HEARING ASSESSMENT BY BRAINSTEM AUDITORY EVOKED RESPONSES (BAER) IN NEONATES AT RISK

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ABSTRACT

In the present study, brainstorm auditory evoked responses (BAER) were recorded in 68 at risk neonates discharged from the neonatal ICU of Safdarjung Hospital. The high risk group of 35 neonates included 13 neonates with multiple (3-4) risk factors and 22 neonates with single risk factors, viz., prematurity (<32 weeks) low birth weight (LBW) (<1500 g), hyperbilirubinemia requiring exchange transfusion, severe birth asphyxia, craniofacial malformations and sepsis with meningitis treated with amikacin for 3 weeks. The remaining 33 neonates were grouped in the low risk category who had only one of the following factors: prematurity (33-36 weeks)/ LBW (1500-2000 g), hyperbilirubinemia requiring phototherapy, mild/moderate birth asphyxia, or sepsis treated with amikacin for 2 weeks. The test was performed at the mean conceptional age of 40.2 weeks (range 34-44 weeks) and involved determination of threshold of hearing as per presence of wave V. A normal response had wave V at 30 dB hearing level click stimulus at 50/sec from both ears or to 30 dB hearing level from one ear and 45 dB hearing level from the other ear. Thirteen neonates of the high risk group failed to produce a normal response (5 failed at 30 dB, 6 failed at 45 dB, and 2 failed at 75 dB hearing level). Forty six per cent of them had multiple high risk factors. All the low risk group neonates had normal threshold of 30 dB hearing level in the initial screening. Only the abnormal cases were retested at 3 and 6 months. Eight cases developed normal hearing threshold at 3 months. Two were lost to follow-up and one expired. Remaining 2 cases did not improve even at 6 months follow-up (one with congenital ear malformations and the other with severe birth asphyxia). The incidence of BAER abnormalities in at risk neonates at initial screening was 19.2% and in 8 (61.5%) of them it was of transient nature clearing up within 3 months. By 6 months of age the incidence of hearing impairment was 3% after excluding those lost to follow-up. This justifies the need for screening high risk neonates by BAER test at the time of discharge, to pick up those with transient or permanent hearing abnormality.

Key words: *Brainstem auditory evoked responses (BAER), Hearing assessment, Neonates at risk.*

There is a great interest in the brainstorm auditory evoked responses (BAER) study in infants to pick up those at risk of having hearing loss so that proper habilitation could be provided as early as possible to be successful for language acquisition. There is a possible incidence of 2/1000 cases of hearing loss in all newborns which increases tenfold to 20/1000 in high risk infants(1-3).

Technical advancement has made BAER an easy noninvasive and objective test that is unaffected by sleep, muscle and cerebral activity and is consistently reproducible without requiring any cooperation of the child(4). The test can be performed

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in preterm infants as early as 32 weeks of conceptional age. The response then gradually matures and attains adult values by the age of 2 years(5,6). For audiological purposes emphasis in the BAER test in infants for evaluating hearing is on the determination of minimum intensity of click (threshold) at which wave V is produced, rather than on determination of latencies, which are important for neurological evaluation(7,9). A normal response consists of eliciting wave V to 30 dB nHL by 6 months of age, failure of which is an indication for starting habilitation(9-12). All normal full-term babies have recordable wave V at birth(10).

Some of the advanced neonatal nurseries in the world have programmes to evaluate hearing by BAER in high risk new born infants so that they may pickup infants with hearing handicap early and follow them better(12,13). Our study aims to determine the threshold of hearing in at risk neonates by observing wave V at the minimum intensity of click stimulus in order to see the incidence of abnormalities in auditory functions at this age, the data on which is lacking in our country(14,15).

Material and Methods

Sixty eight neonates who were admitted to the neonatal intensive care unit (NICU) of Safdarjung Hospital were examined by the BAER test (just after their condition was stabilized and were discharged) at the Electro Neuro Diagnostic Centre after an informed consent was obtained from the parents.

