Using Bera To Detect Persistence of Auditory Injury In High Risk Infants

Suranjana Sur Mukherjee¹*, M. V. Sawane² and P. A. Nikose

¹Department of Physiology, Nil Ratan Sircar Medical College, Kolkata, West Bengal.
²NKP Salve Institute of Medical Sciences & Research Center, Nagpur
³Department of Physiology, Jawaharlal Nehru Medical College, Sawangi, Wardha

Abstract

Objective: This cross-sectional comparative study tried to assess the hearing status of the high risk infants by Brainstem Evoked Response Audiometry (BERA) and compare with that of the normal infants.

Material & Methods: BERA was done on 127 infants of 6 to 18 months age of which 87 were high risk. All were given monaural acoustic stimulation using Cz-M₁/M₂ Montage. Waves I, III and V were analysed for absolute & interpeak latencies (in ms) & also for amplitudes (in µv) & their ratio. All the parameters were compared at 70 dB stimulus at p<0.05 significance. Results were analysed by Statistical Package for Social Sciences (SPSS) software, version 14.0.

Results: There was no significant difference of mean age and sex between the two group. In the study group, mean values of all the Absolute and Inter-Peak Latencies of both ears were significantly higher and mean Amplitudes of waves I and V of both ears were significantly smaller than that of the Control group.

Conclusion: The study found evidence of persistent injury to the various parts of the auditory pathway even as the high risk infants grew up.

Key words: BERA, High risk infants, Latencies, Amplitude, Auditory injury.

Introduction

Auditory deficit is the most common deficit in children (1). The prevalence of newborn and infant hearing loss is estimated to range from 1.5 to 6 per 1000 live births (2). Many more are born with less severe degree of hearing impairment, while others may acquire hearing loss during early childhood (3). The prevalence of neonatal hearing disorders has been reported to be increased to 10-50 fold in infants at risk (4).
The 1994 Position Statement (2) recommended hearing screening of infants before 3 months of age for sensorineural and/or conductive hearing deficit and other high-risk factors (indicators) associated with them. However, some children may develop delayed-onset hearing loss (2, 5, 6) who are not identified by newborn screening programme. So, they recommended that infants identified with risk factors (indicators) associated with delayed-onset hearing loss, are also to be brought under screening programme (2).

BERA, as a tool for objective and precise measurement of the function of auditory pathway, came into existence since 1970 (7). Over the years, it has emerged as a better screening tool for hearing screening in newborns with a sensitivity of 100% and a specificity of 98% (8). Thus a targeted screening of babies at risk of having sensorineural hearing loss (SNHL) using BERA has been in place since 1987 (9). In the two Indian studies conducted in New Delhi in 1991 (10) and 1997 (11), the incidence of hearing loss in NICU babies were 19.2% and 18% respectively. In neither of these studies were infants with delayed-onset hearing loss tested. The present study was aimed to assess the hearing status of the high-risk infants at around one year of age, inclusive of both early & late onset, to determine whether high risk infants attain the same degree of auditory maturity at the age of one year as a normal healthy child of comparative age.

Material & Methods

The study is a cross-sectional comparative study conducted in the Neurophysiology Laboratory of the Department of Physiology, Jawaharlal Nehru Medical College, Sawangi (Meghe), Maharashtra. Ethical committee clearance was obtained as per norms.

Infants of 6 to 18 months of age who were identified at birth with one or more risk-factors or for delayed onset hearing loss, recognized by the Joint Committee of Infant Hearing (12) were included in the Study group. There was no specific exclusion criterion except the age of the infants.

Antenatal, natal, perinatal and postnatal history as well as family and developmental history were taken from the documented evidences such as tickets from In-patient & Out-patient departments (IPD & OPD), hospital discharge certificate at the time of birth [from Neonatal/Pediatric intensive care unit (NICU, PICU) or Well-Baby-Nursery] and/or from discharge certificate after any type of hospital stay, any time after birth indicating the nature of illness and treatment received.

