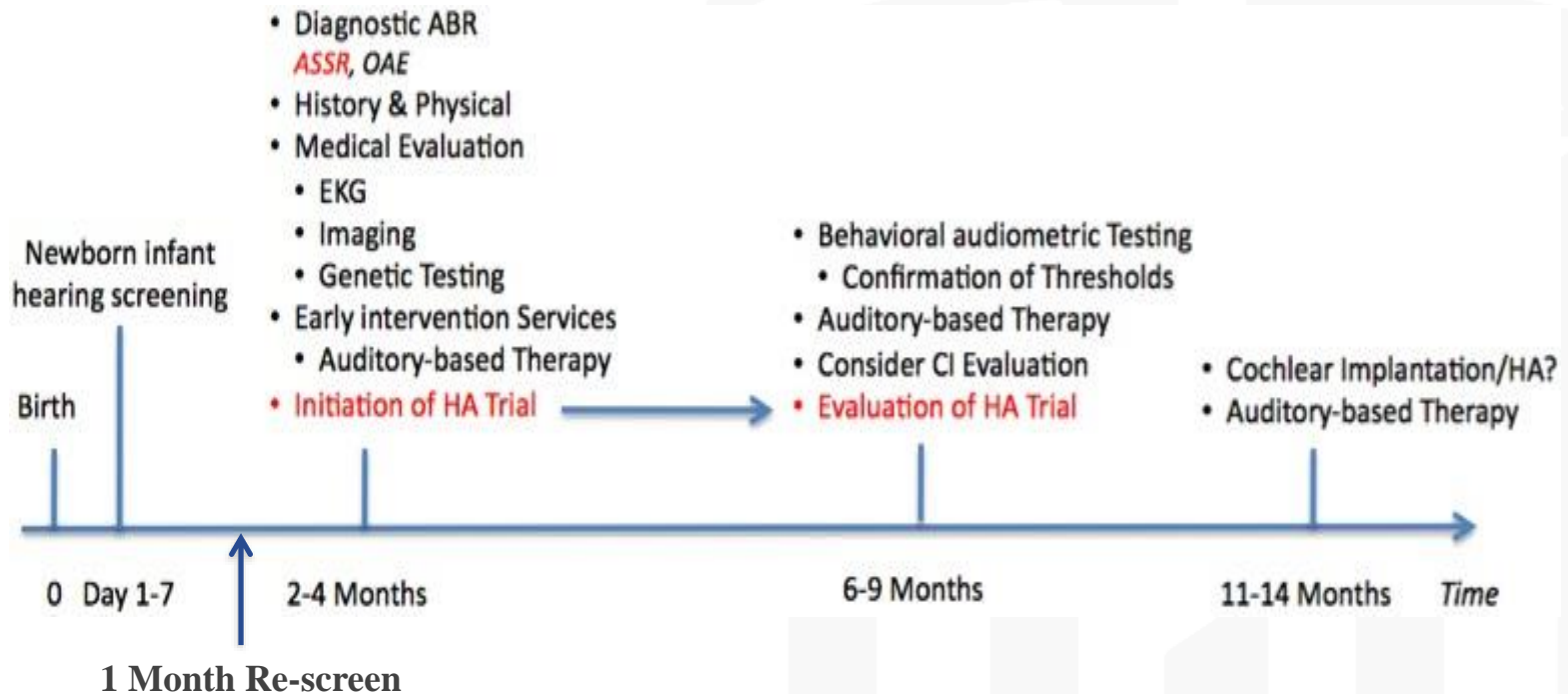
Management of Hearing Loss in Infants: What's Needed?



- Timely referral from NB screen
- Comprehensive audiologic assessment
- Otologic examination
- Referral for early intervention
- Hearing instrument programming and verification
- Behavioral audiometry and ongoing follow up
- Referral for CI when indicated
- Outcome Assessment



Timeline Following Diagnosis of HL



Natural sleep ABR for babies under about 3-4 months of age



- Early referral following failed hearing screen allows us to diagnosis hearing loss without need for sedation
- Important that families receive appropriate instructions ahead of time so babies are ready to sleep after arrival in clinic

Goal of Diagnostic Assessment for Infants Following Failed NB Screen

- Complete ABR using tone bursts (500Hz, 1000Hz, 2000Hz and 4000Hz) via air conduction and bone conduction to estimate the type, degree and configuration of hearing loss for each ear, minimally 2000Hz and 500Hz.
- Use click stimuli to rule out neural hearing loss (e.g. auditory neuropathy)
- Otoacoustic emissions testing
- Tympanometry to evaluate middle ear status using 1000Hz probe tone if < 6 months
- Allow time to review test results, counsel the family and take ear impressions if family is ready to proceed with fitting of amplification

