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MATURATION OF BRAINSTEM AUDITORY EVOKED POTENTIAL FROM FULL TERM INFANTS & CHILDREN TO YOUNG ADULT

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ABSTRACT

Age is one of the important factors in the clinical interpretation of Brainstem auditory evoked potential waveform components and it can change the value of peak latencies and interpeak latencies among different age groups. Initial auditory responses in neonates appear in the 26th and 27th weeks of pregnancy. Progressively over time, these follow a “maturation pattern” in which interwave intervals and latencies decrease and the amplitudes of the BAEPs increase. So the following study was performed to show the effect of maturation on BAEP wave latencies and amplitude from infants to children (1 month to 5 years) & adult (18- 25 years). We recorded BAEP from sixty subjects; from them 40 were infants & children and 20 were adults. The recording was done using RMS EMG EP MARK II machine manufactured by RMS recorders and medicare system, Chandigarh. The absolute latencies and interpeak latencies for most waves reached to adult equivalence between 9 months to 3 years. The amplitudes of all BAEP waves increased with age, the greatest changes occurring during early infancy. It is clear that there is a distinct maturation pattern for the Brainstem auditory evoked potential.

Keywords: Brainstem auditory evoked potential, infants, childrens, adults, maturation, amplitude, latency

1. Introduction:

Assessment of hearing loss in the infants and young children is difficult because of limited patient cooperation hence objective laboratory test are particularly needed for such patients. Brainstem auditory evoked response being non invasive & requiring least patient cooperation is considered to be the best choice of all the auditory evoked potentials for objective assessment of hearing acuity in young children. It is a useful technique for demonstrating dysfunction in the brainstem.[1]

On applying auditory stimulus to one ear, activation of peripheral and central auditory pathway occurs. Brainstem auditory evoked potentials (BAEPs) are the electrical activities resulting from the activation of the eighth nerve, cochlear nucleus, tracts and nuclei of the lateral lemniscus and inferior colliculus.[2] Clinical stimuli delivered to one or both ears evoke seven submicrovolt vertex positive waves in the first 10 msec after each stimulus.[3] They are named according to their sequence in roman letters from I to VII.[4]

Age is one of the important factors in the clinical interpretation of BAEP waveform components and it can change the value of peak latencies and interpeak latencies among different age groups.[5] Initial auditory responses in neonates appear in the 26th and 27th weeks of pregnancy.[6] progressively over time, these follow a “maturation pattern” in which interwave intervals and latencies decrease and the amplitudes of the BAEPs increase.[7]

In fullterm infants, the peripheral response, reflected in wave I, is reported to show no signs of maturation or development as a function of age. The central conduction time, reflected by the I–V interval, is reported to mature from 11 to 18 months up to 3–5 years of age. This maturation effect differs for preterm and term infants. Preterm infants have increased absolute latencies compared to term infants up to 2 years of age.[8] Below the age of 2 years, interpeak latencies are prolonged relative to adult values.[9] By the age of 2 years, the ranges for adults are reached, the absolute latencies of wave I, III and V increases by 0.1-0.2 msec with age. However, the I-V interpeak latency remains the same.[10] The reason for the age-related latency shift is progressive myelination of the auditory tract in infants.[11]

Auditory Brainstem Response is the most important tool in diagnosing hearing impairment in infants. Its threshold is important in establishing the degree of hearing loss & latencies for differentiation between type of hearing loss (conductive & cochlear). In infants, latencies are important to identify delayed auditory maturation & neural pathology, such as auditory neuropathy. ABR thresholds show a little age dependent effect whereas latencies are age dependent especially in young infants.[8] So the aim of our study was to assess the effect of maturation on BAEP wave latencies and amplitude from infants to children (1 month to 5 years) & adult (18- 25 years).

