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ELECTROPHYSIOLOGIC ASSESSMENT USING THE AUDITORY BRAINSTEM RESPONSE (ABR)

Threshold Estimation Using Tone Bursts and Chirps

ABR, together with ASSR, are the only means of estimating thresholds for children under 6 months developmental age and for others who cannot cooperate for behavioral testing. This edition of PATHNEWS will address ABR only.

The benefits of using ABR to construct the audiogram far outweigh the limitations. The major limitation is the choice of stimuli that can be used to elicit a response. Synchronous neural firing of multiple neurons is essential to record an ABR. A rapid or abrupt onset stimulus, such as a click or chirp, which stimulates a broad area of the basilar membrane generates synchronous neural discharge in many neurons. The ABR to click or chirp stimuli will provide an overall assessment of the integrity of the auditory pathway and provide a basis on which to start investigating thresholds at specific frequencies.

Frequency Specific Information

The click stimulus contains energy in a broad frequency range. Responses to click stimuli correlate best with audiometric findings in the 2000- 4000 Hz frequency range (Moller and Blegvad, 1976; Coats and Martin, 1977). The use of this stimulus can either underestimate or miss a hearing loss at a particular frequency or frequencies depending on the degree and configuration of the hearing loss. While a chirp stimulus can be substituted for the click, it offers no correlation to any specific frequency range as theoretically, the response comes from more of the basilar membrane. Remember that with a chirp stimulus, the low frequencies are released first followed by the mid and then high frequencies thus allowing contribution from a wider range of frequencies. The click on the other hand stimulates the basil end of the cochlear (higher frequencies) first and response already has occurred before it reaches the more apical region of the cochlea (lowest frequencies) and thus the correlation to the 2000-4000 Hz frequency range.

While the use of age-appropriate latency-intensity functions together with the threshold search will help to identify impairments, exact quantification of the impairment at each frequency cannot be done using the click or chirp stimulus. Frequency specific or tonal stimuli needs to be used. The commonly used stimuli to obtain frequency specific information is a brief duration tone burst or frequency 'specific' chirps or narrow band chirps, all of which are an octave wide. The tradeoff of becoming more tonal is to reduce the synchronous neural discharge due to the more limited area of the basilar membrane being stimulated. The aim is to achieve a balance of tonality with enough synchronous neural firing to elicit a response. However, with less neurons firing synchronously, the response morphology, particularly amplitude, is not as great as is seen with a broadband chirp stimulus.

For tone bursts, it is necessary to maintain a fast enough rise time to elicit a response yet reduce the acoustic splatter to frequencies above and below the nominal frequency of the stimulus. Producing a frequency specific stimulus without significant contribution from other frequencies can be achieved by using gating functions or stimulus shaping envelopes such as Blackman functions (Gorga and Thornton, 1989).

While producing a stimulus that does not have contributions from other frequencies is important, it will not ensure a place specific region of excitation on the basilar membrane. Physiologically, there is an upward spread of excitation on the basilar membrane as the intensity level of the stimulus is increased beyond 70 dB SPL (Pickles, 1988). Spread of energy to frequencies with better hearing will result in an underestimation of threshold level.

Predicting the Audiogram

Prediction of the audiogram using the ABR is possible if proper testing conditions and parameters are used. Responses to both air and bone conducted stimuli should be obtained. While there are intensity output limitations in bone conduction testing, it often helps to confirm the type of auditory impairment. Threshold levels between air and bone conduction stimuli in individuals with normal hearing and in individuals with sensorineural hearing loss should agree closely. There are maturational changes in latency with bone conduction response that should be taken into consideration when testing infants (Mauldin and Jerger, 1979; Yang et al, 1987, Hooks and Weber, 1984; Stuart et al, 1990).

Threshold differences of greater than 15 dB with better bone conduction threshold than air conduction threshold is indicative of conductive involvement. To obtain valid results, the tester must assure adequate headband pressure (Yang et al, 1987) and proper placement of the bone vibrator on the mastoid. For infants, a super-posterior placement from the pinna is recommended as it is easier to maintain position with better quality responses and less variable in latencies (Stuart et al., 1990).