Single channel BERA was done on RMS EMG EP MARK-II using sweep speed 1 ms/div with a Sensitivity - 0.2 µV/div. Highcut & Lowcut filters were kept at 3000 Hz & 100 Hz. respectively & Input impedance was kept <5 Kohms. Electrical activities were recorded with silver electrodes (Ag/AgCl) using Monaural montage Cz (Vertex)-M1 (Mastoid) or M 2. Ground electrode was placed at the nasion (Fz). In case of infants, the reference electrode (Cz) was placed on the forehead at hairline (13) as the anterior fontanelle is still widely open in them.

After the infants were sedated with Triclofos or Promethazine, they were delivered monaural stimulation with clicks of alternating polarity from TDH-39 earphone at a frequency of 250-8000 Hz and the evoked potentials were recorded. Click duration was 100 µs square wave & envelope used was linear.

The stimulation was first applied during a two-minute period of adaptation, preceding the recording. Thereafter, it’s intensity was progressively increased by 10 dB from 30 dBnHL until it reached 90 dBnHL. The rate of stimulation was 11.1 per sec. The ear not being tested was masked with white noise 30 dB below the intensity of the stimulus. The response to a total of 2000 stimulations were averaged and the process was repeated to ensure reproducibility of the response. The most reproducible and easily detectable components at 70 dB stimulus intensity level i.e waves I, III and V were considered for analysis.

The following parameters were studied in each ear separately : i) Absolute Latency of waves I, III and V in milliseconds (ms) ii) Inter-peak Latencies like I-III, III-V and I-V in ms iii) Absolute Amplitude of
waves I and V in microvolts (µv) and iv) V/I amplitude ratio. The results were analyzed by SPSS 14.0 software and the following tests were used: i) Fisher Exact Test was used to test the association between qualitative parameters like age and sex ii) Z-test - for testing the significance of difference of each parameter between the study and control groups. In both cases, results were tested at 5% level of significance.

Results

127 infants were screened for hearing impairment by BERA. Of them, 40 infants had no risk factor for hearing loss at birth or later and hence were termed the control group. 87 infants had at least one risk factor for hearing loss either at birth or for late onset hearing loss and hence termed study group. The mean age of the study group was 11.36±4.12 months & of the control group was 12.27±2.83 months with no significant difference between them (p=0.25). There was no significant difference in the male to female ratio between the two groups (p=0.69).

As 9 infants had no Brainstem Auditory Evoked Potential (BAEP) tracing at 70 dB nHL (absolutely deaf), comparison of various parameters was done between study subgroup of 78 infants with 40 control infants.

The mean values of Absolute Peak Latencies (APLs) were first compared between the two ears within a group. It was found that there was no asymmetry between the two ears of the control group (Table-I) & thereby proved the homogeneity of data in the control group. However, there was asymmetry between the mean values of the APLs between the two ears in the study group (Table-II). Hence, while comparing the parameters of the study & control group, the mean values of all the parameters were

<table>
<thead>
<tr>
<th>Wave</th>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>z-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Ear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Study</td>
<td>78</td>
<td>2.07</td>
<td>0.38</td>
<td>0.04</td>
<td>5.05</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>40</td>
<td>1.80</td>
<td>0.18</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Study</td>
<td>78</td>
<td>4.36</td>
<td>0.41</td>
<td>0.04</td>
<td>7.01</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>40</td>
<td>3.94</td>
<td>0.22</td>
<td>0.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>Study</td>
<td>78</td>
<td>6.54</td>
<td>0.47</td>
<td>0.05</td>
<td>8.27</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>40</td>
<td>5.96</td>
<td>0.28</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Right Ear |
| I | Study | 78 | 2.18 | 0.42 | 0.04 | 4.82 | p<0.001 |
|    | Control | 40 | 1.84 | 0.18 | 0.02 |     |         |
| III | Study | 78 | 4.51 | 0.51 | 0.05 | 7.81 | p<0.001 |
|    | Control | 40 | 3.95 | 0.25 | 0.03 |     |         |
| V  | Study | 78 | 6.68 | 0.53 | 0.06 | 9.42 | p<0.001 |
|    | Control | 40 | 5.97 | 0.29 | 0.04 |     |         |

Interpretation: Mean values of all the APLs of both ears of the Study group are significantly higher than that of the Control group.
Study group (Table-V). V/I ratio of both ears of the Study group were significantly higher than that of the Control group (Table-VI).

