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RESEARCH ARTICLE

BRAINSTEM EVOKED AUDITORY RESPONSE IN PRETERM AND FULL-TERM INFANTS

Lakshmi T Venkatesh[1], Brid SV Shivagirao[2]

[1] Department of Physiology, Chamarajanagar Institute of Medical Sciences, Chamarajanagar, Karnataka, India
[2] Department of Physiology, S. Nijalingappa Medical College Bagalkot, Bagalkot, Karnataka, India

Correspondence
Lakshmi T Venkatesh
(jenydrlaks@gmail.com)

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Background: The survival of preterm infants has increased substantially over last few decades because of improvements in obstetric and neonatal care. However, the newborn experience many perinatal complications including peripheral or central hearing loss. The prevalence of hearing loss is reported to be 1.5–6 per 1000 newborn in the well-baby nursery population. Brainstem evoked response audiometry (BERA) is a simple, noninvasive way of evaluating the hearing function and has been widely used for early detection of hypoacusis and neural conduction irregularities in the auditory pathway. Several risk factors associated with hearing loss during early infancy, such as hereditary cause, in utero infection, prematurity, asphyxia, hyperbilirubinemia, and ototoxic medications, have been described by the Joint Committee on Infant Hearing.
Aims & Objective: To analyze and compare BERA responses in preterm and term infants.
Materials and Methods: The infants (30 preterm and 30 term) attending Pediatric OPD of Bapuji Hospital and Chigateri General Hospital satisfying the inclusion criteria were subjected to BERA. Parameters such as absolute latencies of waves I, III, and V, and interpeak latencies (IPLs) I–III, I–V, and III–V were assessed and analyzed by using unpaired *t*-test.
Results: Preterm babies had highly significant increased wave V threshold than controls. Waves III and V were delayed in preterm babies, IPLs of wave III–V were increased in the preterm group, and statistically significant increase was observed in IPL of wave I–V.
Conclusion: This study indicates that preterm infants have prolonged latency of wave V, which reflects immaturity of the auditory system. Therefore, it is essential to screen all preterm infants at the earliest to prevent adverse effect on the developing auditory pathway.

INTRODUCTION

Auditory evoked responses are electrophysiologic recordings of responses from within the auditory system that are activated by sounds. The evoked transient responses can be recorded up to 500 ms from time of onset of the sound stimulus. The evoked potentials of the first 10 ms, that is, short latency response, is commonly known as brainstem evoked response audiometry (BERA).[1] Auditory brainstem response (ABR) is generated using 100 μs rectangular pulse or clicks, and recorded with surface electrodes placed on the forehead and mastoid or ear lobes. Recording consists of a series of vertex positive peaks traditionally labeled with Roman numerals I to V. Primary application of ABR is as a tool for estimating audiometric thresholds, assessing integrity of auditory pathway till the level of brainstem, screening of newborn hearing, and monitoring eighth nerve and auditory brainstem function during certain neurotologic operations.[2]

As per the WHO report, there are about 250 million people with hearing impairment in the world and is the second most common cause of disability. The WHO estimates that every year 38,000 children with hearing impairment are born in Southeast Asia. India has 6.3% prevalence rate of moderate to severe hearing impairment.[3]

Hearing impairment has a devastating, detrimental, and invariably adverse effect on the development of children. The Joint Committee on Infant Hearing[4] promulgated a list of specific risk factors to identify infants at risk for hearing impairment so that careful follow-up and assessment can be done. Later the consensus recommended screening of all newborns. Most of the neonatal facilities in the United States and European Union have enforced mandatory screening of all newborns. In a developing country like India,

newborn hearing screening is yet to be implemented. Prevalence and incidence rates of hearing loss in India are quiet alarming. Studies show varying prevalence rates from 1% to as high as 40%.[5] BAEP recording is more difficult in children than that in adults, but it provides valuable clinical information. BAEP response in children is smaller and background electrical noise from the ECG and scalp muscles is often higher compared to adults. Recording during sleep can reduce these artifacts. Because ABR is not affected by sedation, infants can be sedated to avoid problems related to muscle activity. BAEP response of infants is slower than that of adults, therefore the recording sweep should be slower with low-frequency filter at 20–30 Hz. Clicks presented preferably rarefaction clicks. In newborns, BAEP can be recorded with stimulus intensity as low as 30 dB. The lowest click intensity at which the BAEP potentials are apparent is considered as BAEP threshold.