A practical consideration in bone conduction testing is electrode placement. Electrodes cannot be placed on the mastoid when bone conduction testing is being done because of the small area of the mastoid in children and the electromagnetic interference that can occur when the electrode is close to the bone vibrator. Moving the electrode off the mastoid to the earlobe or in front of the tragus in young infants is necessary. The use of insert earphones permits placement of the bone vibrator and masking earphone on a small child's or infant's head. Bone conduction testing does require the use of masking, although there appears to be more interaural attenuation in young children than adults (Stuart et al, 1990).

Suggested Sequence of Testing

The goal of using the ABR is to predict the audiogram sufficiently so that if a sensorineural impairment is present, amplification can be fit. The optimal time to conduct an ABR on an infant is during sleep, but there is always an uncertainty as to how long an infant will sleep. Therefore, there should be a prioritization of the sequence of the frequencies used during testing. Since the ABR to click or chirp stimuli provides the best response it is reasonable to start with this stimulus. This allows for evaluation of the response morphology and evaluation of the neural conduction time or calculation of the inter-wave latencies. If using a click stimulus that provides information in the 2000-4000 Hz frequency range, it would then be followed by a low frequency stimulus, such as a 250 or 500 Hz tone burst. Following this, more frequency specific testing at 4000 and 1000 Hz and lastly 2000Hz. For a chirp stimulus, starting off in the higher frequencies would be more ideal, followed by low frequencies than the mid frequencies. If elevated response levels are obtained, bone conduction testing should be completed. While this is a guideline on the sequence of testing, each child's findings must be viewed and decisions made online to maximize obtaining information about the type, degree, and contour of hearing loss.

While the ABR is paramount for prediction of auditory thresholds in young infants, it should be remembered that the ABR does not measure hearing in the true meaning of the word. Instead, it measures the integrity of a portion of the auditory system through approximately the lower brainstem. For young infants, it is important to have a full battery of tests and include for example, acoustic immittance testing, otoacoustic emissions, ASSR, as well as case history and a cursory evaluation of an infant's behavioral response to sounds.

References

Coats AC, Martin JL. Human auditory nerve action potentials and brain stem evoked responses: effects of audiogram shape and lesion location. Arch Otolaryngol. 1977 Oct;103(10):605-22. doi: 10.1001/archotol.1977.00780270073012. PMID: 907564.

Gorga MP, Thornton AR. The choice of stimuli for ABR measurements. Ear Hear. 1989 Aug;10(4):217-30. doi: 10.1097/00003446-198908000-00002. PMID: 2673891.

Hooks RG, Weber BA. Auditory brain stem responses of premature infants to bone-conducted stimuli: a feasibility study. Ear Hear. 1984 Jan-Feb;5(1):42-6. doi: 10.1097/00003446-198401000-00009. PMID: 6706026.

Mauldin L, Jerger J. Auditory brain stem evoked responses to bone-conducted signals. Arch Otolaryngol. 1979 Nov;105(11):656-61. doi: 10.1001/archotol.1979.00790230026006. PMID: 496714

Møller, K., & Blegvad, B. (1976). Brain Stem Responses in Patients with Sensorineural Hearing Loss Monaural Versus Binaural Stimulation. The Significance of the Audiogram Configuration. ***Scandinavian Audiology***, ***5***(3), 115–127. https://doi.org/10.3109/01050397609043104.

Pickles, J. ***An Introduction to the Physiology of Hearing***. 2nd ed., ***Academic Press***, 1988.

Stuart A, Yang EY, Stenstrom R. Effect of temporal area bone vibrator placement on auditory brain stem response in newborn infants. Ear Hear. 1990 Oct;11(5):363-9. doi: 10.1097/00003446-199010000-00007. PMID: 2262086.

Yang EY, Rupert AL, Moushegian G. A developmental study of bone conduction auditory brain stem response in infants. Ear Hear. 1987 Aug;8(4):244-51. doi: 10.1097/00003446-198708000-00009. PMID: 3653538.