### Discussion

There are two general uses of the ABR: the threshold compared on either side instead of taking the mean of the two ears. It was found that the mean values of parameters like absolute peak latencies (APLs) of wave I, III and V (Table-III) and interpeak latencies (IPLs) like I-III, III-V and I-V (Table-IV) were all significantly higher in the study group on either side compared to the control group and amplitudes of waves I and V were significantly reduced in the study group (Table-V). V/I ratio of both ears of the Study group were significantly higher than that of the Control group (Table-VI).
estimation and identification of the auditory nerve and brainstem lesions (14). With ABR, one can diagnose with reasonable accuracy not only the extent of hearing loss but also the type of hearing loss i.e bilateral or unilateral; conductive or sensorineural (15). The diagnosis is based on several characteristics of the response including latencies and amplitudes of the various waves (16, 14). Of these, latency-based measures typically are used and are considered to be more reliable than amplitude-based measures (17, 14). In this study, we have analysed the major ABR waves like I, III & V with respect to absolute and interpeak latencies, amplitudes and their ratio.

Normative data for absolute peak latencies of wave I, III and V at 12 months of age as given by Salamy A, Eggermont & Mochizuki in ‘Clinical neurophysiology of infancy, childhood and adolescence’ (17) & also by Beiser M et al (18). In our study the mean APLs of all three major waves in either ear in the control group have approximated the values of Salamy A & Eggermont but slightly more than that of Mochizuki & Beiser M. And the mean APLs of wave I, III and V in the present study group of both ears are significantly (<0.001) higher than that of the Control group (Table III) signifying injury to the various parts of the auditory pathway from periphery to midbrain.

In the present study, the interaural latency difference in the control group is <0.2 milliseconds for all the three waves (Table I) whereas it is >0.2 milliseconds for waves III and V in the study group (Table II). Jiang ZD (19) also has recommended this comparison of interear differences as BAEPs may be abnormal on the affected side and normal on the other side. Abnormal asymmetry between the sides suggests a conduction defect from the ear that has relative prolongation (17). But for identification of retrocochlear pathology in a subject, interaural latency difference along with interwave latency between I-V are to be considered, which is discussed in the following section (20, 14).

Normally, in an adult, the I-III IPL and the III-V IPL should be below 2.2 milliseconds and I-V IPL should be below 4.2 milliseconds (20). In a child, all the interpeak latencies approach adult values by 18 months with little change beyond this age and I-V IPL is about 4 milliseconds at about 18 months (17). Normative data for Interpeak latencies I-III, III-V and I-V at 12 months of age as given by Eggermont & Mochizuki (17) & also by Beiser M et al (18). The present study shows significant increase in all interpeak latencies in the study group compared to their age and sex-matched controls (Table-IV). This corroborates the findings of various other studies viz. Pauels HP et al (21), Chadha S et al (11) and Fuess et al (22), Jiang ZD et al (23), Pobiano et al (24), Tan et al (25) and Kilic I et al (26).

Lengthening of the interpeak latencies is probably attributable to a delay in maturation of the auditory pathway in the brainstem (22). Abnormality of the I-III interpeak interval results from demyelination between the distal eighth nerve and lower pons which is a common sequelae of injuries by high risk factors on the developing neural pathway (27). If the disease process also involves lower pons or eighth nerve, both the I-III and the III-V interpeak intervals are prolonged (27), which has probably occurred in the study group (Table-IV). According to Mishra and Kalita (16), prolongation of both I-III and III-V IPLs in one or both ears is suggestive of multilevel disturbances of conduction in the brainstem auditory pathway.

I-V interpeak latency represents the central transmission time (CTT) as a whole. Increase in either I-III or III-V interpeak interval results in prolongation of I-V IPL. An increase in CTT indicates sensorineural hearing loss commonly due to defective myelination of the auditory pathway in high risk infants. In conductive hearing loss, the CTT remains normal as I-V is not greatly affected but absolute latencies of all waves increase (17, 14).

