ISSN Print: 2664-7591
ISSN Online: 2664-7605
Impact Factor: RJIF 5.2
IJAN 2023; 5(2): 90-93
www.pharmaceuticaljournal.in
Received: 15-05-2023
Accepted: 21-06-2023

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Maturation time course for brainstem auditory evoked potential in preterm and full term infants

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DOI: https://doi.org/10.33545/26647591.2023.v5.i2b.66

Abstract

Background: Auditory system neurological maturity is a two-phase process. The first phase is intrauterine and is over by the sixth month of gestation; at this point the peripheral auditory pathways are mature. The second phase starts after birth and ends at about 18 months of life; at this point the auditory pathways along the central nervous system up to the brainstem reach maturity.

Objective: The aim of this study was to evaluate hearing in preterm infants and to study the neurologic maturation and integrity of the auditory pathway by comparing the latencies of the waveforms with that of the full-term infants.

Material and Methods: In the present study the recording was done using RMS EMG EP MARK II machine manufactured by RMS recorders and medicare system, Chandigarh.

Statistical Analysis: The data obtained was analyzed by using mean ± standard deviation and student's t test.

Results: There were no significant differences for latencies and interpeak latencies between term and preterm infants. (p>0.05)

Conclusion: There was no significant relation between BAEP variables in preterm and full-term infants, suggesting that gestational age do not affect the brain stem evoked potential.

Keywords: Preterm infants, term infants, Brainstem auditory evoked potential, latencies, interpeak latencies

Introduction

Brainstem auditory evoked potential (BAEP) used in neonatology to evaluate normal physiological maturation and integrity of the auditory system, to diagnose brain damage and to provide a prognosis for the outcome. (Rotteveel JJ *et al* 1987; Cox C *et al* 1992; Kohelet D *et al* 2000) [1-3]. The first behavioural response of the foetus to a sound stimulus at a high intensity level of >110 dB and with a low frequency of 250–500 Hz observed at around the 20^{th} gestational week, the required intensity level gradually decreasing and the frequency band broadening towards term age (Hepper PG & Shahidullah BS 1994) [4].

Electrophysiological studies for the auditory system demonstrated that the maturation of the structures occurs from the periphery to the core, without following a hierarchical pattern. In the first month of life, (a period of greater neuronal plasticity), important changes are observed in the absolute latency and inter-peak intervals of BAEP which occur up to the completion of the maturational process around 18 months of life in full-term newborns, when the response is similar to that of adults. (Raquel Beltrao Almorim 2009) [24].

The brainstem auditory evoked potential consists of registering the electrical activity in the auditory system from the inner ear to the brainstem by presenting an acoustic stimulus. Auditory system neurological maturity is a two-phase process. The first phase is intrauterine and is over by the sixth month of gestation; at this point the peripheral auditory pathways are mature. The second phase starts after birth and ends at about 18 months of life; at this point the auditory pathways along the central nervous system up to the brainstem reach maturity. (Raquel Leme Casali 2010) [6]. The BAEP responses in neonates and nursing infants are affected by the maturity of the auditory system. The effect of maturity is even more evident in premature infants thus the response pattern in these children differs from those in term neonates. (Sleifer P 2007, Starr A 1977, Eldredge L 1996) [7, 23, 19].

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Since maturation of ABR amplitude and latency are dependent on innate as well as environmental factors and the health of the infant, it is conceivable that prematurely born infants show a different maturation profile from that of full term infants (JJ Eggermont, 1988; maturational Tc) [8]. Hence, in present study BAEP recording is done to evaluate hearing in preterm infants and to study the neurologic maturation and integrity of the auditory pathway by comparing the latencies of the waveforms with that of the full-term infants.

Method

Our study included 60 subjects (30 preterm and 30 full term infants). The preterm infants were those born before 37 weeks of gestation and were referred from the pediatric department for assessment of auditory functioning. The full-term infants were recruited from among those attending the Paediatric department for routine immunization and from the general population. Infants with a history of craniofacial anomalies, chromosomal disorders, TORCH (toxoplasmosis, other infections, rubella, cytomegalovirus infection, and herpes simplex) infection at birth, birth trauma, metabolic disorders or intracranial infections were excluded from the study. All the infants underwent audiologist evaluations to exclude altered hearing. Informed consent was obtained from the parents of all infants. Term newborn infants underwent the BAEP recording session between 48 hours to 7 days of age. In the preterm group, BAEP was performed at a mean postconceptional (gestational age + age after birth).

