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Experimental Research Article

Assessment of Defects in Peripheral and Central Transmission of Auditory Pathway Using Brainstem Auditory Evoked Potentials in Preterm Babies

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ABSTRACT

Introduction: Brainstem Auditory Evoked Potentials (BAEP) play a crucial role in pediatric audiology, particularly for evaluating auditory function in children when behavioral testing is not possible. It serves as a valuable tool for assessing the auditory pathways of the brainstem.

Methods: This study aims to compare latencies of wave I and wave III through Brainstem Auditory Evoked Potential (BAEP) in preterm babies (32 to 36 weeks) against age specific normal responses. The goal is to identify potential hearing impairment indicated by any increased BAEP latencies in wave I and wave III.

Results: The study involved 50 preterm newborns divided into three groups based on gestational age: Group A (32 weeks, n=12), Group B (34 weeks, n=18), and Group C (36 weeks, n=20). The infants underwent BAEP testing using the RMS EMG EP MARK-II machine at the Neurophysiology Unit of the Department of Physiology, Gandhi Medical College, Bhopal. Data interpretation involved comparing the obtained values to established normal values.

Conclusion: The study observed increased absolute peak latencies of wave I and III in preterm babies compared to normal term infants, suggesting defects in peripheral transmission and improper myelination of the BAEP pathway. When comparing between groups, significant differences were found in the absolute latencies of waves I and III in both ears between group 1 and groups 2 and 3. Additionally, significant differences were noted in the latency of waves I and III in the right ear between group 2 and group 3.

Keywords:
Brainstem Auditory Evoked Potential
Peripheral transmission
Improper myelination

Introduction

Early detection and rehabilitation of hearing loss are important for the speech and language development of hearing-impaired children (Maisels JM et al, 1994). BAEP serves as an effective and non-invasive means of assessing the functional status of the auditory nerve and brainstem auditory sensory pathway. Notably, BAEP remains relatively unaffected by the individual's con-

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sciousness, medication effects, and various environmental factors (Agrawal VK et al, 1998).

In older children, changes observed in BAEP are more indicative of irreversible brain damage. Early screening of hearing impairment aims to optimize communication, social, academic, and vocational outcomes for children with hearing loss, highlighting the importance of audiological habilitation (Bilgen H et al, 2000). The Joint Committee on Infant Hearing (JCIH) has identified specific risk factors for identifying infants at risk of hearing impairment, necessitating careful follow-up and assessment. These risk factors, according to the JCIH, include family history, prematurity, birth asphyxia, hyperbilirubinemia requiring intervention, in utero infections, craniofacial anomalies, birth weight below 1500g, ototoxic medications, and postnatal asphyxia. Multiple risk factors have been associated with congenital hearing loss (Joint Committee on Infant Hearing, 2007).

The prevalence of these risk factors is often seen in routine NICU care. Heightened awareness has led to earlier diagnosis and careful counseling. Treating hearing loss before six months of age significantly improves speech and language development during school years. Accurate diagnose of hearing loss requires age-appropriate normal values for Auditory Brain Response (ABR) measurements, posing a challenge due to the ongoing maturation of the auditory system during the perinatal period. Additionally, the course of hearing loss may evolve over time.

Brainstem evoked response audiometry (BERA) is an electro-physiological assessment that examines both peripheral and central auditory pathways. This diagnostic tool is particularly useful in newborn, preterm infants, those with low birth weight, or those with associated neurological conditions. It establishes a direct correlation between specific auditory waveforms and brain stem structures involved in their generation, aiding in identifying and addressing any underlying pathologies.

Wave I in ABR represents the compound auditory nerve action potential, primarily in the distal portion of cranial nerve (CN) VIII. This response is believed to originate from the afferent activity of CN VIII fibers (first-order neurons) as they leave the cochlea and enter the internal auditory canal. On the other hand, Wave III emerges from the activity of second-order neurons (beyond CN VIII), typically located in or near the cochlear nucleus. Wave III is generated in the caudal portion of the auditory pons (superior olivary nucleus). The generation of both wave I and wave III depends on the function of first order neurons (afferents to cranial nerve VIII) and second order neurons, reflecting central and peripheral transmission of the evoked auditory response.

The generation of wave V likely reflects activity of multiple anatomic auditory structures. It's the ABR component frequently examined in clinical settings. While the exact source of Wave V remains a subject of debate, it's generally thought to emanate from the region surrounding the inferior colliculus.