Preterm is defined as birth on or before the end of the last day of the 37th completed week (i.e., 36 6/7 weeks' gestation) after the onset of the mother's last menstrual period, which equates to 259 days in common medical terminology.[6] Advances in perinatal and neonatal medicine in the past two decades have resulted in improved survival rates of premature and very-low-birth-weight (VLBW) infants. Survival with good health into childhood and beyond is the true measure of success of perinatal care. The vast literature reporting the outcome of preterm babies can be a minefield for the unwary reader. The results of outcome studies show a huge variation, and there has been little improvement in the methodology over time. Severe neurodevelopmental disability remains the worst adverse long-term outcome associated with prematurity. The types of neurological disability seen among preterm survivors include spastic diplegia, spastic hemiplegia, and quadriplegia with or without intellectual impairments. Other problems include blindness, deafness, and severe epilepsy. Minor motor problems, specific learning disorders, and attention deficits are commonly recognized among school-age survivors.[7]

The major neonatal complications that affect later development remain preterm brain injury (intraventricular hemorrhage or periventricular leukomalacia), chronic lung disease, necrotizing enterocolitis, and sepsis. Preterm and low-birth-weight infants are more susceptible to hypoxic-ischemic brain injury and bilirubin brain toxicity.[8] Deafness afflicts fewer children but is still a problem in about 1–2%. Early diagnosis by screening can help limit the handicap resulting from deafness.[7] The purpose of this study was to compare BERA in preterm and term infants.

MATERIALS AND METHODS

In this study, 30 preterm infants and 30 age-matched controls (term infants) were selected from Bapuji Hospital and Chigateri General Hospital, attached to J.J.M. Medical College, Davangere, Karnataka, India. Controls were selected randomly from the immunization center and pediatric OPD. Babies less than 1 year old, babies less than 37 weeks gestational age, and normal age-matched term babies with birth weight >2500 g were included in the study. Babies with severe multiple anomalies, incompatible with life, atresia or stenosis of external ear canal, untreated otitis externa, and more than 1 year of age were excluded from the study. Written informed consent was taken from the parents after explaining them the procedure and its significance in their vernacular language. Detailed information regarding medical history was obtained and thorough ENT examination was carried out before the procedure. The infants were subjected to BERA testing on RMS EMG EP MARK-II machine (RMS Recorders & Medicare Systems, Chandigarh, India). The infants were sedated with syrup triclofos (Pedicloryl) 20 mg/kg body weight. Before the placement of electrodes, the skin was cleaned with abrasive strip. Recording of BERA was carried out in a quiet and semidarkened room. Surface electrodes were placed at the vertex (C_Z), both mastoids (Ai and Ac), and forehead (ground). The resistance was kept below 5 K. Monoaural auditory stimulus comprising rarefaction clicks of 100 ms was delivered through electrically shielded earphones at the rate of 11.1 per second. Contralateral ear was masked with pure white noise of 40 dB. A band pass of 150–3000 Hz was used to filter out undesirable frequencies in the surroundings. Responses to 2000 click presentations were averaged. BERA threshold for each ear with absolute latencies of waves I, III, and V, and interpeak latencies (IPL) of waves I–III, I–V, and III–V were considered from the recording for comparison among high-risk infants and controls.

Statistical Analysis: The results were expressed as mean and standard deviation. Unpaired *t*-test was used for intergroup comparisons, and *p*-value of ≤ 0.05 was considered to be statistically significant.

RESULTS

Of 30 preterm babies, no response was obtained from

4 babies. Mean wave V threshold for 26 preterm babies was at 49.94 ± 21 dB, which was highly statistically significant when compared to controls (i.e., 30 dB) (Figure 1).

Absolute latencies of waves III and V were delayed in preterm babies; the delay being statistically significant in wave V. IPLs of III–V were increased in preterm group, and statistically significant increase was seen in IPLs of I–V ($p < 0.05$) (Figure 2 & Table 1).

Table 1: Comparison of BERA parameters in preterm and normal term infants

	Term (*N* = 30)		Preterm (*N* = 26)		Preterm vs. Term	
	Mean	**SD**	**Mean**	**SD**	***t*-value**	***P*-value**
V (dB) Threshold	30	0	49.94	21	–5.15	<0.001**
I	1.68	0.2	1.69	0.23	–0.37	0.71
III	4.24	0.26	4.42	0.56	–1.48	0.14
V	6.33	0.35	6.69	0.79	–2.26	<0.05*
I–III	2.56	0.27	2.68	0.52	–1.1	0.27
I–V	4.66	0.35	5.01	0.78	–2.15	<0.05*
III–V	2.1	0.33	2.28	0.55	–1.51	0.14

