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Agency of Human Services

Vermont Department of Health
Hearing Advisory Council
Recommended Protocol for Auditory Brainstem Response (ABR).

The State of Vermont Hearing Advisory Council and Early Hearing Detection and Intervention (EHDI) Program, based on national best practice guidelines including the Joint Committee on Infant Hearing (JCIH), recommends that children who do not pass their newborn hearing screenings at birth complete a diagnostic auditory brainstem response evaluation before 3 months of age (JCIH ,2007). This testing should be performed by an audiologist with a background in pediatric hearing assessment and specifically trained to perform diagnostic Auditory Brainstem Response (ABR) evaluations. The following protocol should be used to diagnose the presence and degree of hearing loss and to obtain medical clearance for the fitting of amplification when appropriate.

This protocol will focus on non-behavioral, diagnostic evaluation following a failed newborn hearing screening. Children who are not yet developmentally capable of behavioral evaluation should be tested using a comprehensive approach, including diagnostic Auditory Brainstem Response (ABR) evaluation, Otoacoustic emissions (OAE) as well as middle ear assessments. As Auditory Brainstem Response (ABR) testing is currently the gold standard evaluation for early hearing loss detection, this protocol will provide recommendations for equipment setup, testing procedures and results/data interpretation. Frequency specific ABR evaluation is recommended in order to obtain results that are directly transferable to modern amplification systems. The following are evidence-supported recommendations for Auditory Brainstem Response (ABR) evaluation in the infant population.

1. Frequency
    a. 500Hz through 4000Hz are critical frequencies for ABR testing with 2000Hz considered an ideal starting frequency. Use of clinical judgment is recommended when determining which frequencies can be obtained given testing circumstances and/or allotted time available for testing.
    b. The click ABR is a useful and supplementary piece of information, however, the Joint Commission on Infant Hearing (JCIH) clearly states that frequency specific ABR results are priority over Click ABR specifically for the fitting of modern amplification devices (JCIH, 2007).
2. Intensity
    a. Threshold search
        i. 5 to 10 db steps should be used when approaching threshold. Larger steps of 15 to 20db are appropriate when determined on the basis of amplitude and wave morphology. As ABR testing is a time sensitive evaluation, clinical judgment will be critical in determining appropriate use of time.

ii. In the absence of an ABR response, testing should proceed until limits of the equipment are reached for proper identification of profound hearing loss. These limits should be determined prior to testing, and calibration of ABR equipment completed at the manufacturers recommended intervals to ensure transducer output is accurate.

3. Procedure
    a. Preparation
        i. Patient preparation is a critical factor in test efficiency and quality
            1. Explanation of test procedures, required sleep deprivation and feeding pattern for testing day is recommended for the family of the patient. Notification in the form of a letter and/or verbal communication is ideal.
    b. The use of a 2- channel electrode montage is the accepted method for obtaining ABR results. Two commonly used methods are described below.
        i. Vertical: High forehead and nape of neck and ground (common).
        ii. Mastoid: High forehead and each mastoid, lateral forehead or other preferred site (common)
            1. Some evidence supports that the vertical montage provides larger amplitude at lower intensity (King et al., 1992). Both methods are considered acceptable and appropriate for threshold ABR evaluation.
4. Stimulus
    a. Tone-pips
        i. Blackman or linear gated tone pips are currently the preferred form of stimulus for frequency specific ABR evaluation (NHSP, 2012).
5. Transducer
    a. Headphones or insert Earphones
        i. Circumaural or supra aural headphones have a more stable calibration over a larger variability of ear canal volumes and ear impedances in addition to the reliability of stimulus at high intensity levels. Insert phones are less cumbersome and will allow setup of both ears before child is sleeping. This will prevent the possibility of waking the patient when changing ears. Both methods are appropriate for threshold ABR applications (Voss and Herrmann, 2005).