The present study was planned to establish a connection between the latencies of wave I and III and gestational age in preterm infants. Additionally, it aimed to evaluate any anomalies in central and peripheral transmission within the auditory pathway.

Material and Methods

The present study was conducted at the Neurophysiology Lab of the Department of Physiology, Gandhi Medical College, Bhopal, in collaboration with the Department of Pediatrics, Gandhi Medical College and Bhopal. The ethical committee of the institution (ref no. 10292-93/MC/2015) approved the study. Sample selection involved examining preterm infants hospitalized in NICU at Kamla Nehru Hospital, affiliated with Gandhi medical college, Bhopal. 50 preterm infants were included in the study, categorized into three groups- A, B, and C - based on their gestational age: 32 weeks (n=12), 34 weeks (n=20), and 36 weeks (n=18).

The criteria for inclusion were preterm infants with a gestational age less than 37 weeks, devoid of other risk factors causing hearing impairment, and whose parents provided consent for participation in the study.

Critically ill babies with a gestational age of 37 or more completed weeks and patients having risk factor/factors according to JCIH other than those specified in the inclusion criteria were excluded from the study. None of the babies included in the study were premature by weight. BAEP procedures were conducted in a precooled, quiet, and dimly lit room with the sedation of triclofos. A click stimulus was delivered to the ears via headphones, eliciting waveforms of impulses generated at the level of the VIII cranial nerve, brain stem, and cortex.

Electrode placement followed the guidelines of the International Federation of Clinical Neurophysiology

TABLE 1: Normal values of baep parameters in newborn (Engle WA et al, 2007)

Parameter		Normal value (Mean±SD)
Absolute peak latency (ms)	Wave I (ms)	1.58±0.13
	Wave III (ms)	4.35±0.19
	Wave V (ms)	6.76±0.25
Wave I-V Interpeak latency (ms)		5.18±0.26

(IFCN). A mono-aural montage, i.e. Cz-M1/M2, was used. The reference electrode (Cz) was placed at the forehead's hairline, the ground electrode at the nasion (Fpz/Fz), and the active or recording electrode at the mastoid (M1/M2). A single channel BAEP with a sensitivity of 0.2 μV/div, high and low cut filters set at 3000 Hz and 100 Hz respectively, and a sweep speed of 1 ms div was employed, averaging 2000 stimuli.

The auditory stimulator settings were as follows:

- Headphone Type: TDH-39
- Stimulus Type: Alternate click
- Frequency Range: 250-8000 Hz
- Intensity: 30dB to 90 dB nHL
- Presentation: Monoaural, left and right ear
- Click Duration: 100 μs square wave clicks with alternating polarity
- Envelops: Linear
- White noise: contralateral masking by 30 dB less than stimulus intensity
- Presentation Rate: 11.1 stimuli/ Sec

A monoaural auditory stimulus, ranging from 30 dB to 90 dB threshold, was delivered through electrically shielded earphones using rarefaction clicks of 100 microseconds at a rate of 11.1 stimuli per second. The contralateral ear was masked with noise 30dB less intense than the stimulus. The study recorded the hearing threshold, absolute latencies of Wave I, III, V, Wave I-V inter-peak latencies (IPL), and Inter-aural interpeak latency difference. Wave I originate from the peripheral portion of the VIII cranial nerve, adjacent to the cochlea, while Wave III originates from the superior olivary nucleus. Part of wave III is attributed to the medial nucleus of the trapezoid body. Wave I, reflecting peripheral transmission, matures faster compared to subsequent waveforms, which reflect central transmission.

Wave V, the most prominent peak appearing at around 5.5 ms after the stimulus, is believed to originate from the high pons or low midbrain. The maturation of these waves begins at birth and reaches the adult pattern by 2 years of age. Wave V reaches adult values by the age of 2 years, whereas wave I and III mature by 3 months of age.

The observed values were compared with normal term values, and the severity of hearing impairment was graded based on the WHO guidelines.

Statistical analysis involved expressing all values as Mean±Standard Deviation. Intergroup comparisons were performed using Student's t-test. The statistical analysis was conducted using SPSS 16.0 (Statistical Package for Social Sciences).

Result

In this study, a comprehensive ENT evaluation was conducted on all infants before administering brainstem evoked response audiometry (BERA) to rule out any ear-related pathologies. The investigation aimed to explore potential hearing impairment among preterm infants at a heightened risk of developing auditory deficits and subsequent complications.