Twenty two of these neonates had one of the following risk factors to qualify for the admission and were placed in the high risk category: (*i*) Prematurity/Low Birth Weight (<32 weeks/<1500 g); (*ii*) Hyperbilirubinemia requiring exchange transfusion; (*iii*) Birth asphyxia (Apgar <3 at 5 min); (*iv*) Craniofacial malformations; (*v*) Sepsis with meningitis treated with aminoglycosides (amikacin) for 3 weeks.

Thirteen other infants who had more than one risk factor, *viz.*, prematurity/ LBW (<36 wk/<2000 g); hyperbilirubinemia, requiring exchange transfusion or phototherapy; birth asphyxia (Apgar <6 at 5 min) and sepsis with or without meningitis treated with amikacin for 2-3 weeks were also included in the high risk group.

The remaining 33 neonates had only one of the following characteristics and were grouped in the low risk category: (*i*) Prematurity (33-36 wks,)/low birth weight (1500-2000 g); (*ii*) Hyperbilirubinemia requiring phototherapy only; (*iii*) Birth asphyxia (APGAR: 4-6 at 5 min); (*iv*) Sepsis treated with aminoglycosides (Amikacin for 2 weeks).

In all the premature babies, gestational age was calculated from the first day of last menstrual period and confirmed by physical and neurological criterion(16).

The test was performed in the afternoon after they were fed and most of them were in natural sleep. Those who were awake were given 20 mg/kg of Triclofos by mouth. Testing was conducted in a quiet room with ambient noise level of 32 dB sound pressure level as measured with a AP 192, convertible grade sound level meter of Peters, Medi Tech International Limited on the A weighted scale. Active electrode was attached to the ipsilateral mastoid region and was referenced to a vertex electrode. Ground electrode was put on the forehead. The resistance was kept below 50,000 ohms. Right and left ears were tested separately with rarefaction clicks of 0.1 msec duration administered at the rate of 50 per second, with masking noise on the other ear from the TDH-39P

headphones (45 dB less than the test ear), held lightly over the test ear(7). Four thousand responses were averaged with filter setting of 100-3000 Hz on the NDI equipment. Minimum of two tests were performed for reproducibility. BAER developed within 10 msec time and were seen at a gain of 200 nv/div. Wave V was identified by a peak after 7 msec followed by a throughlike deflection crossing well below the baseline which is a useful mark of identification for wave V(7).

The ABR protocol consisted of testing each ear at 75, 60, 45 and 30 dB hearing level (hearing threshold was determined in 20 normal adults to clicks at 10/sec and was found to be 20 ± 5.2 dB hearing level at 1 KHz (Mean ± SD). Initially, the high intensity of 75 dB hearing level was administered. Then the intensity was decreased in steps of 15 dB till 30 dB hearing level, which was taken to be normal threshold of producing wave V.

An infant was considered to have passed the test if wave V was present at 30 dB hearing level in both ears or in one ear at 30 dB hearing level and the other ear at 45 dB hearing level(8-11). If a response was not observed at 60 dB hearing level, testing was done at 75 and 90 dB hearing level. Normative values for BAER in neonates have previously been stated(8). Mean (± SD) latency to wave V at 30 dB HL was 7.4 ± 0.4 as against 7.10 ± 0.08 at 75 dB HL. The infants who passed the initial test were not asked to return for followup. The fail group were divided into 'fail 30' and 'fail 45' depending on absence of wave V in both ears to 30 dB and 45 dB hearing level click respectively. The 'fail 30' group had a clear wave V in at least one ear to 45 dB hearing level. The fail groups were asked for a repeat test after a period of 3 and 6 months.

Statistical methods included calculation of p value by Student's 't' test.

Results

Normal BAER threshold was obtained in 55 (80.8%) of the 68 at risk neonates included in the present study. *Fig. 1* shows a typical BAER response in healthy-term neonate. As evident, wave V is discernible down to 30 dB hearing level click stimulus (normal hearing threshold).