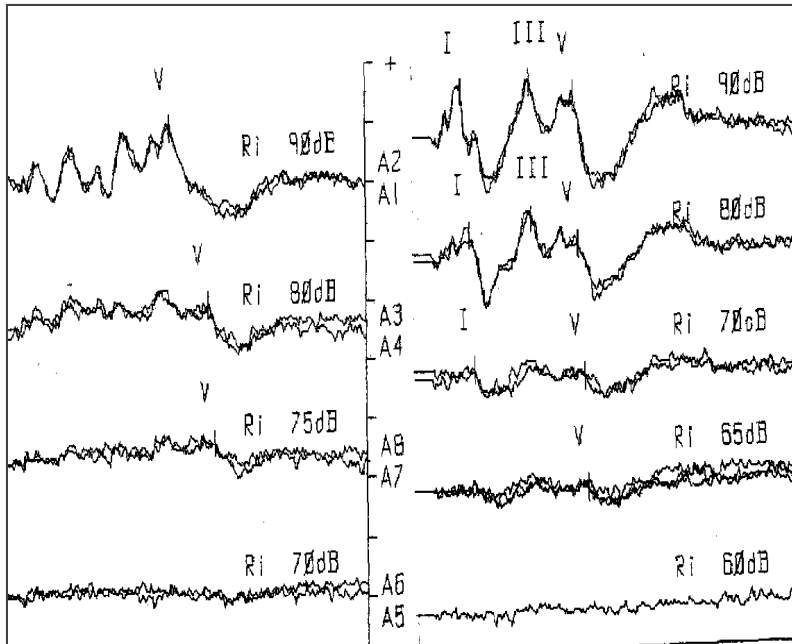


ABR: Important Considerations

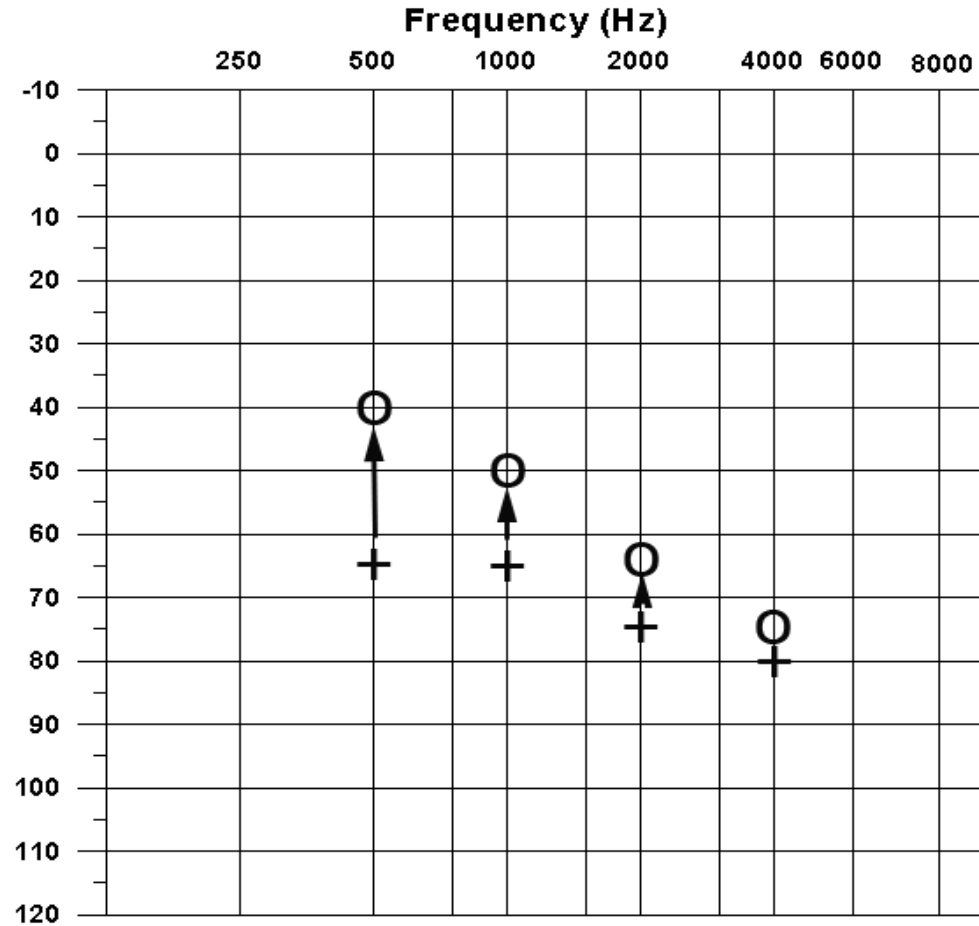
- ABR thresholds in dBnHL are elevated with respect to behavioral threshold (dBHL) for the same stimulus therefore ‘correction factors’ must be applied to determine **estimated** behavioral thresholds in dBeHL for use in hearing aid fitting.
- nHL to eHL correction factors used affected by many factors including:
 - » Stimulus parameters used (tone bursts, clicks, chirps)
 - » System calibration (ppe SPL values)
 - » Transducer type (air or bone conduction)
 - » Age, hearing level

