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Mapping Auditory Maturation from Neonates to Toddlers using Electrophysiological Responses of the Brainstem

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Abstract

age is an important parameter infuencing it. From infants to toddlers, there is a temporal arborisation of the auditory

healthy infants and toddlers, by analyzing the changes observed in BERA with regards to age, as an objective refection

: Auditory pathway; Brainstem evoked response audiometry; Auditory synchrony; Neural plasticity; Neural reorganization

Hearing is the rst special sense which develops in-utero and begins to mature from the time of birth until about 3 years of age, which is deemed as the critical age for auditory maturation. Presence of a robust auditory network in response to complex noise exposure helps the sensory brain to develop normal speech and language skills.

Brainstem Evoked Response Audiometry (BERA) is a popular electrophysiological test with a series of ve wave peaks arising from auditory nerve and brainstem structures. Normal responses arise in the rst 10 milliseconds (ms) of the onset of a moderate-intensity click stimulus in otologically, audiologically and neurologically sound individuals [1]. is structural integrity and synchronous ring of auditory pathway from the spiral ganglia in the cochlear modiolus, onto the lateral lemniscus in the brainstem is evaluated by BERA. On interval of the same wave between the two ears is known as 'inter- aural latency'. In a healthy adult, for a stimulus at 75 dB Sound Pressure

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study was to analyze the changes in BERA wave latencies, amplitudes and morphology in two groups of healthy young children: group I consisted of neonates (from birth to 7 days) and group II consisted of infants and children from 6 months to 3 years of age. e objectives of the study were to compile normative data of BERA in these two groups; to correlate the changes observed in BERA waves between these two groups with the maturation of auditory pathway, and; to estimate the e ciency of BERA as an objective tool to evaluate auditory maturation.

e inclusion criteriae were: neonates from birth till 7 days of life and children from 6 months to 3 years of age; voluntary informed consent from parents of the child for the study; normal otological examination ndings; 'Pass' result by DPOAE (Distortion Product Oto-Acoustic Emission); children born of full term (more than 37 weeks of gestation) institutional deliveries, and; normal hearing of the child as stated by the mother. e exclusion Criteriae were: children with any external and middle ear diseases; cranio-facial anomalies; neurological de cits; family history of congenital deafness; history of maternal illness like gestational diabetes mellitus (GDM), pregnancy induced hypertension (PIH) or TORCH (Toxoplasmosis, Rubella, Cytomegalovirus and Herpes) infections during pregnancy; history of peri-natal complications like birth asphyxia, prolonged labour and meconium aspiration; post-natal insults like Neonatal Intensive Care Unit (NICU) admissions, administration of ototoxic medications, hyperbilirubinaemia, febrile illnesses which necessitated hospital admission, and; 'Refer' result in DPOAE test.

A er getting ethical clearance from the institutional ethical committee in June 2016, assessment and selection of neonates for group I was done from the post-natal wards of the hospital. Infants and children falling into group II were selected from paediatric immunization clinic. Informed consent was obtained from the parents of the children for clinical examination, OAE screening, BERA study as well as for the administration of appropriate dose of oral sedative before BERA test. All the participants were clinically evaluated to rule out any external or middle ear pathology as well as any craniofacial anomalies. All children were tested using OAE screener and only those with 'pass' results were selected for BERA study. e equipment used for OAE screening was OtoRead, manufactured by Interacoustics, Denmark. As per the power calculation done for the study, a minimum of 30 sample size was required in each group to elicit a statistical signi cant di erence. In this study, we had 37 neonates in group I and 31 children in group II (Figure 1).

e BERA test was done when the child was sleeping either naturally or a er administration of sedative. e sedative was used only if the child did not go to natural sleep a er being fed by the mother and waited for 2- 3 hours. e sedative used was Syrup Triclofos Sodium at a dose of 50 mg/kg body weight. e equipment used for BERA testing in this study was Brainstem Auditory Evoked Response equipment – ABR System EP15/EP25 manufactured by Interacoustics, Denmark. Both OAE and BERA testing were done for all participants by the same quali ed audiologist blinded to the study, in a sound treated, air conditioned room with ambient room temperature (28 ± 1 ºC) and lighting (Figure 2).