Thirteen (19.2%) at risk neonates, however, had abnormal BAER threshold in the initial testing performed within the first 6 weeks of life at a mean conceptional age (gestational age + age after birth) of 40.2 weeks (range: 34-44 weeks). Risk factors associated with abnormal BAER results for these 13 cases identified in the present study are presented in *Table I.*

Depending on the auditory threshold, patients with abnormal responses were categorised into three groups; Group I (n = 1, 'fail - 90'): bilateral absence of all waves even at 90 dB hearing level click stimulus (*Fig 2*, Case No. 7). This infant had multiple craniofacial anomalies including bilateral anotia and dysmorphic facial features and showed no improvement in the BAER threshold on 6 months follow-up; Group II (n = 1, absent brainstorm conduction): only wave I of the BAER appeared and that too at click levels of > 75 dB hearing level (*Fig. 3*, Case No 6). This was the case of severe birth asphyxia with hypoxic-ischemic encephalopathy. BAER abnormalities in this infant too persisted on follow up for 6 months; Group III (n = 6, 'fail-45'): neonates in this category had elevated auditory threshold bilaterally with absence of wave V at click levels of < 45 dB hearing level (*Fig. 4,* Case No. 8). Four of them, who could be retested in follow up,

TABLE I--*Risk Factors (Left Column) Associated with Abnormal BAER's for the 13 Neonates Identified in this Study*

Case No. (Hearing threshold)	1 (F-30)	2 (F-45)	3 (F-30)	4 (F-45)	5 (F-30)	6 (F-75)	7 (F-90)	8 (F-45)	9 (F-45)	10 (F-45)	11 (F-45)	12 (F-30)	13 (F-30)
Prematurity/LBW													
32 wks/ < 1500 g	×	×											
33-36 wks/1500-2000 g								×	×	×	×	×	×
Hyperbilirubinemia													
Exchange zone			×	×	×			×		×			
Phototherapy zone											×	×	×
Birth asphyxia													
Severe						×						×	
Mild-Moderate													
Malformations of ear							×						
Sepsis													
With Meningitis									×				
Alone								×		×	×		×
Aminoglyosides													
For 2 wks								×		×	×		×
For 3 wks									×				
Total	1	1	1	1	1	1	1	4	3	4	4	3	4
Follow-up	—	P-30	P-30	—	P-30	F-75	F-90	P-30	—	P-30	P-30	P-30	P-30