(Scollie et al AAA 2018)
- Correction factors are based on group averages and there is significant individual variability.
 - » While ABR gives us a good starting point for estimated thresholds these individual differences must be considered.
- Prior to using estimates of threshold, important to know if corrections have already been applied

Estimate Audiogram Using ABR



Hearing Threshold Level (dB)



'+' = nHL; 'o' = eHL



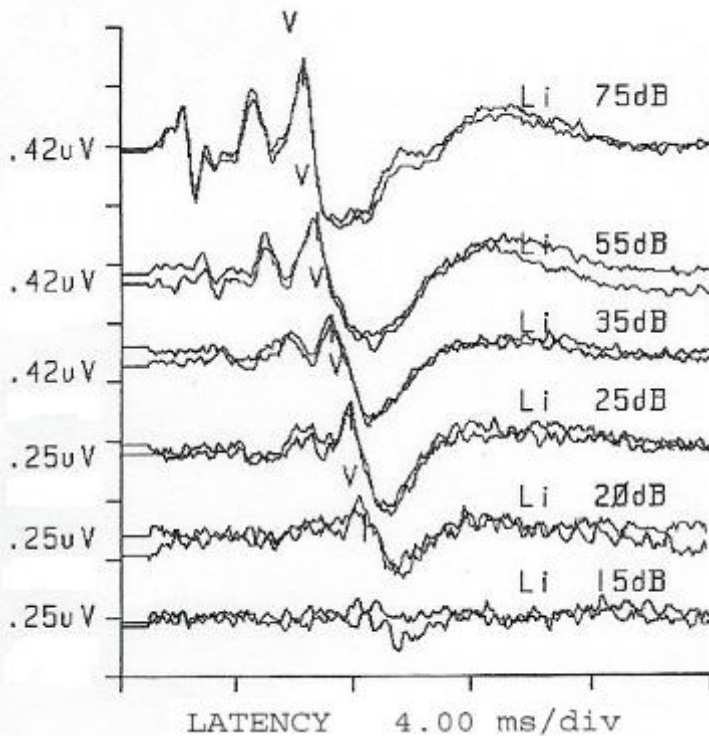
Click ABR - Infant

- In infants, high intensity click (80-90 dB nHL) ABR used to :
 - » Rule out auditory neuropathy or other neural HL
 - » Evaluate waveform morphology
 - Wave I to V Interpeak Latency
- Using click air conduction ABR only,
 - » Cannot adequately diagnose configuration of hearing loss
 - » Not enough information for a hearing aid fitting.
- Also, click only ABR can miss both low and high frequency hearing loss.
- For threshold estimation, frequency specific tone burst ABR is needed

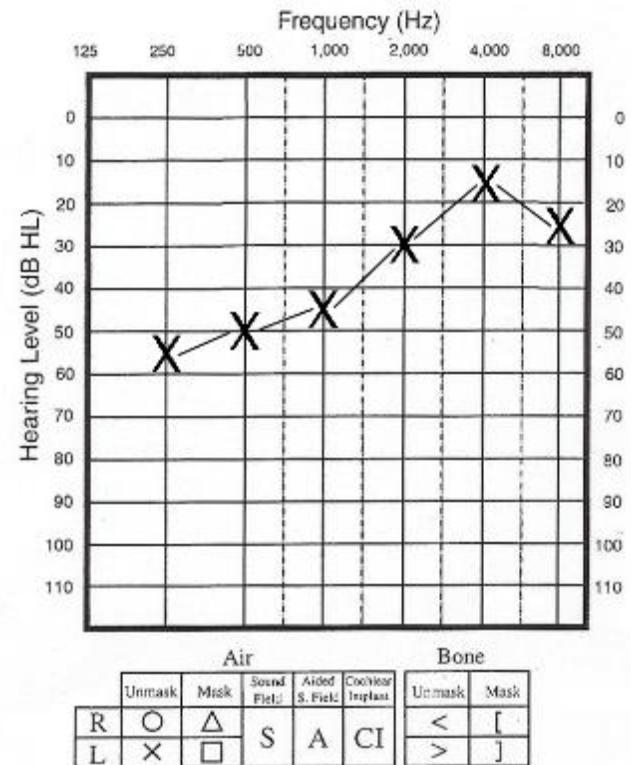
Auditory Brainstem Response (ABR)

