

Washington State Department of Health

Protocol for Diagnostic Audiological Assessment: Follow-up for Newborn Hearing Screening

Overview

The Washington State Early Hearing-loss Detection, Diagnosis and Intervention (EHDDI) program recommends that infants who do not pass their newborn hearing screening have a diagnostic audiological assessment before three months of age. In addition, infants who do pass the neonatal screening but have one or more risk factors for late onset or progressive hearing loss should have at least one diagnostic audiological assessment by 24 to 30 months of age. Frequency of diagnostic follow-up depends on the specific risk factor and/or parental concern. Early and more frequent assessment may be indicated for children with cytomegalovirus (CMV) infection, syndromes associated with progressive hearing loss, neurodegenerative disorders, trauma, or culture-positive postnatal infections associated with sensorineural hearing loss; for children who have received extracorporeal membrane oxygenation (ECMO) or chemotherapy; and when there is caregiver concern or a family history of hearing loss.

This protocol includes guidance from the Joint Committee on Infant Hearing (JCIH) 2007 position statement. A workgroup of 22 audiologists who see infants born in Washington revised the protocol in June 2011. Workgroup members have extensive knowledge and expertise in the screening and diagnosis of hearing loss in newborns and infants.

The recommendations in this document pertain specifically to follow-up from newborn hearing screening, and may differ from those for other purposes. The focus of the diagnostic test components is physiologic assessment. Behavioral audiometry may be appropriate for infants at developmental age of six months and over if reliable ear-specific information is obtained.

Diagnostic test components

This protocol describes how to 1) obtain an estimate of hearing sensitivity across the speech frequency range; 2) determine the type of hearing loss if there is a hearing loss; 3) provide a starting point for habilitation services such as amplification; and 4) provide a baseline for further monitoring. A comprehensive assessment should include both ears even if only one ear did not pass the screening test. Comprehensive evaluations should be completed by audiologists experienced in pediatric hearing assessment.

The auditory brainstem response (ABR) is the core component in assessing young infants because the audiologist can usually obtain accurate, frequency-specific and ear-specific pure tone threshold estimates with this technique. However, otoacoustic emissions (OAE) and middle ear assessments are also mandatory. After completing otoscopy, the order of procedures (ABR, OAE, immittance) is up to the discretion of the audiologist.

Begin by:

- Obtaining hospital screening results and a medical history, including the presence of any risk indicators (see Appendix A at end of this document).
- Performing an otoscopic evaluation.

ABR Procedures

- Attach electrodes to the baby using a 2-channel montage: high forehead (non-inverting); each mastoid process (inverting); lateral forehead (common).
- Have the caregiver feed the infant if necessary, to induce natural sleep. Diagnostic ABR requires a sleeping baby. Infants under six months of age can often be tested while sleeping naturally. This typically does not work with older infants, who may need to see a provider who can do sedation.
- Prioritize the test stimulus order and level to obtain the most information in the shortest amount of time. To obtain frequency-specific estimates of hearing thresholds, begin with tonebursts, though in some cases it may help to start with or switch to a click. See Appendix B at the end of this document for stimulus and recording parameters.
- Perform frequency-specific ABR using unmasked Blackman-gated tonebursts presented via insert earphones. When feasible, insert both earphones at the start of testing to make switching between ears easy.
- Begin with a 2000 Hz toneburst at or near the minimum stimulus level required to classify hearing as normal. See Appendix B. If no response is detected, increase stimulus level by 20-30 dB. If response is present, descend in 10 dB steps until you find the threshold.
- Proceed to a 500 Hz toneburst.
- If time permits, consider obtaining results for 4000 Hz and 1000 Hz tonebursts for each ear (based on results).
- If indicated and feasible, perform bone conducted ABR on each ear using a click. Tonebursts at 2000 and 500 Hz may be used as time permits.
- Perform click-evoked ABR if the infant has elevated or “no response” on toneburst ABR (see Neurodiagnostic parameters in Appendix B).