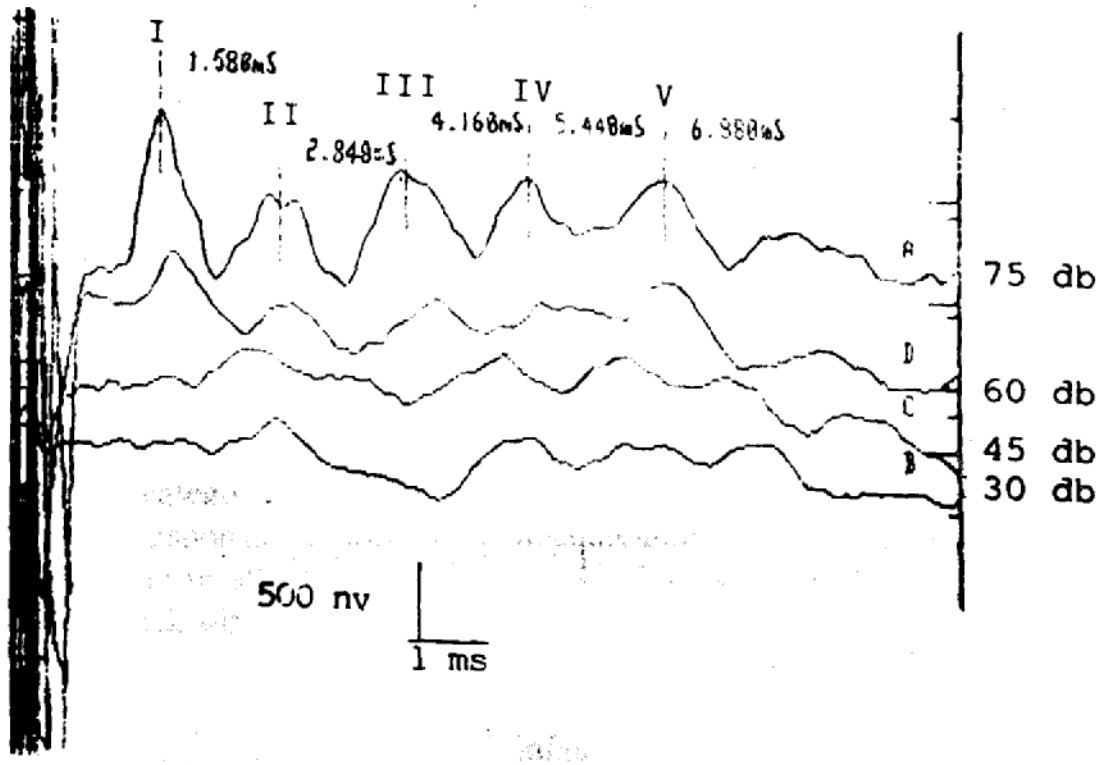

Fig. 1. Normal BAER threshold in a neonate. Note increasing latencies of the main components of waves I, III and V as the stimulus intensity drops. Wave V is recordable down to 30 dB hearing level click stimulus (normal hearing threshold).