Procedure

BAEP recording was done in a quiet air conditioned & darkened room, after feeding and majority of the infants received sedation with phenargan orally (0.5 mg/kg bodyweight). The recording silver cup electrodes filled with conductive paste were used and placed at vertex (Cz, 10-20 international electrode placement system) and the reference electrodes on the right (M1) and left (M2) mastoids. 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. At all recording sites, electrode impedance was kept below 5W. The click stimulation used in the BAEP was 80 dB. Broad band clicks are the only stimuli for infants and the click intensity should be calibrated relative to normal hearing thresholds in the laboratories. The repetition rate of the stimulus was at a rate of 10/sec. A total of 2000 evoked responses were recorded and averaged for two trials each (to assess reproducibility) from the right and left ear. The earphone is to be held above the ear, because the weight of the earphone can collapse the ear canal in preterm infants. Broadband pass filters at 10 to 2500 Hz, restrictive filtering of 100- 3000 Hz. Generation of five electrical waves within the first 10 ms of click stimulation was obtained. The stimuli were delivered first to the right ear and then to the left ear. I, III, V peak latencies and I-III, III-V, I-V interpeak latencies were measured. The peak latencies and interpeak latencies obtained for the left and right ears were averaged to represent each case by one value in statistical analysis. The type of delivery, head circumference, and body weight on I, III, V peak latencies and I-III, III-V, I-V interpeak latencies were evaluated.

Statistical Analysis

The mean and SD of each BAEP variable at each stimulus were compared between preterm & term infants using student's t test with Statistical Package for Social Sciences (SPSS 17.0 and graph pad prism5.0). The correlation between BAER variables and head circumference and birth weight was also analyzed. Statistical significance was considered at $p<0.05$.

Results

This study included 60 infants that were allocated into two groups according to the gestational age. The preterm group (gestational age < 37 weeks) consisted of 30 infants (14 male and 16 female). The term group (gestational age from 37 to 41 weeks) consisted of 30 infants (18 male and 12 female).

Clinical data of term and preterm infants are presented in Table 1. There were no differences in terms of gender, type of delivery, postconceptional age at the time of BAEP records between the two groups ($p>0.05$). The head circumference and weight at the time of BAEP testing were also not different between two groups ($p>0.05$). Apgar scores were lower in the preterm group ($p<0.05$).

There were no significant differences for latencies and interpeak latencies between term and preterm infants. ($p>0.05$) (Table 2). There was no statistically significant difference between right and left ears of all infants for either the absolute latencies (wave I, wave III & wave V) or the interpeak latencies (I-III, III-V and I-V) (Table 3). No statistically significant difference was found for comparing absolute and interpeak latencies in males and females ($p>0.05$) (table 4). There were no correlations between BAEP parameters and head circumference and body weight at the time of BAEP testing in preterm infants.

Table 1: Clinical data of Term and Preterm Infants (mean±SD)

Clinical Data	Term Group (n:30)	Preterm Group (n:30)
Sex (male/female)	18/12	14/16
Gestational age (week)	38.9 ± 0.6*	33.6 ± 3.1*
Caesarean/spontaneous birth	16/14	19/11
Birth weight (g)	3380 ± 381*	1940 ± 665*
Weight (g) at the time of BAEP recording	3368 ± 4.02	3142 ± 801
Head circumference (cm) at the time of BAEP recording	34.7± 0.6	34.5± 1.9
Apgar score at 1 minute (min-max)	8.7± 0.9*	6.5 ±3.4*
Apgar score at 5 minute (min-max)	9.7± 0.6*	8.3 ±1.7*

Table 2: Absolute wave latency & Interpeak latency of Term & Preterm Infants (mean± SD)

BAEP Parameters	Term Infants (n:30)	Preterm Infants (n:30)
I	1.94 ± 0.57	1.93 ± 0.47
III	4.46 ± 0.61	4.45 ± 0.69
V	7.16 ± 0.76	7.85 ± 0.37
I-III	2.43 ± 0.56	2.48 ± 0.54
III-V	2.51 ± 0.43	2.71 ± 0.42
I-V	4.89 ± 0.72	5.21 ± 0.65

