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Hearing Threshold Determination for Children Using Auditory Steady State Response

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ABSTRACT

The auditory steady state response or steady state evoked potential has proven useful in hearing threshold determination for children. The auditory steady state response is another form of auditory evoked potential. The electrophysiological tests today primarily involve auditory evoked potentials through auditory brainstem response audiometry and the auditory steady state response. A primary advantage to these objective measures is that the procedures are effective during sleep and the child may be sedated or anesthetized with no effects on test accuracy. The study is only designed especially for children who cannot be tested by conventional audiometry. The study may be used as a test of audiological or neurological functions. The auditory steady state is one of the latest tools to be added to the audiologist to obtain reliable predications of hearing sensitivity. When testing to estimate behavioral hearing thresholds, as signal intensity decreases the wave amplitude become smaller and latencies increases. Since wave V normally has the largest of the first seven waves, the threshold is considered to the lowest intensity at which wave V can be observed. The brainstem auditory evoked responses may be used as a neurological screening test to assess the intensity of the central auditory pathways. The most significant finding in neurological lesions in increase in the timing of one or more peak in the response, indicating a slowing of the auditory response. This may be due to possibly to other abnormal central nervous system disorders such as demyelinating diseases like multiple sclerosis.

Keywords : Electrodiagnostic instruments, Auditory signals, Headphone, Stimulator, ete.,

Introduction

The major role of brainstem auditory evoked potential (BAEP) in pediatric neurology lies in identification and quantification of hearing loss in children who are unco-operative for audiometry. In children BAEP recording is more difficult than adults but it provides valuable clinical information. The BAEP response in children is smaller and background electrical noise from the EEG and scalp muscles is often higher compared to adults. These can be reduced by recording BAEP during sleep in children. Newborn infants quickly fall asleep; in holder infants waking them early on the day of recording induces sleep recording the test especially after a feed. The BAEP responses in infants are more sensitive to stimulation rate compared to adults; therefore, age specific normative data should be available for the rated used.

An auditory evoked potential is simply a small part of a multiplicity of electrical events measurable from the scalp. This electrical activity which originates in the brain is commonly referred to as electroencephalogram which is used to pick up and amplify the electrical activity from the brain by electrodes placed on the scalp. When changes in activity are observed on a computer monitor or printout, waveforms may be seen that aid in the diagnosis of central nervous system disease or abnormality. In coupling the EEG to a patient to observe responses evoked by sounds, the ongoing neural activity is about 100 times greater than the auditory evoked potential and therefore obscures observation of the auditory brainstem evoked potential. The measurement of auditory brainstem evoked potential is further complicated by the presence of large electrical potentials from muscles. These obstacles were insurmountable until the advent of averaging computers, devices that allow measurement of electrical potentials, even when they are embedded in other electrical activity.

To measure an auditory evoked potential, a series of auditory stimuli is presented to the subject at a constant rate by a transducer. Insert earphones are becoming the standard for auditory evoked potential testing because they are relatively comfortable to wear and help attenuate extraneous room noise. Also, their transducers are 250 m meters from electrodes placed at the ear and therefore produce fewer electrical artifacts. The EEG equipments picks up the neural response, amplifies it, and stores the information in a series of computer memory time bins. Each bin sums neuroelectric activity that occurs at specific numbers of milli seconds after the onset of stimulus. Of course, the computer is summing not only the response to the sound in any particular time bin, but also the random brain activity taking place at the precise moment. However, because the random activity consists of positive and negative voltages of varying amplitudes, summing reduces them to a value at or near zero.

The polarity of the neural response is either positive or negative but not both. Summing alone would cause the amplitude of the response to increase, but the waveform is then averaged by dividing the amplitude by the number of signal presentations. This decreases the summed response to the amplitude of the averages response. While there is no increase in amplitude of the auditory brainstem evoked potential there is decrease in amplitude of the random noise as it is summed and averaged. It might be said that as the summing and averaging process continuous the signal to noise ratio improves. Even though the amplitudes of the responses are extremely small often on the order of 1 to 5 mirco volts (1 micro volt is equal to one millionth of a volt), they can nevertheless be detected and interpreted.

Waveform measurements techniques

An auditory evoked potential is considered neurologically abnormal, indicating neuropathology affecting the auditory pathway of the brainstem, when any of the following occur.