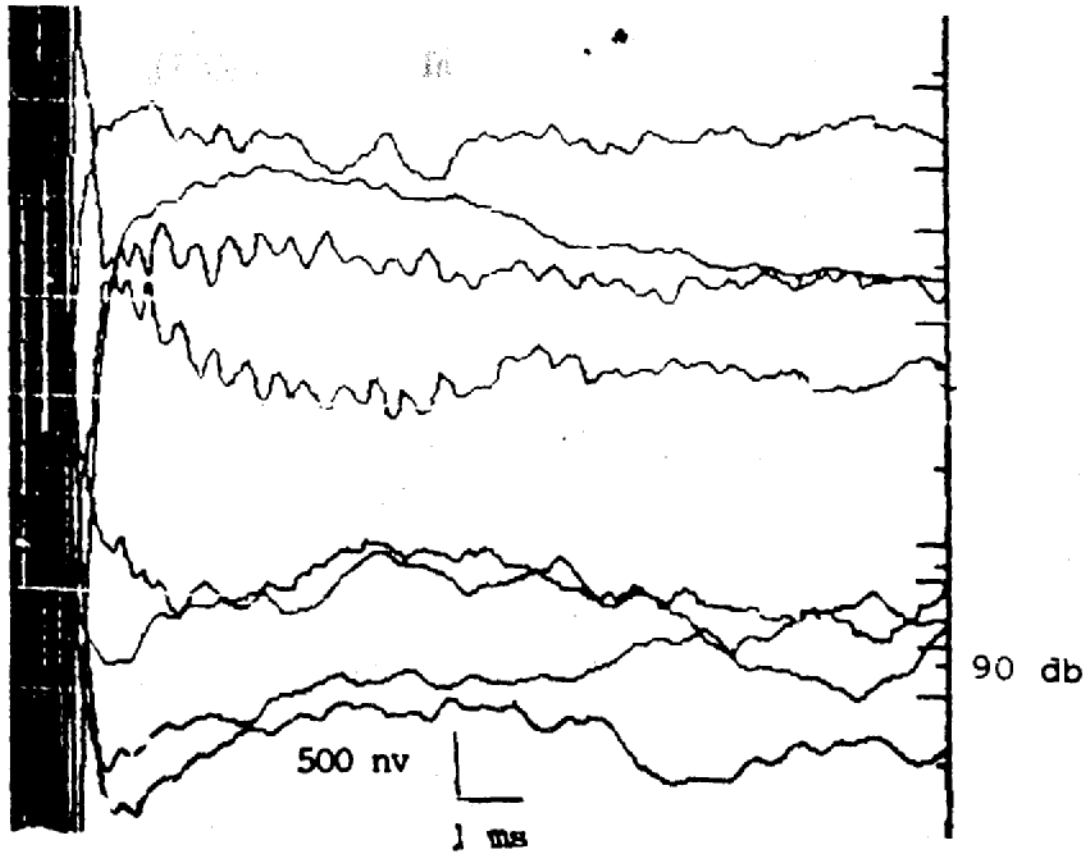

Fig. 2. BAER record from a newborn with craniofacial malformations (Case No. 7): no response obtained with clicks of highest available intensity (90 dB hearing level) in both ears. (upper trace–Rt ear, lower trace–Lt ear.)

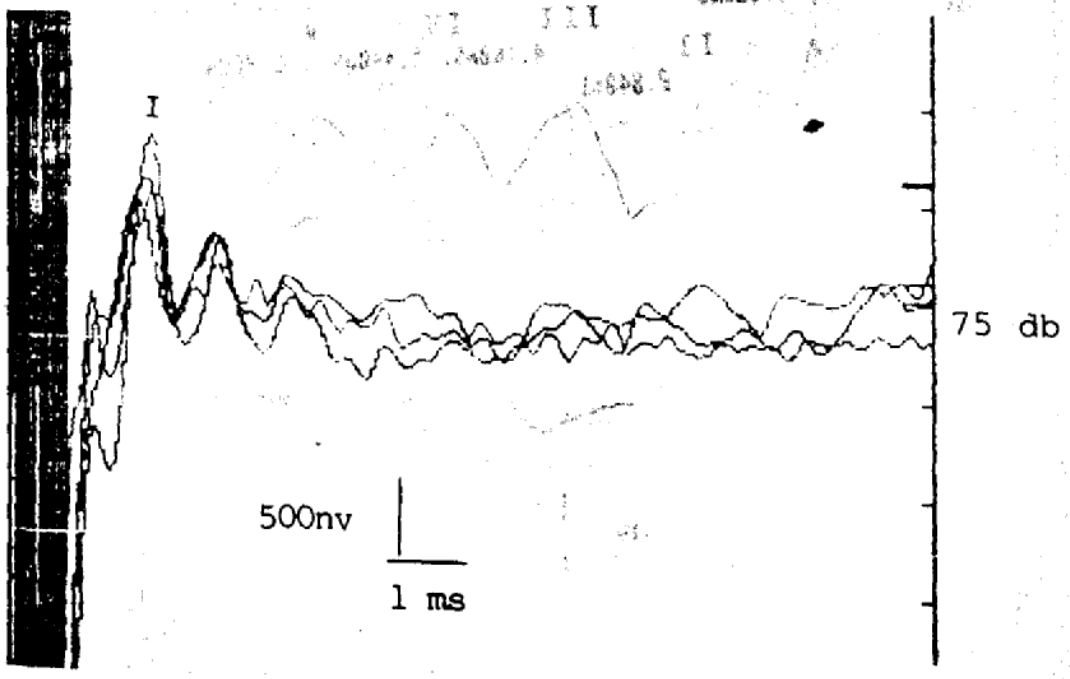

Fig. 3. BAER record (Rt ear) from a newborn with severe birth asphyxia and hypoxic-ischemic encephalopathy (Case No. 6): only wave I of the response is recordable (Cochlear functions) but no brainstem conduction is present (absence of wave II, III, IV and V).