2. Material and Method:

Subjects taking part in this study were 40 full term infants; and children (1 month to 5 years) with normal hearing & neuropsychological development and 20 adults (18-25 Years). BAEP test procedure was explained and written consent was signed from the subjects (> 18 years) and from the parents of each subject who participated in the study. Detailed history and thorough clinical & ENT examination were carried out to rule out any medical problem. Specific history was also taken to rule out any prolonged exposure to noise. BAEP recording was done in a quiet air conditioned room (28 $\pm$ 1 ^{o}C). The recording surface electrodes filled with conductive paste were used and placed at vertex (Cz, 10-20 international electrode placement system) & both ear lobes (Ai and Ac). The ground electrode was placed on forehead (Fz). The recording was done using RMS EMG EP MARK II machine manufactured by RMS recorders and medicare system, Chandigarh. Monoaural auditory stimulus consisting of rarefaction clicks were delivered through an electrically shielded earphone at a rate of 11.1/sec. Clicks of intensity was 60 dB above the hearing threshold. Contralateral ear was masked with pure white noise 40 dB below that of BAEP stimulus. A band pass of 150-3000 Hz was used to filter out undesirable frequencies in the surrounding. Impedance of electrode was kept below 5 k ohms. Responses to 2000 click presentations were averaged for 10 msec. BAEP waves were identified & labelled. The peak latencies of waves I, II, III, IV & V were measured. The interpeak latencies I-III, I-V and III-V were computed. Amplitudes of waves were also measured from peak to following trough of the wave.

3. Observation and Result:

The mean and standard deviation of the absolute latency & interpeak latency in milliseconds are shown in table 1 and amplitude in table 2.

We found that the most reliable waves during the first month of life are waves I, III & V. The latencies of the BAEP components decreased with maturation. Wave V changed in latency from 6.82 msec at 1 month of age to 5.80 msec at 3 years. The auditory processes related to peripheral and central transmission (PT & CT) were shown to mature at differential rates during the first period of life. By the age of 3 years, in fact, wave I latency had reached the adult value; in contrast, wave V latency match that of the adult until approximately 5 year old.

The absolute latencies and interpeak latencies reached to adult equivalence between 18 months to 3 years. The III-V/I-III interpeak ratio suggests that after term the I–III interpek latency decreases more than the III–V IPL. I–III, III–V and I–V IPLs shortened from the 1 month to 5 year old group.

The amplitudes of all BAEP waves increased with age, the greatest changes occurring during early infancy. Adult values were reached at 6 months of age for wave I and 2 years for wave V. The two waves continued to increase above the adult values, until the highest amplitude value was reached at 3 years for wave I and 5 years for wave V. Subsequently, the amplitudes decreased towards the values in adults. The V/I amplitude ratio was slightly lower than the adult value shortly after birth, decreased during the first year of life and reached the minimum value between 1 and 4 years. Thereafter, it increased towards the adult value. Throughout the maturational stages the ratio was smaller than in adults.

4. Discussion:

The BAEP wave latencies and conduction time regularly change during the first two year of child's life due to myelination in auditory pathway. In calculating references values, the temporal characteristics of the main BAEP wave's I-V are assumed to reach definite values at the age of three years. At the same time, the BAEP wave amplitudes may gradually increases at an age of four or five years and then slightly decrease. The transition to adulthood entails changes such as an increase in latencies & IPL and decrease in the amplitudes of BAEP waves.[12]

The auditory function related to peripheral transmission and central transmission was shown to mature at different rates. PT reached the adult pattern around the age of 3 months; whereas CT matched that of adult until or soon after 1 year of age. In addition, the waveforms of ABR display an independent course for development. By 6 months of age, the adult configuration replaces the infantile response; so in our study the maturational stages of BAEP components from infants to adults are in accordance with the Tarantino V et al (1988), Jiang et al (1991), Jiang et al (1993) and Hung K L (1989).[11, 13,14,15]

The controversy is with Mochizuki Y et al (1982), who evaluated 200 BAEPs from 165 normal human subjects ranging from infants to young adults. He indicated that the peripheral auditory apparatus attains functional maturity during the first 2 months of life, whereas the central transmission time shortens up to the age of 5 to 8 years. III-II and V-IV interpeak latencies showed maturational changes similar to those of V-I IPLs, in contrast II-I and IV-III showed little changes. A clear increase of the amplitude of peak V up to 4 years of age and a subsequent decreasing tendency was observed.[16]

The majority of investigators agree that prior to the third month of life, absolute latency values for wave I do not alter significantly with increasing age, thereby suggesting that middle ear and auditory nerve transmission is very close to maturity in a term birth **(**Gafni et al, 1980; Paludetti et al, 1981; Hecox, 1982; Fria, 1984; Beiser et al, 1985; Zimmerman et al, 1987; Eggermont & Salamy, 1988; Gorga, et al, 1989; Jiang et al, 1991; Hurley et al, 2005). [17-25]