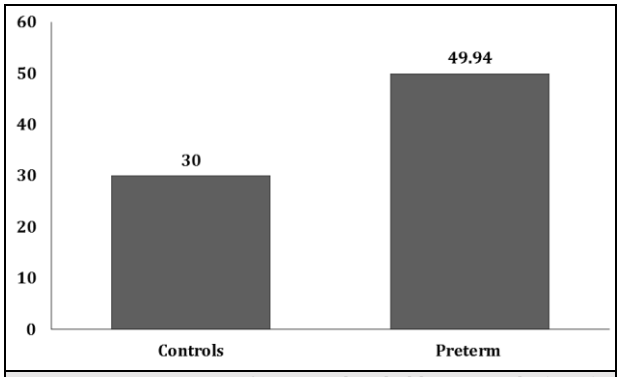

Figure 1: Comparison of wave V threshold in controls (term) and preterm infants

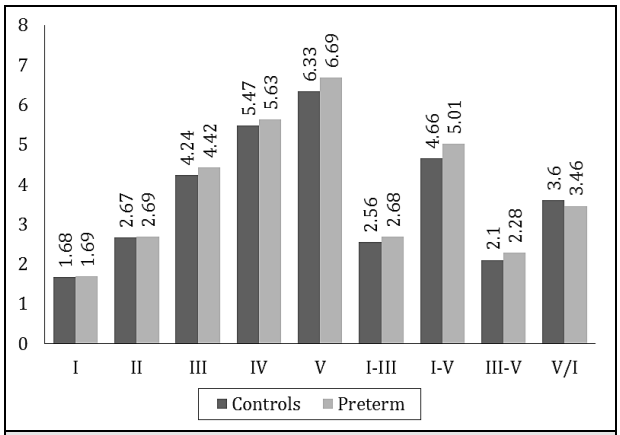

Figure 2: Comparison of BERA parameters between controls and preterm infants

DISCUSSION

Preterm babies had prolonged absolute latency of wave V (6.69 ± 0.79 ms) and IPL of I–V (2.28 ± 0.55 ms) compared to normal term babies. These observations reflect a delayed maturation of central auditory pathway and support the earlier findings[9,10] that brainstem auditory evoked potential waveform latencies are delayed in preterm infants due to prematurity itself.

Increase in absolute latency observed in premature infants compared with that in term infants may be related to delay in electrical conduction through the process of myelination of the structures of the auditory pathway to the brainstem that is still under development, suggesting that the degree of myelination and immaturity of nerve fibers of auditory pathways affect the latencies of waves. Similar findings were observed by Roopkala et al.[11], Jiang et al.[12], and Pasman et al.[13]. In the study by Casali and Santos[14], absolute latencies of waves I, III, and V of preterm infants were also prolonged. However, in the study by Kilic et al.[15], there was no difference in absolute latencies and interpeak latencies between term and preterm babies. In the study by Marlow et al.[16], preterm infants with sensorineural hearing loss had longer periods of intubation, ventilation, oxygen treatment, and acidosis, and more frequent treatment with dopamine or furosemide. According to the review by Cristobal and Oghalai[17], VLBW may not have a severe impact on hearing and is commonly associated with multiple other risk factors that may experience increase risk of progressive or delayed onset hearing loss.

Interpeak intervals in relation to the delay in central conduction time compared to adult population may also be related to changes in neural conduction velocity associated with myelination and/or changes in synaptic efficiency of various nuclei of auditory pathway. Prolonged I–V IPL is in accordance with other studies.[12–14] However, the values of interpeak intervals become smaller as the routes get longer because they continue to specialize in their function after birth, increasing the speed of a driving rhythm that exactly compensates for the physical growth of auditory pathway.

There is an inverse correlation between gestational age and absolute latencies with increasing gestational age, and hence the maturation of central auditory system to the level of the brainstem is a continuous decrease of absolute latencies of all the waves in term and preterm infants. This decrease is related to the progressive myelination of central nervous system structure, increase in axonal diameter, the improvement in synchrony of neural activity, establishment of effective structural connections, and increased functionality of the synapses. Studies report a systematic decrease in latency as a function of

increasing age.[9] We could not see similar findings as sequential study of preterm babies was not done. It is also possible, however, that auditory sequelae are more frequently associated with increased survival of preterm births exposed to multiple potentially ototoxic factors.

CONCLUSION

Considering preterm as the risk factor, significant delay was seen in absolute latency of wave V and IPL of III–V. In addition, the threshold of hearing was increased in preterm with respect to control term babies, all of these reflect the immaturity of auditory pathway. We believe that a larger sample and the follow-up of these infants at risk by means of the study of BERA potentials offer valuable information on the state of maturation of the acoustic pathways achieved by these children.

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