A total of 86 infants underwent screening using the New Ballard score (Ballard JL, 1991), from which 50 preterm babies meeting the defined inclusion and exclusion criteria, and with parental consent, were enrolled in the study.

Progressive maturation was observed with advancing gestational age, evidenced by a decrease in absolute peak latencies of waves I and III across subsequent Groups A, B, and C. However, all three groups exhibited increased latencies in both waves compared to normal term values (Table 1), indicating potential delays in the maturation process.

Upon inter-group comparison, significant differences ($p<0.05$) were noted in the absolute latencies of waves I and III in both ears between Group A and Groups B and C. While no significant variance was found in the left ear latency of wave III between Groups B and C ($p>0.05$), notable differences were observed in the la-

TABLE 2: The absolute peak latency of wave I and wave III in the study group is presented as Mean±SD. It was observed that the latency of both wave I and III gradually decreased with an increased age of gestation. Initially, group A (32 weeks) displayed increased wave latency, which progressively decreased with advancing gestational age.

Parameter		Group A 32 week (n=12)		Group B 34 week (n=20)		Group C 36 week (n=18)	
Absolute peak latency (ms)	Normal values (ms)	Left	Right	Left	Right	Left	Right
Wave I (ms)	1.58±0.13	2.12±0.17	2.11±0.2	1.95±0.10	1.96±0.1	1.81±0.2	1.83±0.13
Wave III (ms)	4.35±0.19	5.15±0.21	5.18±0.13	4.88±0.18	4.92±0.18	4.85±0.1	4.81±0.1

TABLE 3: Intergroup comparison of absolute peak latencies in the study group: Significant differences in wave latency were observed among different gestational age groups (Group A – 32 weeks, Group B – 34 weeks, Group C – 36 weeks) upon comparison.

	Left ear (p value)		Right ear (p value)	
Intergroup comparison	Wave I	Wave III	Wave I	Wave III
A vs B	< 0.005	< 0.005	< 0.005	< 0.005
A vs C	< 0.005	< 0.005	< 0.005	< 0.005
B vs C	< 0.005	NS	< 0.005	< 0.005

P < 0.05 = Statistically significant, NS- not significant

tency of wave I and III in the right ear between these two groups (Table 3).

Conclusion and discussion

The study aimed to assess the presence of hearing impairment in preterm babies. Early diagnosis through screening can mitigate the handicaps resulting from a hearing deficit.

As an objective test BAEP was used to identify auditory impairment and to grade the severity.

The maturation process involves the development of the outer/middle ear, cochlea, axonal myelination, dendritic growth, and increased synaptic efficacy (Pasman JW et al (1996), Goldstein AD (1994), Eggermont et al (1988), Despland PA et al (1985), Salamy et al (1984), Shah et al (1978).

The peripheral portion of the auditory pathway undergoes complete morphological development within the first week of post-term life. Synaptogenesis occurs during the perinatal and postnatal periods, with a surge in dendritic growth following birth (Yakovlev PI 1967, Norman MG, 1975). Myelination initiates in the second half of gestation and continues up to the second postnatal year (Dobbing J et al 1973).

The study findings revealed extended absolute latencies and increased inter-peak latencies in preterm infants when compared to normal term values, thus supporting the hypothesis of delayed myelination in this population. Similar findings were reported by Venkatesh LT et al (2015), Roopkala et al (2011).

Previous studies have similarly noted heightened absolute peak latency and interpeak latency values in preterm infants compared to their term counterparts. These findings suggest an influence of the hearing system's maturation process on these parameters.

However, Jiang ZD et al (2008), found no differences in absolute peak latencies and IPL among premature neonates with gestational ages ranging from 33 to 36 weeks. Similar observation was reported by Kilic et al (2007).

Consistent findings from recent and past studies indicate a decrease in absolute peak latencies with increasing gestational age. This trend aligns with the rapid myelination of the auditory system observed between 30 and 34 weeks of conceptional age. Recognizing the influence of gestational age on auditory system maturity is crucial in interpreting BAEP results for diagnosing hearing impairments in preterm infants.

An inherent limitation of this study lies in the immaturity of BAEP waves at birth, particularly in preterm infants, leading to raised wave latencies compared to normal peak values. The ongoing maturation process extends up to 2 years of age. A longer-term follow-up of these infants until the age of 2 would have provided a more comprehensive assessment of auditory pathway transmission defects.

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