OAE Procedures

In evaluating OAEs, perform the following procedures in conjunction with ABR as a cross check for determining outer hair cell function. OAEs are not a substitute for ABR. Note that these procedures for diagnostic assessment differ from parameters for OAE screening because the audiologist determines the protocol and interprets the results (i.e., the result is not a “pass” or “refer”). See DOH document, “Protocol for Newborn Hearing Screening”, found at www.doh.wa.gov/Portals/1/Documents/Pubs/344-023_EHDDINBScrnProto.pdf, for screening parameters. Either or both of the following OAE tests may be used.

Transient Evoked Otoacoustic Emissions (TEOAE)

- Complete at least 60 runs.
- Start testing at 80 dB peSPL, and go up to 86 or down to 74 after that, depending on initial results.
- For TEOAEs to be considered present and normal, the response must have a minimum of a 3 dB SNR (signal to noise ratio) and 70% reproducibility at any particular frequency band. In addition, the overall response amplitude should fall within the range typical for normal hearing children of comparable age.

Distortion Product Evoked Otoacoustic Emissions (DPOAE)

- Stimulus levels L1=65 dB SPL, L2=55 dB SPL or L1=65 dB SPL, L2=50 dB SPL
- DPOAE data interpretation is very equipment-specific. The minimum SNR needed for a response to be considered present depends on how the equipment manufacturer calculates the noise floor.
- In general DPOAEs are considered to be present and normal if the response SNR is > 3 to 6 dB at the majority of frequency bands tested and the overall response amplitude falls within the range typical for normal hearing children of comparable age.

Immittance Procedures

Obtain acoustic immittance measures (using a 1000 Hz probe tone if the infant is six months or younger). Incorporate an immittance battery with caution due to the difficulty in classifying tympanometric measures numerically—tympanograms obtained with a 1000 Hz probe tone require visual interpretation. The acoustic reflex can be a useful part of the audiologic test battery in infants. A present reflex adds support for determining normal middle ear function and provides a cross check for ABR measurements. It is also important to use a high-frequency probe to measure the acoustic reflex in infants less than six months of age. For infants older than four months, the immittance battery becomes more reliable and valid. For all ages, obtain a tympanogram with a 226 Hz probe tone to estimate ear canal volume.

Referrals

- Infants identified with hearing loss should be fit with appropriate amplification if the family chooses this option and see an ENT for medical/surgical care. A Family Resources Coordinator (FRC) can help families enroll children into the Early Support for Infants and Toddlers (ESIT) Program and Early Intervention services. Children should receive regular audiologic follow-up every three to six months until three years of age.
- Infants who are not identified with hearing loss, but who have one or more risk factors, should be evaluated at least once before 24-30 months of age. For infants over six months of age, a behavioral audiologic evaluation may suffice if reliable ear-specific information is obtained.

Other referrals may include: Hands & Voices™ Guide-By-Your-Side program (a parent support program), genetics, neurology, ophthalmology, developmental pediatrics, speech-language pathologists, and other professionals.

Sharing Diagnostic Results with Families

1. Recognize the emotional impact that a diagnosis of hearing loss can have on a family. Audiologists should give the family information about the degree of hearing loss, its potential impact on speech and language development, the treatment and intervention options available, as well as the positive impacts of early identification.
2. Deliver information and test findings in a positive manner, with sensitivity to the emotional needs of the parents.
3. The information format should be consistent with the family's needs and desires, language and cultural needs, and their ability to interpret the information. Audiologists should give families information that addresses, but is not limited to, the following subject areas related to educating parents and families about hearing loss and its impacts:
 - a. The FRC's role, scope of responsibility, and how to access these services.
 - b. How to access parent/family support groups, and support networks in the deaf/hard-of-hearing communities. The Washington State Hearing Loss Helper is a guide for families of children with hearing loss: www.doh.wa.gov/Portals/1/Documents/Pubs/344-017_EHDDIResourceGuideEng.pdf.
 - c. Future diagnostic follow-up and referral to early intervention services.
4. If the family wants to use FRC services, get the parents' permission to contact the FRC to facilitate follow-up.