6. Bone conduction
    a. Bone conduction ABR can and should be performed when test conditions allow. Best opportunity for useful information with BC testing falls within 1K-4K. Correlation of AC- and BC-ABR thresholds for clicks with AC and BC pure-tone thresholds was highest in the 1–4 kHz range (Cone-Wesson et al, 1995)
    b. BC oscillator artifact may obscure definition of ABR peaks, particularly wave I. This can be ameliorated by using a Cz–C7 (vertex to low nape of neck) recording montage that has the added benefit of increasing wave V amplitude near threshold, thus enhancing detection (Singer & Don, 1989).

7. Results
    a. Determination of a present wave V in the ABR recording and a threshold response is based upon an active and ongoing assessment of the electrophysiological data obtained. Wave morphology, amplitude and clinician judgment will dictate when threshold is obtained for each individual frequency. It is important to note that success in ABR assessment will rely more on obtaining individual thresholds with "clean" data as apposed to multiple thresholds that rely on incomplete or "noisy" data.
    b. Threshold conversion must be completed from dBnHL to dBeHL prior to fitting amplification in infants. Many hearing aid manufacturers have implemented this conversion within their fitting software. While a psychophysical measurement of individual equipment is highly recommended, the use of an existing standard conversion is considered a reliable and accepted alternative (BCEP 2008)
    c. In the presence of any degree of hearing loss following ABR testing, tympanometry and otoacoustic emissions are recommended when possible to support future otologic consultation.
8. Follow up
    a. Regular audiological monitoring is recommended from birth to 36 months of age when a hearing loss has been diagnosed. Diagnostic Auditory Brainstem Response should be repeated at re-evaluation until reliable behavioral audiometric data can be obtained (JCIH, 2007).

For a more comprehensive view on diagnostic audiology in the pediatric population, please refer to the British Columbia Early Hearing Program's diagnostic audiology protocol. The following data provides guidance for setup using the Biologic Navigator Pro ABR equipment and is authored by the NHS Antenatal and Newborn Screening Programs, UK. Biologic Nav Pro is the preferred equipment choice of the Early Hearing Detection and Intervention program.

	Click & 2kHz / 4kHz tone pip	0.5kHz / 1kHz tone pip
Electrode location[1]	Positive : High forehead (as close to vertex as possible but avoiding fontanelle) Negative : Ipsilateral mastoid Common : Contralateral mastoid	
Stimulus type:	Alternating polarity	
Stimulus timing:	Click: 100 µs click. Tone pip: 2-1-2 cycles (rise –plateau – fall)	
Stimulus rate[2]:	45.1[4] - 49.1/s 17.1 - 19.1/s for wave I on BC[5]	35.1[4] - 39.1/s
Calibration values for 0dBnHL:	Refer to NHSP calibration data	
Amplifier reject levels:	± 3 to ± 10 µV peak to peak. Start at +/- 5µV peak to peak	
Amplifier filters:	Low frequency: 30Hz High frequency: 1500Hz	
Window length:	20ms[3]	25ms[3]
Number of sweeps averaged per replication:	Typically: 2000 click, or 3000 for TP Minimum: 1500 click, or 2000 for TP	
Display scales:	Maximum of two fixed scales. Use scale appropriate to result. (1) 0.05-0.1 µV (50-100nV) ≡ 1 ms (2) 0.025-0.05 µV (25-50nV) ≡ 1 ms	
Display	Wave V up	

Biologic (Windows software version 6.3 & 7.0)

The parameters are set in: Setup/Collection Protocols and in each protocol by selecting the relevant tab in the software headed 1/Recording, 2/Stimulus, 3/Amplifer.