Table 3: Comparison of absolute & interpeak latencies between right & left ears of infants (mean ± SD in ms)

BAEP Parameters	RT Ear	Left Ear	P value
I	1.64 ± 0.35	1.60 ± 0.34	0.27
III	4.08 ± 0.29	4.15 ± 0.27	0.19
V	6.25 ± 0.45	6.30 ± 0.39	0.10
I-III	2.67 ± 0.38	2.70 ± 0.41	0.09
III-V	2.23 ± 0.36	2.20 ± 0.35	0.48
I-V	4.65 ± 0.40	4.72 ± 0.47	0.08

Table 4: Comparison of absolute & interpeak latency between male & female of term and pre term infants (mean ± SD in ms)

BAEP Parameters	Term Infants			Preterm Infants		
	Male	Female	P value	Male	Female	P value
I	1.58±0.31	1.60±0.26	0.770	1.71±0.35	1.68±0.35	0.720
III	4.11±0.33	4.05±0.29	0.301	4.20±0.30	4.16±0.27	0.222
V	6.29±0.38	6.18±0.40	0.186	6.51±0.29	6.45±0.48	0.085
I-III	2.45±0.43	2.44±0.33	0.665	2.47±0.37	2.41±0.36	0.195
III-V	2.30±0.48	2.24±0.29	0.154	2.35±0.34	2.28±0.35	0.364
I-V	4.60±0.42	4.65±0.39	0.662	4.81±0.45	4.72±0.43	0.221

(P value <0.05, significant)

Discussion

A recognisable BAEP can be recorded in preterm infants of 28-32 weeks gestational age (Schulman-Galambos C 1975) [9], consisting of a series of three major waves (I, III, and V). The neural generators for Waves I and III in humans are the auditory nerve and cochlear nucleus, respectively. The generator for Wave V is the termination of the fiber tract of the lateral lemniscus (Moller AR 1982) [10]. The absolute latencies of BAEP waves and their inter-peak latencies progressively decrease over the course of neurological development (Amin SB 1999) [11]. The BAEPs undergoes rapid changes and development in the first 4 days of life in a full-term infant (Yamasaki M 1991) [12].

We did not find any statistically significant difference of BAEP parameters (Absolute wave latency and interpeak latency) between preterm and term infants, this is in accordance with Ilknur Kilic *et al* 2007 [13], Jiang ZD 2008 [14], Raquel Beltrao Almorim *et al* 2009 [24], Porto MA *et al* 2011 [15], Eggermont JJ & salamy 1988 [8] though it is not consistent with other Studies (Chiang MC 2001, Sleifer P, 2007, Raquel Leme Casali *et al* 2010, Roopkala *et al* 2011) [16, 7, 6, 17] reported that, maturation of the auditory system as measured by ABR, occurs differently between premature and full-term children, suggesting that gestational age be taken into consideration when using ABR in premature children younger than 20 months old.

A comparison of wave I, III and V absolute and interpeak latencies in our study revealed no statistically significant gender differences. These findings concur with (Sleifer P 2007, Fichino SN 2007, Raquel Leme Casali 2010) [7, 18, 6] but contradicted by (Eldredge L 1996, Esteves MCBN 2009, Lourenço EA 2008) [19, 20, 21] due to faster cochlear responses in female, which may underlie earlier brainstem responses.

In the present study, there was no statistically significant difference between the right & left ears for the absolute latencies and interpeak latencies, which indicates that the maturational process occurs in a similar manner in preterm as well as full term infants. Similar finding is reported by Guilhoto LMFF 2003 [22], Fichino SN 2007 [18], Sleifer P 2007 [7], Raquel Beltrao Almorim *et al* 2009 [24], Roopkala *et al* 2011 [17].

The reduction in head size implies shortening of intracerebral distances and thus shortening of transmission distances along the auditory pathways. The reduction in distance led to a reduction in the latencies for wave III and V (Ilknur Kilic *et al* 2007) [13]. In our study the head circumference at the time of BAEP testing was not different between the preterm & term groups and no correlation was found between head circumference and BAEP parameters.

Conclusion

There was no significant relation between BAEP variables in preterm and full-term infants, suggesting that gestational age do not affect the brain stem evoked potential.

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