- Inter-peak intervals are prolonged.
- Wave latency is significantly different between ears.
- Amplitude ratios are normal (Normally wave V is larger than wave I)
- Wave V is abnormally prolonged or disappears with high rate stimulations.

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Measurements are normal values of brainstem auditory evoked potentials in the following parameters are measured for analysis.

- Absolute latency and amplitude.
- Inter- peak latencies
- Amplitude ratio of wave V/I or IV-V complex.
- Inter ear inter-peak differences.

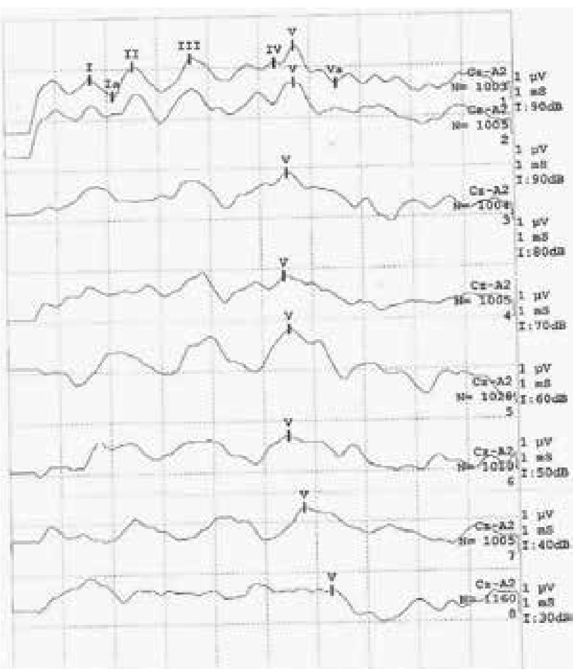
Auditory brainstem response audiometry has been useful in diagnosing central auditory disorder as long as any hearing loss in the two ears is essentially symmetrical and no more than a mild loss exists in either ear. Central lesions will generally slow the conduction velocity of electrical impulses sent through the nerve fibers.

In testing for lesions of the brainstem, it is useful to compare the latencies and intervals of waves I, III and wave V as a function of increased click rates. Although the auditory evoked potential results may provide important diagnostic information in testing for central auditory lesions, interpretation can be difficult when it is complicated by the absence of some waves, the influence of unusual audiometric configurations, and the patients age and body temperature. The auditory brainstem evoked potential is generally the most sensitive and specific test currently for diagnosis of auditory brainstem lesions.

Formation and methods

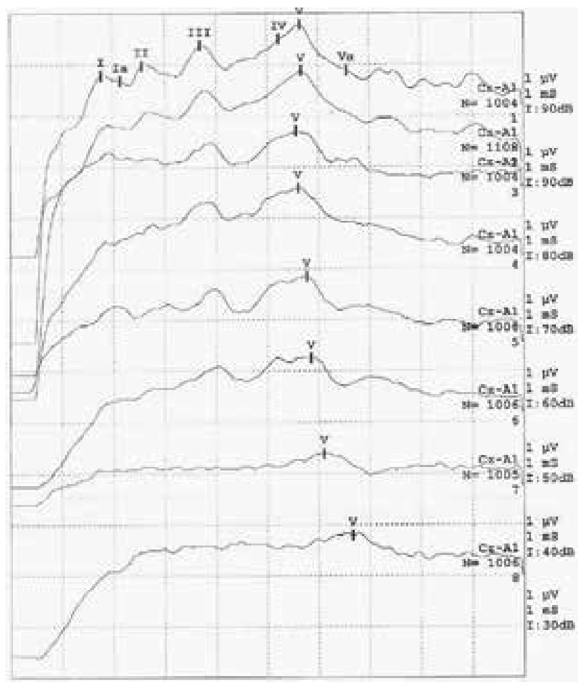
For measuring responses from the brain, electrodes are usually placed on the mastoid process behind the outer ear and the vertex, with a ground electrode placed on the opposite mastoid, the forehead, or the neck. Stimuli with rapid rise times, such as clicks, must be used to generate these early responses. Tone pips, or bursts which provide some frequency specific information, can be used. When a summing computer is used, seven small wavelets generally appear in the first 10 m seconds after signal presentation. Each wave represents neuro electrical activity at one or more generating sites along the auditory brainstem pathway.