If an appropriate tracing was not obtained, the child was subjected to the test again on a di erent day. Impedance electrode was kept below 5 K Ohms. e sound stimuli presented to the ear by insert ear phones were, clicks of 40 dB HL of negative polarity at a rate of 20.1/second, 2000 stimuli in total, in a frequency range of 300 – 3000 Hz (Hertz), with 15 ms analysis window. e following electrophysiological data from the BERA wave recordings were measured and analyzed;

Absolute latencies of waves I, III and V of both sides in ms

Inter- wave / inter- peak latencies (IPL) of wave I to III, III to V & I to V in ms

Inter-aural latency di erence of wave V

Amplitude evaluation of waves I & V of R and L in micro volts (µV), & the inter-aural wave V amplitude di erence (VR- VL)

Ratio of wave V to wave I (V/I) on both sides, & the inter-aural V/I ratio di erence (V/I R- V/I L)

Wave morphology patterns based on 3 recognizable peaks - Good versus Poor (Figure 3).

Example of BERA tracing obtained in each group is given in Figure 3. All the measurements of latencies, amplitudes and morphology were interpreted from the BERA graph, by the same blinded audiologist. Morphology of the BERA tracing was assessed by evaluating the number of waves among I to V appeared in each recording. Good morphology was de ned as presence of waves I, III and V. Poor morphology had less than three recognisable waves at 40 dB at the same auditory threshold. e data was collected on master chart, cross checking and data cleaning was done. Data analysis was performed using Microso excel and the so ware MINITAB-1513.

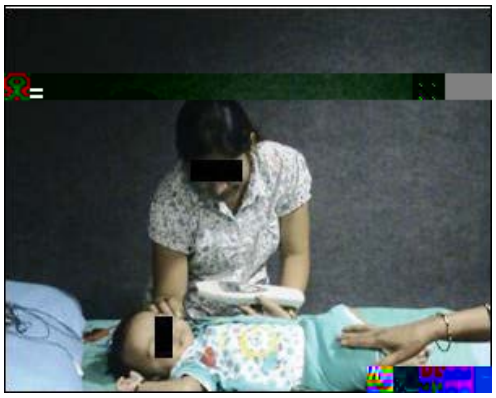

Figure 1:

Figure 2:

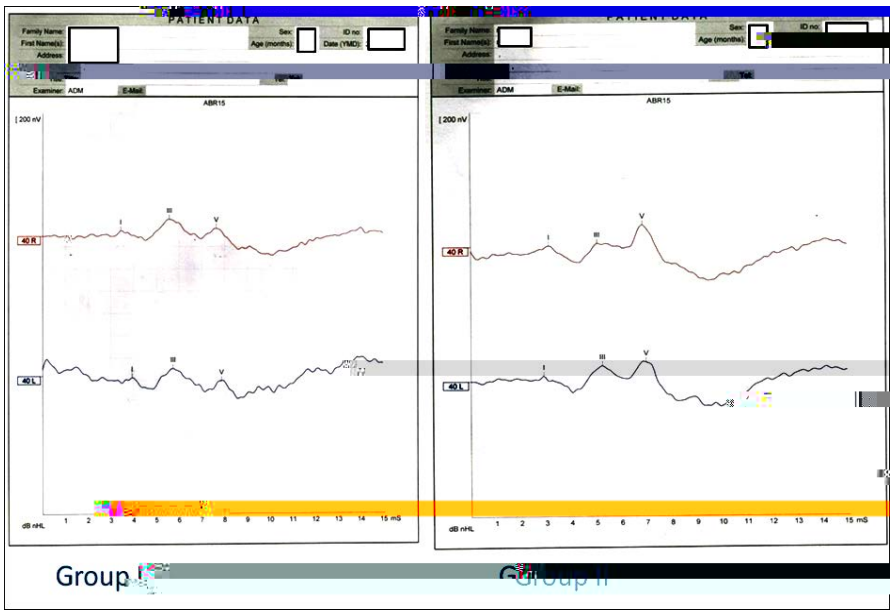

Figure 3:

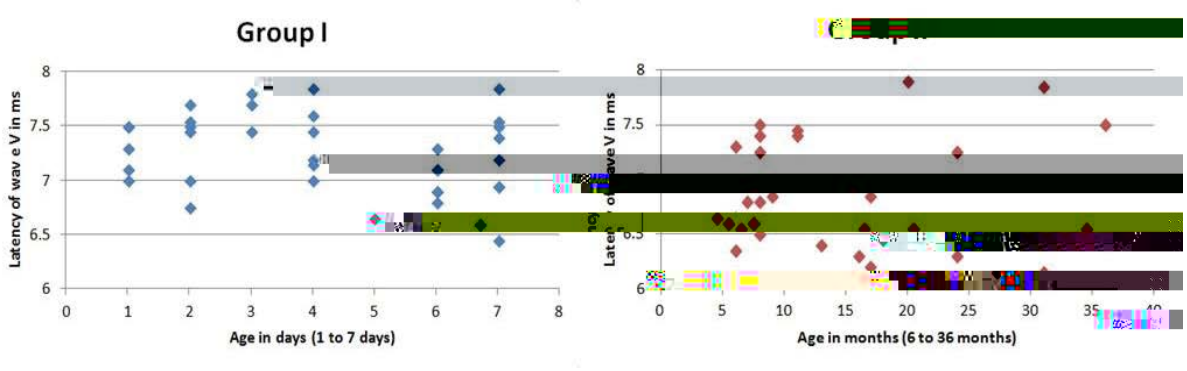

Figure 4:

For statistical analysis of descriptive values, appropriate comparisons were made using paired t- test. Wherever the di erences between the characters forming a pair was calculated in the rst instance, one sample t- test was applied. For inter-group comparisons of amplitude and latency, Analysis of Variance (ANOVA) using General Linear Model (GLM) was used. Fisher exact test for proportions of error means, was used for the summative wave response analysis. For all tests, a P value < 0.05 implied a statistically signi cant di erence.

In group I, there were 21 females with a mean age of 4.38 days and 16 males with 4.25 days, forming an average age of 4.32 days for the group. In group II, 12 females had a mean age of 15.83 months and 19 males had 14.74 months, with the mean age for the group of 15.16 months. Analysis of wave-wise amplitude distribution between the groups is shown in (Table 1).

In both right and le ears of group I & II, the V/I ratios were more than 1, with a higher V/I ratio in group II, which indicated a higher amplitude for wave V in both groups and more maturation of the wave morphology in group II. Intra-group analysis of amplitudes of waves I, V and the V/I ratio di erence between the ears, in both groups is shown in Table-2 along with their 95% CI and p-values (Table 2).

Inter-group comparison of wave amplitudes between the ears is given in table 3 (statistically signi cant values are indicated in bold and su xed with an asterix) (table 3).

Table 4 provides the descriptive statistics for analysis of wave latencies generated in both groups (Table 4).

Intra-group comparisons of wave latencies between the ears along with their 95%CI and p-values are shown in (Table 5).

In both the groups, there was no statistically signi cant di erence between the R and L ears for wave latencies. ANOVA based Fisher Exact test was used for inter-aural and inter-group analysis of wave latencies. ese results are summarized in Table-6 (statistically signi cant values are indicated in bold and su xed with an asterix) (Table 6).

With respect to the di erences in mean latency between group I and group II, for all waves, group II had shorter latency values than group I

Table 5:

(I=wave-1, V=wave-5, Lat=Latency, R=Right, L=Left, Diff=Difference) . W. (A

References