5. Recognizing that families may not be ready to absorb all of the information in the initial diagnostic evaluation, the audiologist should arrange further discussions with the family, appropriate to their needs and desires. These follow-up discussions may include additional counseling visits, telephone conversations, or counseling coordinated with future clinic visits.

Reporting to DOH

Report diagnostic information to the Department of Health (DOH) after each evaluation until you determine whether or not the infant has a permanent hearing loss. If a hearing loss is present, report each evaluation until the type and degree of hearing loss has been diagnosed. Report this information to the DOH by using the EHDDI program's secure web-based application or by faxing the results to the EHDDI program using the "EHDDI Diagnostic Evaluation Form." Please do not send printouts of test results without interpretive information.

The diagnostic information reported should include (but is not limited to) the following:

- Patient information (patient name, date of birth, mother's name)
- Date of evaluation
- Name of audiologist performing the evaluation
- Risk factors associated with hearing loss present
- Results of test(s) performed (ex: immittance, OAE, ABR)
- Hearing loss present – yes, no, or undetermined
- If hearing loss is present, the type and degree of hearing loss
- Referrals (ex: further evaluation, ENT, Family Resources Coordinator)

Appendix A

Risk indicators associated with permanent congenital, developmental or progressive hearing loss in children (<http://jcih.org/>, 2007 Position Statement):

(1) Parental or caregiver concern regarding hearing, speech, language, and/or developmental delay, (2) family history of permanent childhood hearing loss, (3) neonatal intensive care of more than five days or any of the following regardless of length of stay: ECMO, assisted ventilation, exposure to ototoxic medications (gentamicin and tobramycin) or loop diuretics (furosemide/Lasix), and hyperbilirubinemia that requires exchange transfusion, (4) in-utero infections with cytomegalovirus, herpes, toxoplasmosis, rubella or syphilis, (5) craniofacial anomalies, including those that involve the pinna, ear canal, ear tags, ear pits, and temporal bone anomalies, (6) physical findings, such as white forelock, that are associated with a syndrome known to include a sensorineural or permanent conductive hearing loss (7) syndromes associated with hearing loss or progressive or late-onset hearing loss, such as neurofibromatosis, osteopetrosis, and Usher syndrome; other frequently identified syndromes include Waardenburg, Alport, Pendred, and Jervell and Lange-Nielson (8) neurodegenerative disorders, such as Hunter syndrome, or sensory motor neuropathies, such as Friedreich ataxia and Charcot-Marie-Tooth syndrome (9) culture-positive postnatal infections associated with sensorineural hearing loss, including confirmed bacterial and viral (especially herpes viruses and varicella) meningitis, (10) head trauma, especially basal skull/temporal bone fracture that requires hospitalization, (11) chemotherapy.

Appendix B

ABR Protocol for 0-6 month old infants, page 1

Re: dB nHL: dB above behavioral threshold for given stimulus (or 0 dB nHL)

dB eHL: Estimated behavioral thresholds taking all correction factors and adjustments into consideration.