Recording

Epoch time(window)
- For Clicks & tone pips at 2kHz & 4kHz: 21.33ms
- For Tone pips at 500Hz & 1kHz: 26.67ms

Points (No. of data points in average): 512 (only 256 possible with 26ms epoch)
Pre/post: 0
Blocking: See table below
Maximum number of averages (sweeps) 3000 for clicks, 4000 for tone pips.
Fsp details: tick enable but not stop criterion See table below for range; set skipped points to 0.
Provisional value for Fsp corresponding to 3:1 snr is 10 but this is under review. The Biologic manual is known to be wrong in this regard.
Residual noise: Set to most strict (lowest value) if you do not want to auto-stop. Note that the NHSP 25nV "gap" criterion is likely to correspond to an RMS noise value of 15nV

Stimulus

Transducer: headphones/insert earphones/bone oscillator
Insert delay: 0.80ms
Polarity: alternating
Stimulus rate: 45.1/s (for a 21.33ms window)
35.1/s (for a 26.67ms window)
NB check stimulus rates can be achieved and that high rate does not produce an artefact.

Intensity (initial level for 4kHz pips but refer to NHSP guidelines; aim is to start at discharge level +10dB):
Headphone: 40dBnHL
Insert earphone: 30dBnHL
Intensity step 5dB
Stimulus type:
- *Click*
  - Duration 100µs.
- *Tone burst (tone pip)*
  - Rise/fall time: 2 cycles
  - Plateau: 1cycle

N.B. Earlier software may require values in ms as follows:

	500Hz	*1000Hz*	*2000Hz*	*4000Hz*
Plateau	*2*	*1*	*0.5*	*0.25*
Rise time	*4*	*2*	*1*	*0.5*

Ramp: Blackman or linear (not critical)
Mask: none
(Noise calibration: 0dB of noise is actually 20 dB SPL)

Amplifier

Channel 2 enable: unchecked
Gain: 240,000 or 300,000
Artefact reject level: ±5µV to ±9.9µV (±3µV for CM tests)
WARNING reject level can change if the gain is changed - check reject levels are correct on display, especially after changing the gain setting.

Filters: Low 30Hz High 1500Hz. Notch filter: unchecked
Input 1:Cz Input 2: A1/A2
Electrode switching: use only if you understand how this works.

Display
Setup/Default Display parameters. Waveform Grouping: Select user positioning as default but manually select superimpose for interpretation. Scale: Normally split screen, format (two charts side by side – Ear Panel Same). Specific 0.2μV (0.3 for large responses). Do not manually alter chart size /position with the mouse – likely to alter aspect ratio.

Fsp range & blocking duration:

Stimulus	Blocking (ms)	Fsp range* (ms)
Click	1.5	6-14
4k Pip	1.5	6-14
2k Pip	2.5	8-16
1k Pip	5.0	11-19
500 Hz Pip	10.0	13-21

* Revised July 2011
There is an option to show the waveform (response) or show a flat line over the blocking period. The default option should be "show response" and the "show flat line option should be used only if the size of the stimulus artefact causes the chart to expand unreasonably. This tends to occur only when testing by BC at high stimulus levels. The default option is set in: Setup, Default Display Parameters, Stimulus Blocking Appearance. Toolbar buttons are provided to temporally change the option when required.

Adding Waveforms

Select the waveforms to be added: select the first waveform by clicking on it on the control panel listing. Hold the Ctrl key down and do the same for the second waveform to be added. Repeat process if more than two traces are to be added.
This highlights the traces to be added in the control panel.

Select: Analysis (from toolbar at top of screen)
Calculations (from drop menu)
Weighted Add
The weighted added trace appears on the waveform display

Maximum stimulus levels:
The following levels, in dBnHL, are typical for the Nav Pro when calibrated the levels advocated by NHSP. Users can use these as an approximate guide as a check for appropriate calibration. Individual systems are unlikely to have maximum stimulus levels that depart from these levels by more than 5dB. When making this check it is necessary to set the system to a stimulus step size of 1dB (not 5dB).

	Click	4k	2k	1k	500
TDH	99	107	107	114	109
Insert	100	109	109	112	109
BC	61	55	69	61	58

References:

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