Otolaryngology online journal

ISSN: 2250-0359 Volume 5 Issue 1 2015

Brain stem evoked response audiometry A Review

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Abstract:

Brain stem evoked response audiometry (BERA) is a useful objective assessement of hearing. Major advantage of this procedure is its ability to test even infants in whom conventional audiometry may not be useful. This investigation can be used as a screening test for deafness in high risk infants. Early diagnosis and rehabilitation will reduce disability in these children. This article attempts to review the published literature on this subject.

Methadology:

Internet search using google scholar search engine.

Key words used:

BERA, Brain stem evoked response audiometry, Evoked response audiometry, Objective tests for hearing, BAEP (Brainstem auditory evoked potential).

Synonyms:

Brainstem evoked response audiometry, Auditory brain stem response,BAER (Brain stem Auditory Evoked Response audiometry).

Introduction:

It was in 1967 Sohmer and Feinmesser [1] published the first known reported recording cochlear potentials using surface electrodes in humans. They erroneously attributed all the waves generated to the potentials arising from cochlea. The fact that these potentials can be recorded in an non invasive manner excited one and all. It was only in 1971 Jewett and Williston gave clear description of these waves and interpreted that the later waves were generated at the level of brain

stem. In 1977 Selters and Brackman [2] described the importance of prolonged interpeak latencies in patients with acoustic tumors. They also postulated that this time delay was directly proportional to the size of the tumor. In 1975 it was Starr and Achor [3] reported the effects of ABR (auditory brain stem response) in patients with pathology in the brain stem.

Eventhough BERA provides information regarding auditory function and sensitivity, it should not be considered as a substitute for other methods of audiological evaluations. More over ideally it should be viewed in conjunction with other audiological investigations.

This test involves recording of all forms of electrical response generated at the level of brain stem in response to click / tone impulse by placement of electrodes in the scalp. Stimulus is ideally provided by a transducer placed in the insert ear phone / head phone.

Electrode placement in BERA:

Since the electrodes used to record BERA should be placed over the scalp, the scalp hair should he oil free. Patient should be instructed to give shampoo bath to the hair on the day of the investigation [4]. The non inverting electrode is placed over the vertex of the head, and the inverting electrode, the inverting electrode is placed over the ear lobe or mastoid prominence. One more electrode known as the earthing electrode is placed over the forehead. This earthing electrode is very important for the proper functioning of preamplifier. Electrodes that are placed over the mastoid process or ear lobe should be symmetrical. All the electrodes should run towards the top of the patient's head. This helps in active separation of electrodes from transducer cable. It also minimizes the risk of cable getting dislodged if the sleeping baby wakes up.

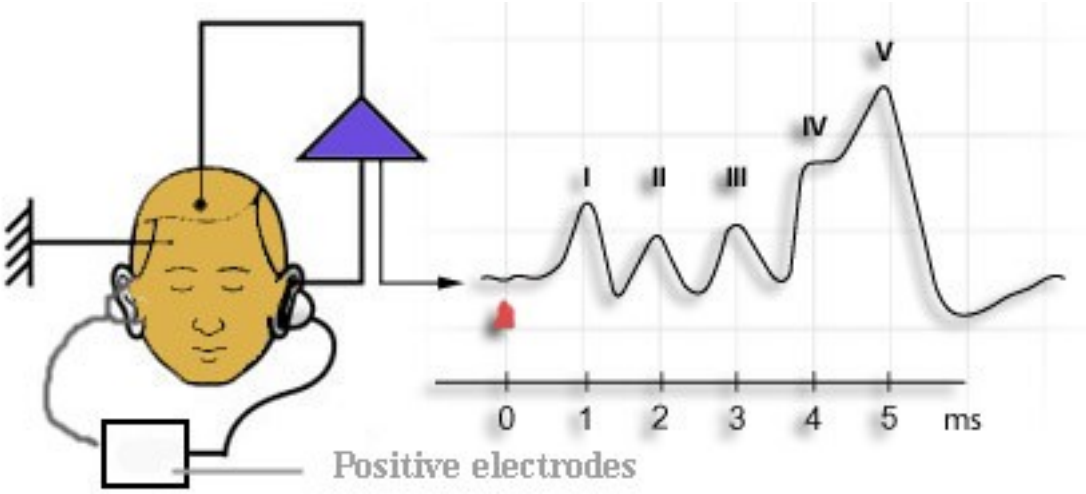

Figure showing placement of BERA electrodes

Potentials recorded by the machine is from far field hence it would be very weak and low in amplitude, hence needs to be amplified. Ideal amplification of the signal is achieved by improving the signal : noise ratio.