There are several ways in which routine auditory brainstem evoked potential audiometry is performed. The subject is first seated in a comfortable chair, often a recliner, which is placed in electrically isolated shielded room. The skin areas to which electrodes will be attached are carefully cleaned and a conductive gel or paste is applied to the area. One electrode is placed on the vertex or the forehead and one on each earlobe or the mastoid process behind the external ear. An electrode opposite the ear being tested serves as a ground. After the electrodes are tapped in place, electrical impedance is checked with an ohmmeter. The lights are usually dimmed and the chair is placed in a reclining position. The auditory brainstem evoked potential is not affected by sleep state; therefore the subject may sleep while the responses are being recorded. The procedure is carried in a sound proof room. The stimulus is provided using head phone in one ear followed by second ear. The electrical response is recorded by small plates (electrodes). The study is not painful during recording test.



Tr	Mont	I (mS)	II (mS)	III (mS)	IV (mS)	V (mS)	I-III (mS)	I-V (mS)	III-V (mS)	I-Ia (µV)	V-Va (µV)	Amp (R)
1	Cz-A2	1.63	2.52	3.65	5.31	5.69	1.96	4.00	2.04	0.33	0.73	2.17
2	Cz-A2					5.69						
3	Cz-A2					5.52						
4	Cz-A2					5.44						
5	Cz-A2					5.52						
6	Cz-A2					5.48						
7	Cz-A2					5.77						
8	Cz-A2					6.29						

Figure1. BAEP Potentials (Right)



Tr	Mont	I (mS)	II (mS)	III (mS)	IV (mS)	V (mS)	I-III (mS)	I-V (mS)	III-V (mS)	I-Ia (µV)	V-Va (µV)	Amp (R)
1	Cz-A1	1.77	2.56	3.69	5.23	5.65	1.92	3.88	1.96	0.09	0.86	9.57
2	Cz-A1					5.67						
3	Cz-A1					5.56						
4	Cz-A1					5.60						
5	Cz-A1					5.77						
6	Cz-A1					5.85						
7	Cz-A1					6.10						
8	Cz-A1					6.67						

Figure2. BAEP Potentials (Left)

Technical specifications

The impedance between the skin and the electrodes, and between any two electrodes, must be controlled for the test to be performed properly. An insert receiver is placed into the test ear, or a circumaural ear phone is placed over the test ear, and the patient is asked to relax. A series of maximum 2000 clicks presented at rate of 11.1 clicks per second. These trails are averaged to get a good quality recoding. The click rate is divisible by 1, in order to differentiate the real response from electrical artifacts in the lab, such as the 50 Hz electrical current. In response to the stimulus, the auditory brainstem evoked potential waveforms appears as several narrow peaks and through within 1 to 10 m sec of the signal onset. The main positive peaks are labeled in Roman numerals for waves I, II, III, IV and V. Figure (1) & (2) shows the brainstem auditory evoked potential wavesforms from 100Db to 30 Db. Wave V could obtained upto 30 Db in both right and left ears respectively.

Occasionally a large number of trails have to be averaged if the recording is noisy or waveforms are not clear. Two repetitations are used to be superimposed to check reproducibility. In general, the brainstem auditory evoked potential repetition should superimpose almost exactly. The latency values measured on the separate repetitions should agree with each other within 0-1 m sec or less. The amplitude values should agree with each other within 10%.

The brainstem auditory evoked potentials are produced by a brief click stimulus which is usually a square wave pulse of 0-1 m sec duration. The pulse can move the earphone diaphragm either towards or away from the ear. The earphone movement towards the ear is called condensation phase stimulus, whereas the one away from the patient's ear is called rarefaction stimulus.

Wave I amplitude tends to be greater with rarefaction compared to condensation stimulus. Since the recognition of wave I is very important, rarefaction click polarity is usually employed. Wave II is usually appears as small peak along the down going slope of wave I or in the up going slope of wave III. Wave III is usually a prominent peak and is followed by a prominent peak III through. The two waves IV and V which are almost close but still visibly separated in the form of double peak. In V/I amplitude ratio, the absolute amplitude of different waves does not have clinical important because of wide variation of normal subjects. Wave I amplitude is measured from the peak of wave I to the bottom of the tough of wave I.