1. Pediatric Threshold Estimation

Parameters		Notes
Stimulus	2000 Hz toneburst	
Transducer	Insert	
Polarity	Variable	Some authors recommend alternating; others recommend rarefaction
Ramping	Blackman	
Duration	2-0-2	1 msec rise/fall and 0 msec plateau
Intensity	≤40 dB nHL to begin	20-25 dB nHL is WNL. Replicate at threshold. Correction for dB eHL= -5
Filter Settings	30 Hz; 1500 Hz or 3000 Hz	high-pass; low-pass; NO notch
Time window	25 msec	
Stimulus Rate	21.1-39.1/sec	

Stimulus	500 Hz toneburst	
Transducer	Insert	
Polarity	Alternating	To reduce periodic waves
Ramping	Blackman	
Duration	2-0-2	4 msec rise/fall and 0 msec plateau
Intensity	≤50 dB nHL to begin	30-35 dB nHL is WNL. Replicate at threshold. Correction for dB eHL= -15
Filter setting	30 Hz; 1500 Hz or 3000 Hz	high-pass; low-pass; NO notch
Time window	25 msec	
Stimulus Rate	21.1-39.1/sec	

Stimulus	4000 Hz toneburst	
Transducer	Insert	
Polarity	Variable	Some authors recommend alternating; others recommend rarefaction
Ramping	Blackman	
Duration	2-0-2	.5 msec rise/fall and 0 msec plateau
Intensity	≤40 dB nHL to begin	20 dB nHL is WNL. Replicate at threshold. No correction needed for dB eHL.
Filter Settings	30 Hz; 1500 Hz or 3000 Hz	high-pass; low-pass; NO notch
Time window	25 msec	
Stimulus Rate	21.1-39.1/sec	

Stimulus	1000 Hz toneburst	
Transducer	Insert	
Polarity	Alternating/variable	To reduce periodic waves
Ramping	Blackman	
Duration	2-0-2	2 msec rise/fall and 0 msec plateau
Intensity	≤40 dB nHL to begin	20-30 dB nHL is WNL. Replicate at threshold. Correction for dB eHL= -10.
Filter Settings	30 Hz; 1500 Hz or 3000 Hz	high-pass; low-pass; NO notch
Time window	25 msec	
Stimulus Rate	21.1-39.1/sec	

Threshold Estimation, cont.

Parameters		Notes
Stimulus	Click	
Transducer	Insert	
Polarity	Rarefaction Condensation (if needed to enhance wave V)	Rarefaction provides larger amplitude and shorter latency than condensation. Replicate at threshold.
Duration	.1 msec	
Intensity	Variable	20 dB nHL is WNL; no correction needed for dB eHL.
Time window	15 msec	
Rate	21.1-39.1/sec	Slower rate if enhanced response is needed
Filter setting	30 Hz; 1500 Hz or 3000 Hz	high-pass; low-pass; NO notch
Sweeps	≥ 600	Enough to adequately overcome SNR and replicate

2. Pediatric Neurodiagnostic

Parameters		Notes
Stimulus	Click	
Transducer	Insert	Bone conduction, circumaural headphones only when necessary
Polarity	Condensation & Rarefaction	1 run each to identify wave I vs. stimulus artifact or cochlear microphonic; also 1 run with earphone tube clamped
Duration	.1 ms	
Intensity	≥70 dB nHL	
Rate	21.1-39.1/sec	Slower rate if enhanced response is needed
Filter setting	30 Hz; 1500 Hz or 3000 Hz	high-pass; low-pass; NO notch
Sweeps	≥ 400	Enough to adequately overcome SNR and replicate
Analysis time	15 msec	Pre-stim baseline: -1 msec

3. Bone Conduction

Parameters		Notes
Stimulus	Click	Tonebursts as a supplemental measure
Transducer	Bone oscillator that came w/ system (leave inserts in ears after air conduction testing)	Use Velcro or leather headband, or hand-hold
Polarity	Alternating	
Filter Settings	30 Hz; 1500 Hz or 3000 Hz	high-pass; low-pass; NO notch
Duration	.1 ms	
Intensity	≤ 50 dB nHL	Identification of Wave I will rule out crossover to non test ear
Time window	15 msec	
Stimulus Rate	21.1-39.1/sec	Reduce rate if poor morphology

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Funding provided by Maternal and Child Health Bureau (MCHB) and Health Resources and Services Administration (HRSA).



DOH 344-016 August 2012

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