CAUTION:

Normal click threshold...but low frequency loss



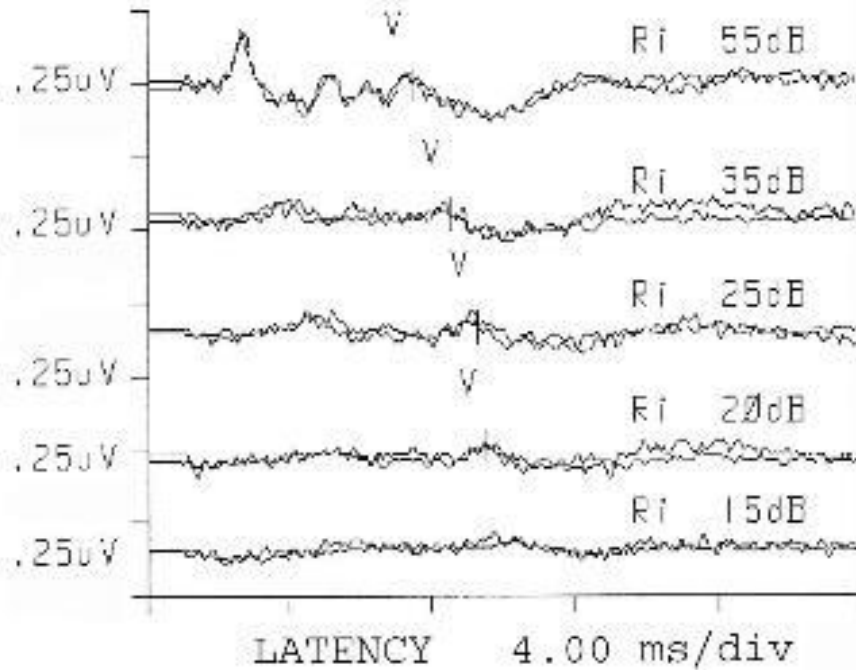
3-year old



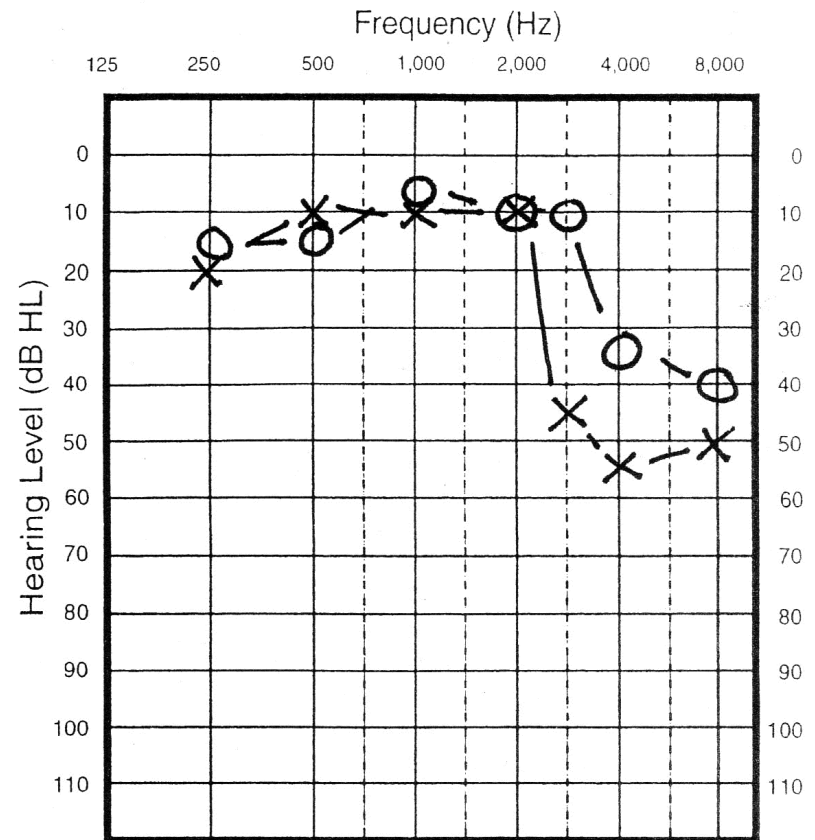
Auditory Brainstem Response (ABR)