Latency Intensity slope

A latency intensity curve can be drawn by plotting the latency of wave V on different stimulus intensities. The slope of change in wave V latency can be calculated in micro second / decibels. A normal slope is usually considered to be less than 50-55 micro second / decibels in the range of 30-70 db n HL intensities. Conductive hearing impairment usually shows results in an elevated threshold but a relatively normal slope. Sensory neural hearing impairment reveals an elevated threshold with a steep slope and a low amplitude or absent wave I. Figure (3) & (4) showed the latency verses hearing threshold comparisons. From the graph, the latency simultaneously prolongation when the threshold keep on reducing by 10 Db.

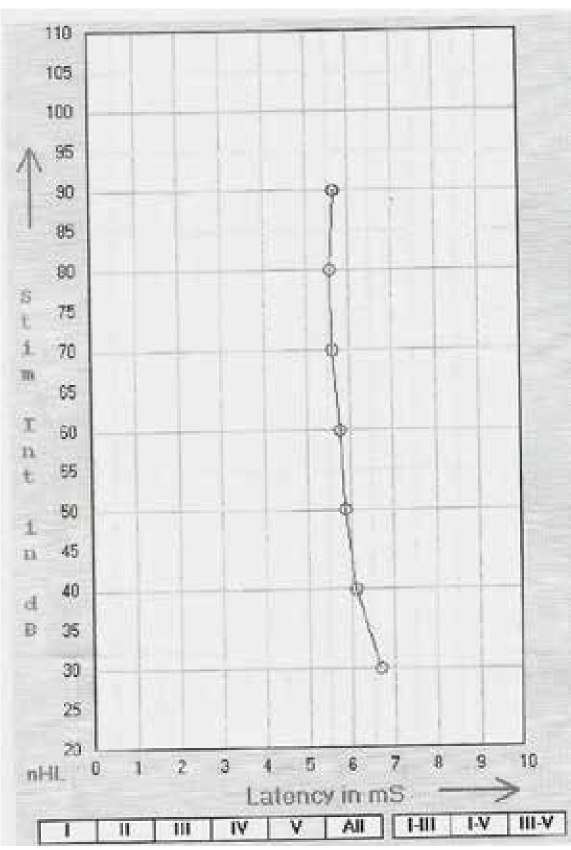


Figure (3) Latency intensity curve (Rt)

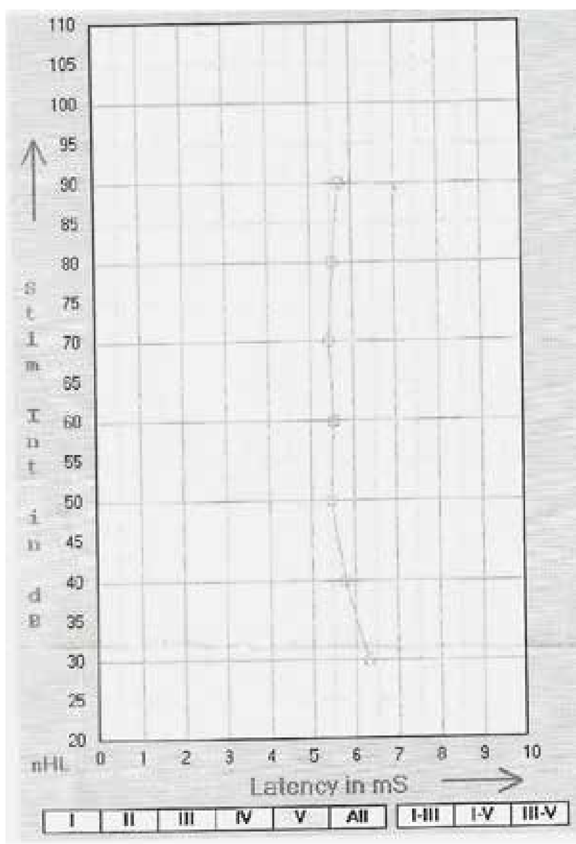


Figure (4) Latency intensity curve (Lt)

Results and discussions:

Wave I-V is seen in most normal individuals. Occasional in normal subjects, wave IV may form a wave wave IV-V complex. In such a situation, absence of wave IV does not indicate an abnormality. Wave II can be difficult to distinguish in some normal subjects. By changing the stimulus intensity, rate and phase, wave II can be identified in most normal sub-

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jects. Absence of all the waves I-V is abnormal. It is also abnormal to record wave I only and not the succeeding waves. Similarly presence of waves I and II but absence of waves IV and V is also abnormal. These conclusions are valid in a technically satisfactory recording in which the background noise has been eliminated. The right to left latency asymmetry exceeding 0.5 ms is also abnormal.

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