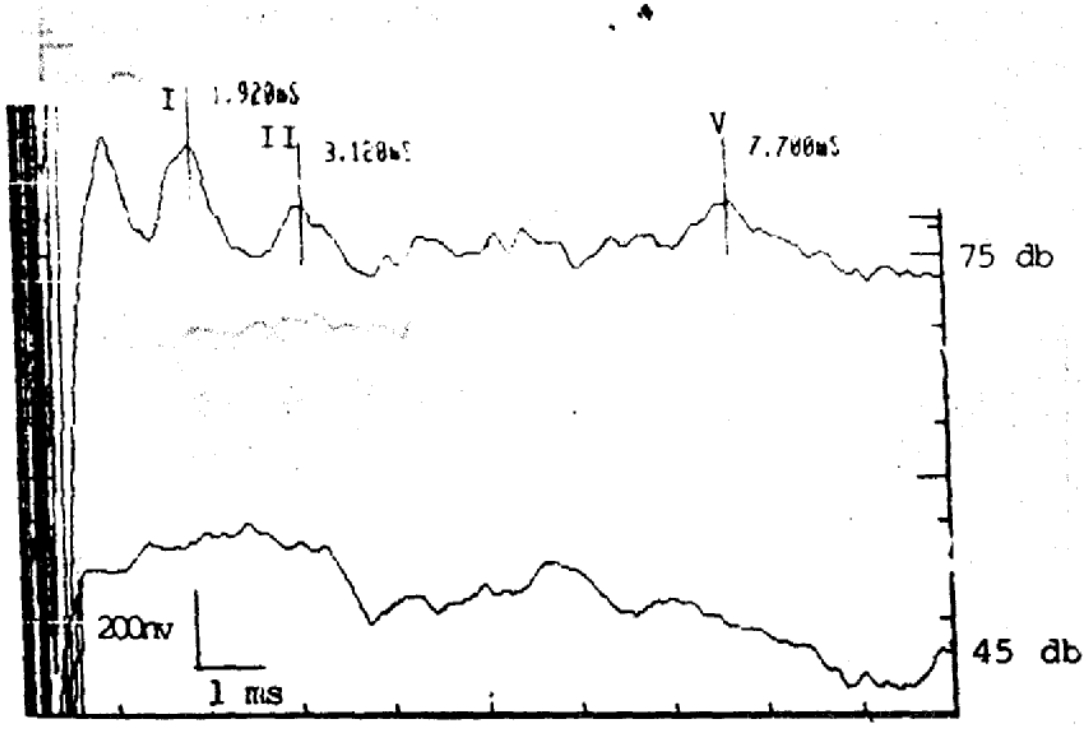

Fig. 4. BAER record (Rt. ear), from a newborn with hyperbilirubinemia (serum bil–35 mg %), Case No. 8): prolonged brainstem conduction time (I-V interpeak latency >2 SD, i.e., >5.32 sec) and absence of wave V at 45 dB (fail 45).

developed a normal hearing threshold of 30 dB hearing level (*Fig* 2, Case No. 8); Group IV (n=5, 'fail-30'): wave V was not recordable at 30 dB hearing level click stimulus bilaterally but was demonstrable at 45 dB hearing level click stimulus in at least one of the ears. Hearing threshold in four of them became normal ('pass-30') at 3 months followup, one having been lost to followup.

Further, as evident from *Table I*, none of the neonates in the category of 'low risk' had abnormal BAER response and wave V was consistently present in all neonates at 30 dB hearing level click stimulus (normal hearing threshold).

Discussion

Interest in high risk neonates has been to identify those with hearing impairment(1,12,13,17-21). Wave V abnormalities are regarded to be the earliest indication of such a disorder, which such children are prone to develop(7,9,11,12,19,21). In the present study abnormal BAER threshold was observed in 13 neonates (19.2%) at the first examination in the first 6 weeks of life. The selection of our patients represented cases at risk admitted to the NICU. Similar high percentage of abnormal BAER results has been observed in other studies from NICU of other places(1,13,17,19-22).