CAUTION:

Normal click threshold...but high frequency loss



2-year old





If hearing loss is confirmed... Otologic Exam, Hearing Instrument Selection and Ear Impressions taken on day of ABR



- If family ready to proceed, ear impressions taken
- Hearing instruments selected
- Return appt for hearing instrument fitting two weeks later
- Ideally between 2-3 months of age



ABR Under Sedation or GA



- For infants over 4 months of age or...
- For children who are older but can't participate in behavioral testing:
 1. Sedation for ABR only
 2. In conjunction with tubes or other procedures
 3. ABR in conjunction with MRI/CT
- While it's best to avoid unnecessary sedation, also important to obtain accurate diagnosis as soon as possible



ABR Under Sedation or GA



- Must have physician support
- OR time in short supply and procedure often requires 45-60 minutes of OR time
- Generally, electrical artifact not a problem in our setting
- If a problem, check the following sources of artifact:
 - Intravenous infusion pumps ***
 - Bed warmers
 - Ice machine
 - Nearby laptops
 - Equipment used in adjacent rooms



Otologic exam and work up

- Imaging of the ear (MRI in most cases, CT when needed)
 - » Especially for babies with:
 - No response on ABR
 - Asymmetric hearing loss
 - Auditory neuropathy
- CMV and connexin testing completed using blood spot taken at birth for metabolic screening
- Genetic consultation if parents wish to proceed
- Electrocardiogram (To rule out Jervell and Lang-Neilson)
- Lab studies as needed
- Eye examination
- Other medical referrals as needed



Referral for Early Intervention



- Referral to early intervention on day hearing loss diagnosed
- Family contacted within one week of diagnosis and home visit from early childhood specialist scheduled
 - » Written materials and video provided to family
- Weekly home visits with teacher of the HI scheduled as soon as family decides on initial educational approach
- Diagnostic evaluations and teletherapy also available from UNC therapists and teachers



Follow up

- Behavioral audiometry and hearing aid check every 3 months until 3 years of age and every 6 months after age 3.
- Assessment of progress with hearing aids using age-appropriate aided speech perception measures
- Ongoing speech and language services
- Referral to cochlear implant team when appropriate

ABR PROTOCOLS



2016

Version 2016.02

PROTOCOL FOR AUDITORY BRAINSTEM RESPONSE – BASED AUDIOLOGICAL ASSESSMENT (ABRA)

Ontario Ministry of Children and
Youth Services
Ontario Infant Hearing Program
June 1, 2016



<https://www.mountsinai.on.ca/care/infant-hearing-program/documents/protocol-for-auditory-brainstem-response-2013-based-audiological-assesement-abra>



BC Early Hearing Program

A service of BC Children's Hospital
and the Provincial Health Services Authority

Audiology Assessment Protocol

Version 4.1

November 2012

https://www.researchgate.net/publication/242482099_British_Columbia_Early_Hearing_Program_BCEHP_Audiology_Assessment_Protocol



*Antenatal and Newborn
Screening Programmes*

NEWBORN HEARING SCREENING AND ASSESSMENT

**Guidance for Auditory Brainstem Response testing in
babies**

Version 2.1

March 2013

NHSP Clinical Group

Graham Sutton¹, Guy Lightfoot² (Co-editors)

**Contributors: John Stevens³, Rachel Booth⁴, Siobhan Brennan⁵, Rachel Feirn⁶,
Rhys Meredith⁷**

1. Newborn Hearing Screening Programme Centre, London, UK
2. Dept of Medical Physics and Clinical Engineering, Royal Liverpool University Hospital, Liverpool, UK.
3. University of Sheffield, Sheffield, UK.
4. Audiology Dept, Central Manchester Hospitals, Manchester
5. Regional Department of Neurotology, Sheffield Teaching Hospitals, Sheffield, UK
6. Formerly of Children's Hearing Centre, Bristol, UK
7. Audiology Dept, Abertawe Bro Morgannwg University Health Board, Swansea, UK

http://www.thebsa.org.uk/wp-content/uploads/2014/08/NHSP_ABRneonate_2014.pdf



Considerations when deciding on protocol to use:

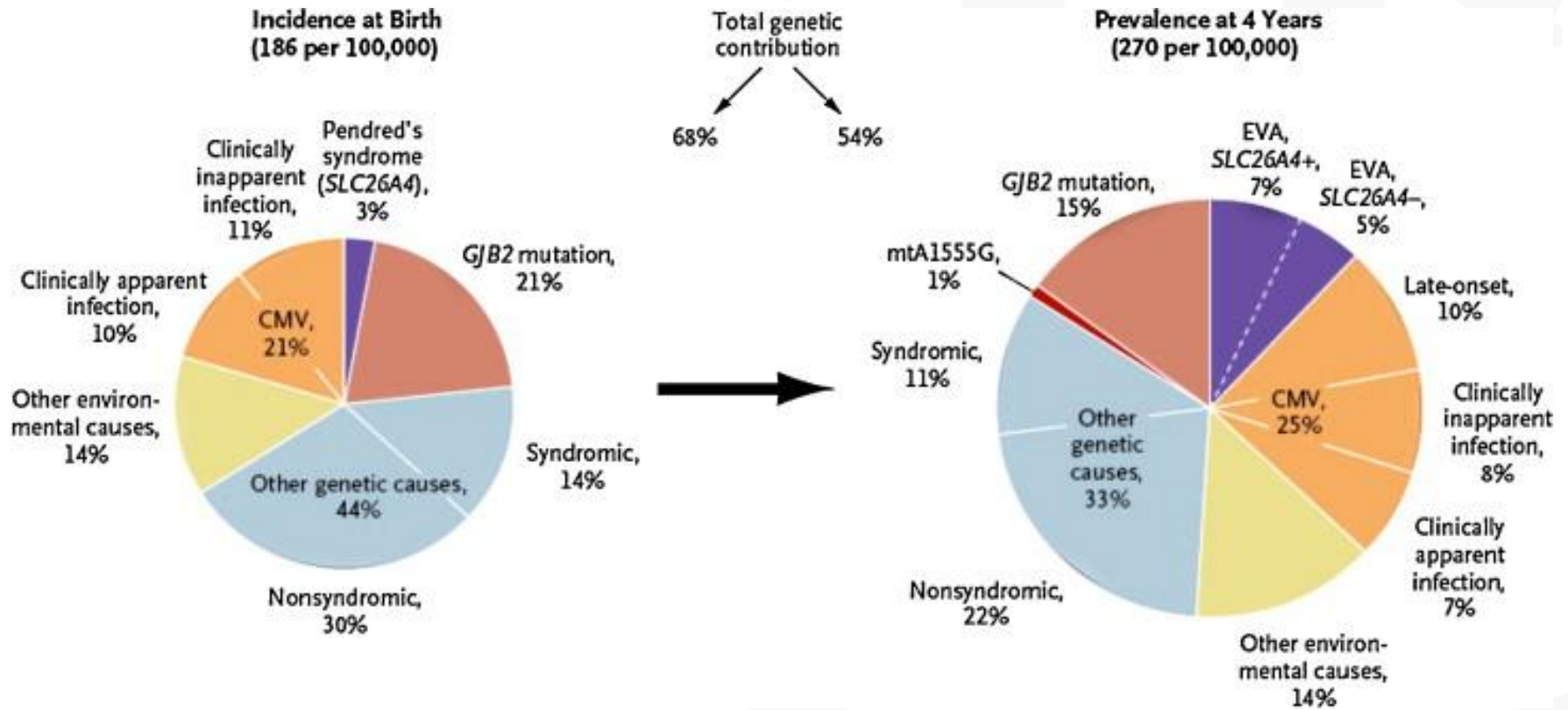
- Targeted hearing loss of program
- Information known about individual infant prior to test
- Type of setting audiologist is working in:
 - » Tertiary care medical center
 - » Local ENT clinic
 - » EHDI referral center
- Access to sedation for ABR testing

Accurate assessment with behavioral audiometry still essential!

- Following referral from newborn hearing screen, initial thresholds are estimated using physiologic tests such as ABR and ASSR; however, accurate behavioral audiometry remains essential in order to:
 - » Confirm degree of HL and monitor thresholds over time
 - Some children will have progressive hearing loss
 - » Determine hearing thresholds in children with Auditory Neuropathy Spectrum Disorder (ANSD)
 - » Determine residual hearing in children who have no response on ABR or ASSR



Estimates of Causes of Deafness at Birth and at Four Years





Visual Reinforcement Audiometry (VRA) 6-24+ months of age

- Can be completed in sound field, with insert earphones, or via bone-conduction
- Baby's own earmolds can be attached to earphone transducer
 - » Helpful in obtaining ear specific measures on young infants already fitted with hearing aids