Absolute latency changes for waves III and V are much more pronounced than for wave I and continue to decrease post-term (Paludetti et al, 1981; Beiser et al, 1985; Zimmerman et al, 1987; Hurley et al, 2005**)**[18, 21, 22, 25] , until about the second year of life demonstrating a caudal-to-rostral, or peripheral-to-central, progression of auditory neurodevelopment (Hecox , 1982; Fria & Doyle, 1984; Eggermont & Salamy, 1988; Gorga et al., 1989; Jiang et al., 1991).[19, 20, 23, 24]

Interpeak intervals also show an age dependency, with longer latencies and greater intersubject variability in newborns compared to adults. (Hecox, 1982; Morgan, 1987).[19 & 26] Investigators speculate that this age dependency is due to less advanced myelination (which gives rise to lower conduction velocity) along the auditory pathway in newborns (Salamy & McKean, 1976).[27]

There is considerable variability among investigations regarding the developmental time course of interpeak latency values. Some studies have reported the I-III interval to be slower in maturation than the III-V.[13 & 19] Other investigations have reported the III-V interval to be slower in maturation than the I-III and I-V interval (Salamy, 1984; Schwartz et al, 1989). [28, 29] while still others have reported the III-V did not vary as a function of age.[20, 22] Although a variety of growth trends suggested for interpeak latency values, these trends demonstrate differential maturation of the structures along the neurophysiological pathway of the ABR.

Response amplitudes of ABR waves also exhibit independent age-related changes. In general, all ABR wave peaks showed an increase in amplitude as a function of age. Although adult configuration replaces the infant response by three to six months of age, amplitude peaks for ABR waves I and III were found to reach adult value by nine months of age, whereas amplitude peaks for ABR wave V were found to reach adult value by 2 to 3 years of age (Mochizuki et al, 1982; Eggermont & Salamy, 1988).[16,23] However, because amplitude measures are susceptible to substantial variability due to stimulus (e.g., intensity, rate and stimulus frequency) and extraneuronal influences (e.g., resistance-capacitive properties of the skull) their clinical usefulness is limited (Hecox & Burkard, 1982; Silman & Silverman, 1991; Schwartz et al, 1994).[19, 30,31]

In conclusion, differences in recording protocol notwithstanding, it is clear that there is a distinct maturation pattern for the ABR. Differential changes in ABR latency and amplitude reveal that auditory maturation involves both the peripheral and the central auditory structures. Overall, results of studies reveal that waveform morphology of an infant response reaches adult configuration between three and six month of age, whereas developmental changes in absolute and interpeak latency values gradually develop from peripheral to central, reaching adult values by approximately 18 months to two years of age.

It is estimated that the first one year of life is the critical period for the development of auditory function, both peripheral and central pathways. ABR is a reliable test to show the maturational changes of auditory and brainstem function.

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Table 1: Mean Latency & Interpeak Latency of BAEP in Infants to Adults

BAEP	1 Month	3 Month	18 M-2 Year	3 Year	5 Year	18- 25 Year
I	1.92 ± 0.15	1.90 ± 0.14	1.84 ± 0.16	1.74 ± 0.13	1.70 ± 0.21	1.73 ± 0.12
III	4.76 ± 0.22	4.65 ± 0.17	4.20 ± 0.26	3.97 ± 0.17	3.91 ± 0.15	3.92 ± 0.13
V	6.82 ± 0.21	6.64 ± 0.20	6.01 ± 0.25	5.80 ± 0.22	5.67 ± 0.18	5.65 ± 0.16
I-III	2.81 ± 0.16	2.75 ± 0.16	2.36 ± 0.18	2.24 ± 0.14	2.20 ± 0.14	2.22 ± 0.13
III-V	2.04 ± 0.21	1.98 ± 0.12	1.81 ± 0.15	1.80 ± 0.13	1.78 ± 0.14	1.82 ± 0.16
I-V	4.87 ± 0.22	4.82 ± 0.23	4.20 ± 0.23	4.15 ± 0.20	4.12 ± 0.24	4.16 ± 0.16

Table 2: Amplitudes of BAEP waves in Infants to Adults

BAEP	1 Month	3 Month	6 Month	Adult
I	0.18 ± 0.61	0.25 ± 0.10	0.19 ± 0.04	0.17 ± 0.12
III	0.09 ± 0.05	0.18 ± 0.09	0.21 ± 0.15	0.16 ± 0.10
V	0.19 ± 0.08	0.28 ± 0.19	0.37 ± 0.24	0.39 ± 0.19