The abnormalities have been reported greater frequency in high risk group with multiple risk factors than in those with single risk factor (6/13 in multiple risk group vs 7/22 in single risk group, $p<0.001$) as shown in *Table I*. Role of multiple risk factors in producing abnormalities in BAER test has been well documented by others(19,21).

At 3 months follow-up, 8 (61.5%) cases developed normal hearing threshold, 3 having been lost to follow-up. The transient abnormalities observed in at risk infants have been attributed to middle ear effusion, collapse of ear canals, immaturity of peripheral neural structures or temporary effect of toxic insults, such as, bilirubin, asphyxia and aminoglycosides(13,19,22,24,25). However, it is difficult to determine the exact cause of transient BAER failures(13).

Two (20%) had persistent abnormalities when followed upto 6 months, when lost to followup were excluded. In the final analysis, we observed an incidence of 3%

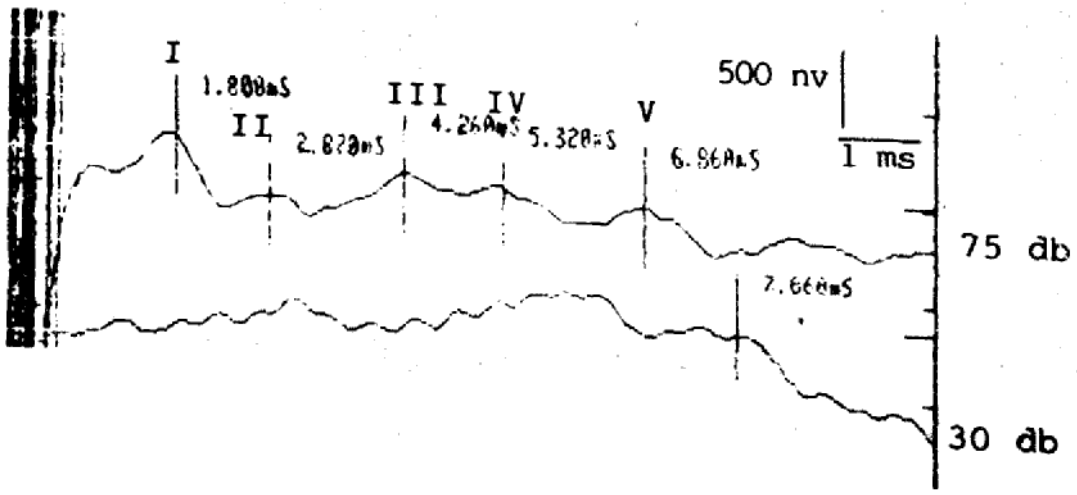

Fig. 5. Repeat BAER record (Rt ear) from Case No. 8 three months later showing recovery in conduction time (I-V interval) and hearing threshold (pass 30 dB).

hearing impairment at 6 months of age in at risk infants after excluding those lost to follow-up, which is quite in agreement with the previously published data(12,13,17-20,22,23).

This incidence justifies the use of BAER test as screening procedure in the NICU to identify those at risk of developing hearing impairment at this time, because they may not be seen again for 2 years or so when their delayed speech and language become evident and it is too late for audiologic habilitation(3). The ideal time for screening is suggested to be 3 to 6 months of age(11,24) and is corroborated by our findings also. However, it is worthwhile to assess the high risk neonates while they are in the hospital than to risk their not returning for the test several months later. This at least picks up 20% of those at grave risk of developing hearing disorder. An early pretest by the age of 3 months often will pick up those with transient abnormalities and will reduce anxiety of the parents. Those who still fail should be followed up for another 3 months and habilitation started by 6 months of age.

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NOTES AND NEWS

SIXTH NEPALESE CONGRESS OF PEDIATRICS

The Sixth Nepalese Congress of Pediatrics is being held in Kathmandu from *25-28th March, 1992* with the theme "Development of Pediatric Specialities in Nepal".

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