UNC Hospitals, Chapel Hill, NC

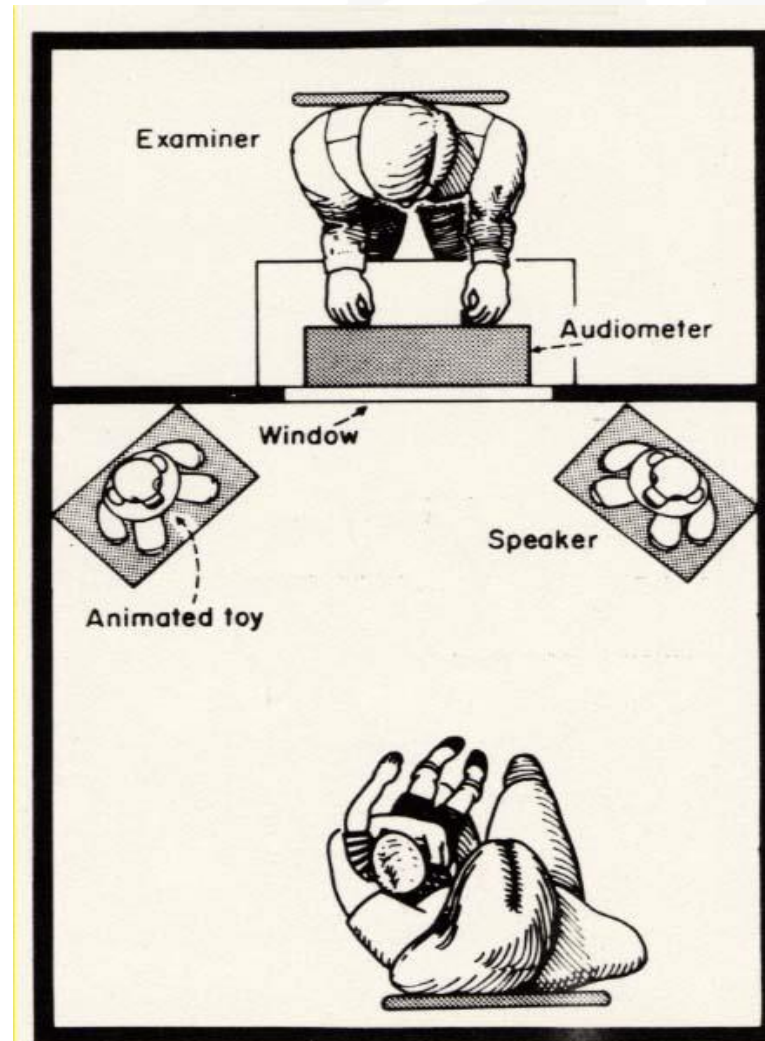


Coupling Insert Earphones to Personal Earmolds





Example of sound room configuration for VRA





A better sound room configuration for VRA





Visual Reinforcement Audiometry (VRA)

- Works best if infant is able to sit up and has good head control
- Normal hearing infants condition more easily than infants with hearing loss
 - » Children with HL lack auditory experience
- Children with severe to profound HL may need to be conditioned using a vibratory signal from bone conduction transducer
- Several protocols for VRA available:
 - » Widen et al 2000
 - » Ontario Infant Hearing Program 2008