Amplitude of wave V is a useful parameter in detection of functional and structural abnormality in the brainstem (19). It can yield information independent of that from the I-V interpeak interval and in some clinical situations, the utility of wave V amplitude proves superior to the V/I ratio (19).
Normative data of amplitudes of wave I and V at 12 months of age is given by Salamy A (17) and Jiang ZD et al (19). The present study shows significant decrease in amplitude values of wave I and V in the study group (Table-V). Our findings are corroborated with that of various other studies viz. Stockard JJ et al (28), Lenhardt ML (29), Fuess et al (22). According to Sandra L.Helmers (17), wave V amplitude is usually about twice the size of the wave I. With a significant amplitude loss or absence of wave V, a conduction defect in the brainstem auditory system rostral to the lower pons is suggested.

Jiang ZD et al (19) have found that V/I amplitude ratio exhibits a clear developmental change with age. Normal V/I ratio is between 50% and 300% (16, 30) and consensus on V/I ratio is that values less than 0.5 are abnormal (11) but according to Mishra and Kalita (16) lower limit in full term infants is 30%. Normative data of V/I ratio at 12 months of age as given by Eggermont (17) is 1.78, Jiang ZD et al (19) is 0.40 (lower limit). Though absolute amplitudes of waves I and V were significantly decreased in the study group, V/I ratio has been found to be significantly increased in the study group whereas the ratio is within normal limit in control group (Table-VI). This finding suggests relative decrease in amplitude of wave I which is in contrary to the observations by Fuess et al (22). In our study, the infants who had conductive hearing loss, had a very small amplitude of wave I, thus increasing the V/I ratio abnormally which probably has affected the result because while taking the mean we have not discriminated between the conductive and sensorineural hearing loss.

V/I ratio should be interpreted conservatively in the pediatric population but an abnormally small V/I amplitude ratio definitely reflects central hearing impairment (27) e.g multiple sclerosis, hydrocephalus (30). Similarly, increase in V/I ratio definitely points to a peripheral hearing impairment (30) and values more than 300% indicates peripheral hearing impairment especially of a high frequency or a sensorineural type (16).

The overall outcome of this study can be summarised as follows : Significant difference of mean values of the BAEP parameters in the study group from their age and sex-matched controls establishes that high risk infants, even if their hearing is preserved, do not attain the same degree of auditory maturity as a normal healthy child of comparative age does. This study is probably only one in India that assessed the hearing status of high risk infants at one year of age with BERA, both in terms of hearing threshold (31) and affection of auditory pathway. The other published studies from India (10, 11) has estimated the incidence of hearing loss in high risk infants in the neonatal period, but no estimate has so far been done to assess the prevalence of hearing loss in these infants in the later part of their infancy. As literature tells that hearing loss may develop any time throughout the childhood as a progressive illness, it makes auditory testing a vital ongoing process (6, 32).

The following recommendations should help in promoting early and systematic screening of infants with hearing impairment as promptness of intervention also affect the impact of hearing loss on a child (5):

a) All the babies of Neonatal Intensive Care Unit (NICU) are to be screened for hearing by BERA before discharge (2, 33) and followed up every 3-6 months upto 3 years. The screening at 3-6 months may be more accurate than screening at neonatal period as it excludes the abnormalities due to peripheral conductive deafness (16).

Diagnosis by BERA is justifiably used in all screening programmes as Transient Evoked Otoacoustic Emission (TEOAE) fails to diagnose auditory neuropathy (34, 35).

b) Systematic hearing screening of all high risk infants within first six months of their life is to be incorporated under public health programmes (36).

c) To gradually implement Universal Newborn Hearing Screening (UNHS) as recommended by
Acknowledgements

We sincerely acknowledge Dr. D.A. Biswas, Professor & Vice-Dean (UG), JNMC, Sawangi & Dr. V.K. Deshpande, Professor & Pro-VC, DMIMS (DU) for all the institutional & logistic support. Source(s) of support in the form of grants, equipment, drugs or all of these, if any: Nil.

References