Mechanisms used to improve signal : noise ratio in a BERA recording:

Three approaches have been used to achieve optimal result. These include:

Filtering:

This functions by reducing the recording bandwidth thus facilitating recording of important components only.

Repeated stimulation:

Synchronous repeated stimulation when performed increases the amplitude of the components of the signal. The above two approaches can be performed in real time by connecting the recording electrode to a preamplifier with appropriate filter settings.

Polarity alteration:

By altering the polarity of the impulses recorded, the artifacts can be cancelled making the brain stem waves stand out.

The auditory evoked potentials that are of value is neurogenic arising from activity of neurons in the auditory pathway. It should also be borne in mind that myogenic potentials arising from scalp musculature in response to stimuli could contaminate BERA recordings. These myogenic potentials are variable and are of no significant value and may contaminate neurogenic potentials.

In auditory brain stem evoked response, the potentials are generated by the brain stem. These recorded impulses contain a series of peaks and troughs. The peaks are positive potentials (vertex positive) and are indicated by Roman numerals I-VII.

These wave peaks have been postulated to arise from:

1. Cochlear nerves – waves I and II

2. Cochlear nucleus – Wave III

3. Superior olivary complex – Wave IV

4. Nucleus of lateral lemniscus – Wave V

5. Inferior colliculus – Waves VI and VII

These peaks are known to occur in the best readable form in response to click stimuli presented over a period of 1-10 milliseconds in normal hearing adults.

The quality of BERA recording is not affected by sleep / sedation / anesthesia. Its sensitivity threshold is about 10 dB within the recorded value of pure tone audiometry.

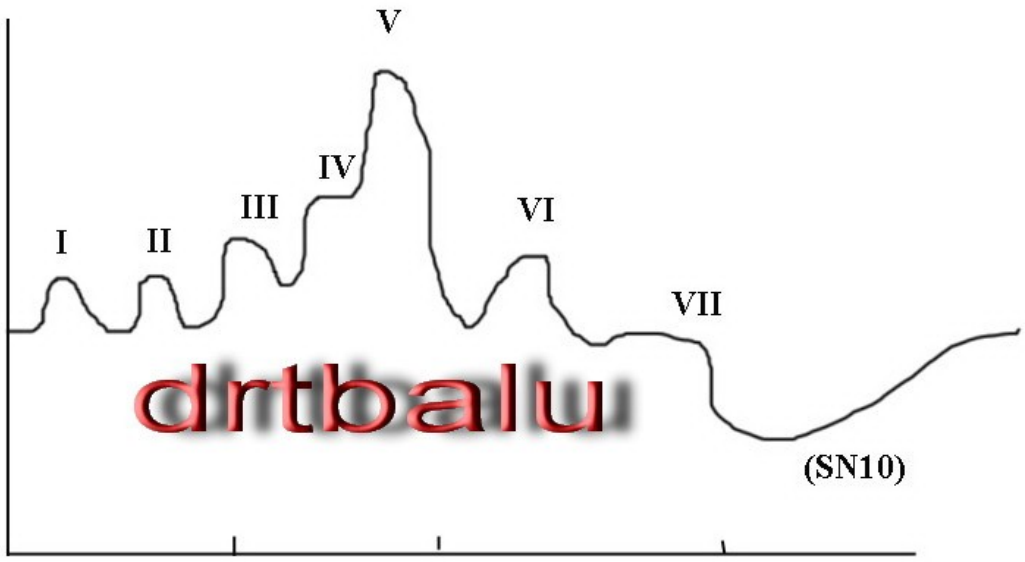

Illustration showing the various wave forms of BERA

There are two different types of auditory evoked potentials that can be recorded. These two potentials are used as adjuncts to routine diagnostic testing. These include:

1. Auditory brain stem response

2. Auditory cortical response

In general terms as the latency of a recorded response increases, the neural generator becomes more central. In far field recordings in humans three subclasses of recorded latency response has been identified. These include [5]:

1. Early response (within first 10 ms) - Potentials from brain stem

2. Middle response (between 10 – 80 ms) – Potentials from thalamus

3. Late response (Between 80 – 500 ms) – Potentials from cortex

Uses of BERA:

1. Auditory brain stem response is a valuable objective measure of hearing. With decreasing stimulus intensity, wave latencies increase systematically until the hearing threshold is reached. Below this hearing threshold the reponse is absent. Thus it is possible to estimate hearing threshold even in individuals who cannot be tested by behavioral methods. It should be borne in mind that adult like BERA responses are acquired only after the age of 2. It is possible to test newborn's hearing using BERA using age appropriate norms. BERA is unaffected by sleep or sedation hence infants can be sedated before performing this test.

2. Can be used to detect demyelinating lesions involving auditory pathways.

3. Can be used to detect lesions and tumors involving auditory pathway.

4. It also helps the neurosurgeon in intraoperative monitoring of the audio vestibular system during extensive neurosurgical procedures involving this area

Auditory cortical response:

Records the impulses generated by brain in response to tone stimuli. It is recorded using cortical response audiometry (CERA). CERA is very useful for threshold estimation of hearing, where as BERA is highly useful for objective threshold estimation of hearing as well as differential diagnostic purposes. These reponses are more generalised and originate form the brain cortex occurring between 50 - 300 milliseconds after the onset of stimulation. Since these responses are generally elicited with a tone burst lasting approximately for about 200 milliseconds, its responses are highly frequency specific. This is in contrast to BERA because brain stem responses are evoked by click stimuli and are not frequency specific. Interpretation of CERA is easy and straightforward. Threshold is defined as the minimum stimulus level that gives a consistent and identifiable response. The patient must be lying still during the recording process. This test is hence unsuitable for young children who may not co-operate

Differences between BERA and CERA

BERA	CERA
Recording is made from brain stem potentials	Recording is made from cortical potentials
Click stimulus is used	Tone stimulus is used
Responses are not frequnency specific	Responses are frequency specific
Can be performed in awake and restless patients	The patient must lie still through out the process
Responses begin after 1 - 10 milliseconds after stimuli	Response begins after 50 - 300 milliseconds after stimulation
Suitable for even young children	Unsuitable for children

BERA is very useful in identification of retrocochlear pathologies causing hearing loss. BERA findings that indicate retrocochlear pathology includes:

1. Latency differences between interaural wave 5 (prolonged in cases of retrocochlear pathology)

2. Waves I - V interaural latency differences - prolonged

3. Absolute latency of wave V - prolonged

4. Absence of brain stem response in the affected ear

BERA has 90% sensitivity and 80% specificity in identifying cases of acoustic schwannoma. The sensitivity increases in proportion to the size of the tumor.

Currently BERA is extensively being used in screeing neonates for deafness. Since this is a complicated investigation only high risk infants are screened at present. Indications for screeing BERA in an infant are:

1. Parental concern about hearing levels in their child

2. Family history of hearing loss

3. Pre and post natal infections

4. Low birth weight babies

5. Hyperbilirubinemia

6. Cranio facial deformities

7. Head injury

8. Persistent otitis media

9. Exposure to ototoxic drugs

Eventhough typical BERA recordings are performed using short duration simple stimuli like clicks, complex sounds like human voice with long duration can also be used in BERA. BERA responses to speech sounds can be used as a marker to identify complex disorders involving auditory processing [6].

Conclusion:

BERA is an useful tool in identifying deafness in neonates. It can be used as a screening tool for early detection of deafness in high risk infants. It also gives a reasonably accurate assessment of hearing threshold levels objectively when used in adults. When used with speech stimuli it helps in the identification of complex auditory disorders involving auditory processing areas of brain.

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