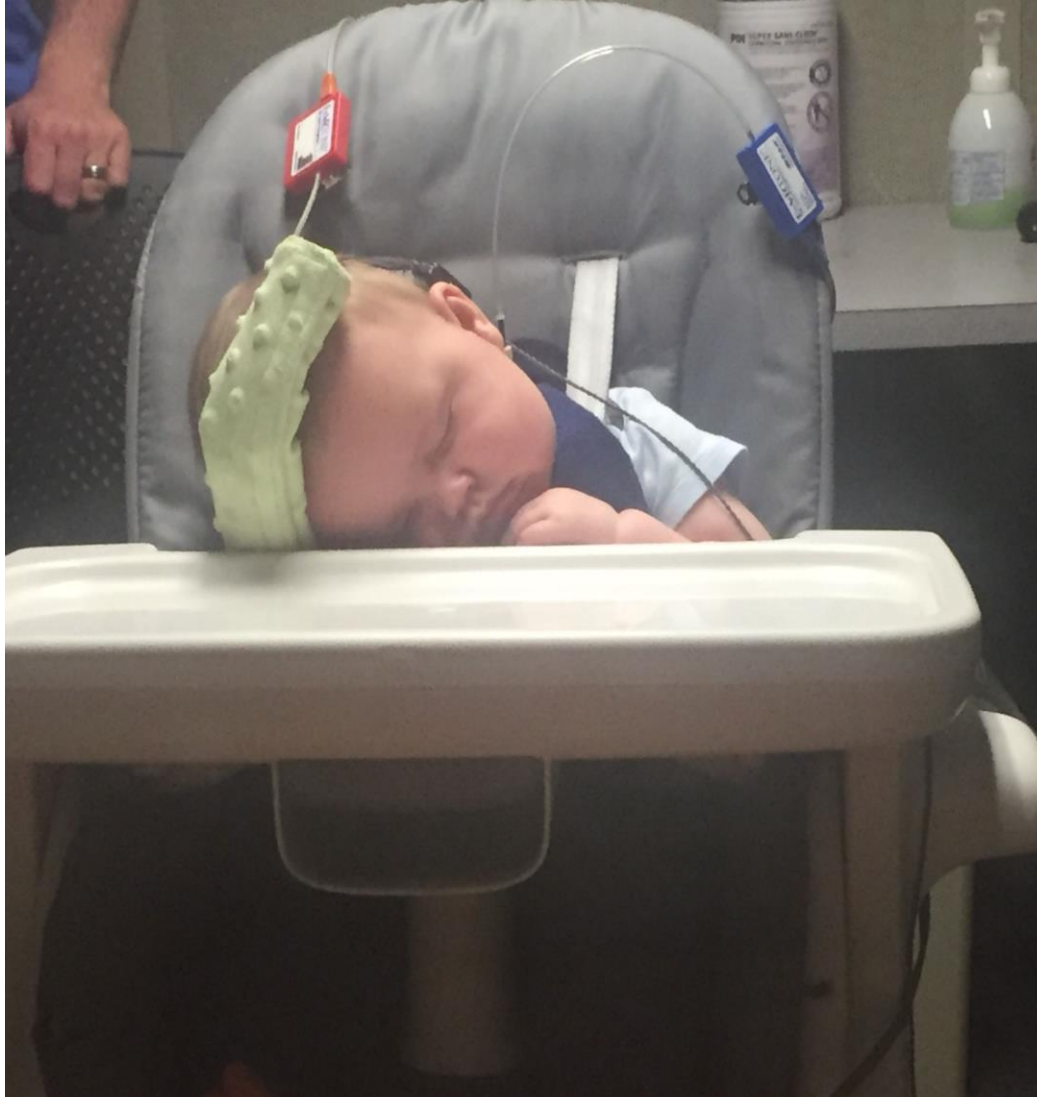
VRA six month old (profound HL)
Bone conduction, then air conduction



VRA with edible 'puffs' and hand raising 😊



When enough is enough...



Play Audiometry 24 months-5+years of age Table and chair for cooperative child...





Play Audiometry with Video Reinforcement





Visually Reinforced Operant Conditioning Audiometry (VROCA)



Audiology Protocol – Conditioned Play Audiometry

There are at least two possible explanations for a child's inability to provide conditioned responses to air-conducted stimuli.

- First, the auditory stimuli might not be audible. In this situation, a bone vibrator should be used for conditioning purposes (either placed on the head or held in child's hand). If child conditions with the bone vibrator, bone conduction thresholds to pure tones should be obtained and examiner should re-attempt conditioning with air-conduction stimuli.
- Second, if the child does not condition with the bone vibrator, the task might not be developmentally appropriate or appealing, and visual reinforcement audiometry should be utilized.



Summary

- Physiological tests such as ABR remain the best method for estimating thresholds for purposes of HA fitting for infants under six months of age.
- Behavioral audiometry is essential in management of infants with hearing loss and can provide reliable thresholds for infants who are at a developmental age of 6 months and older
- For best results use established protocols such as those described by Judith Widen and Judith Gravel
- Accuracy of hearing aid fitting is only as good as our ability to determine an infant's auditory capacity



**UNC Hospitals
Pediatric Audiology**

Children's Cochlear Implant Center at UNC

Pediatric Audiologists:

Danielle Doyle, AuD
Shana Jacobs, AuD
Sarah Martinho, AuD
Laurel Okulski, AuD
Jill Ritch, AuD
Molly Widney, AuD
Patricia Roush, AuD
Melissa Auchter, AuD
Erika Gagnon, AuD
Lisa Park, AuD
Jennifer Woodard, AuD

Speech Language Pathologists

Hannah Eskridge, AVT
Lillian Henderson, AVT
Sandra Hancock, AVT
Erin Thompson, AVT
Maegan Evans, PhD

Otolaryngologists:

Kevin Brown, MD
Brendan O'Connell, MD
Carlton Zdanski, MD
Harold Pillsbury, III, MD



Gracias!

Patricia Roush, AuD

University of North Carolina

School of Medicine

Chapel Hill, NC 27514

Email: pat.roush@unchealth.unc.edu