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# Pattern of BAER abnormalities in neonatal hyperbilirubinemia

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**ABSTRACT**

This study was done to determine the various abnormalities of Brain Auditory Evoked Response (BAER) in neonates with hyperbilirubinemia and to correlate the specific BAER abnormality with a particular range of bilirubin levels. Prospective study was done in 100 cases in a tertiary care hospital over a period from 2007-2008. All cases with hyperbilirubinemia were subjected to BAER test. Fifty five percent (n=44) out of 80 cases showed abnormal BAER test and 24 of them showed bilaterally in babies having peak serum bilirubin levels of more than 20mg/dL. Seventy five percent (n=33) showed prolong interpeak latency in wave III-V indicating that the conduction from superior olivary complex (wave III) to inferior collicullus (wave V) were more commonly affected with peak levels of bilirubin when compared to control which were found to be statistically significant ($p<0.05$). BAER is a simple and effective tool for determining the auditory functions in neonates with hyperbilirubinemia and could predict the impending encephalopathy or to identify subtle findings that could be reversed.

## INTRODUCTION

Neonatal jaundice is a common problem. Neurological disturbances such as athetoid dystonic palsy, gaze palsy, developmental delay and impaired intelligence are serious problems due to high level of serum bilirubin. Chronic bilirubin encephalopathy also lead to partial to complete sensorineural deafness. Although profound sensorineural hearing loss are easily diagnosed, and cause a great degree of disability, educationally, socially and economically. However mild degree of hearing loss in otherwise normal child are not easily diagnosed but can cause developmental and educational delay (Martin and Cloherty, 2004). Clinical estimation of jaundice severity is notoriously inaccurate. This fact coupled with early discharge of newborns, often before bilirubin levels have peaked, makes hospital-based risk assessment an essential intervention before discharge (Cabra and Whitfield, 2005). Brainstem auditory evoked response (BAER) is an effective and non-invasive investigation for detection of sensorineural hearing loss in difficult to test patients like infants and mentally retarded or malingering subjects. This test can be carried out in deeply sedated and anaesthetised patients, when patients cannot follow or respond adequately in the test. Hyperbilirubinemia has been associated with abnormalities in BAER and is recognized as the most objective method of evaluating the auditory system in neonates and infants (Haslam, 2004).

BAER measures activity from the auditory nerve up to the level of brainstem stimulated by acoustic stimuli. A response reflects synchronous activation of primary onset type neurons within the auditory system.

The response occurs within a 5 to 6 milliseconds period following presentation of a high intensity acoustic stimuli and presents as a series of major peaks in waveforms. Wave V is considered to be the most robust at low stimulus intensities. Degree of hearing loss is estimated by determining the lowest intensity level at which wave V is present. It is generally accepted that BAER provides information regarding the region of 1000 to 4000 Hz (Chen, Yang and Kwan, 1996).

The present study is to gain insight about the various abnormalities of BAER in neonatal hyperbilirubinemia.

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## MATERIAL AND METHODS

The study was conducted in the Department of Paediatrics, Himalayan institute of medical sciences, Swami Rama nagar, Dehradun over a period of 12 months.

All term babies delivered at Himalayan institute of medical sciences or brought there with a complaint of jaundice were included in the study.

Preterm babies, babies with family history of hereditary sensineural hearing loss, babies with perinatal infections, craniofacial anomalies were excluded. Informed consent was obtained from the parents of all the neonates who took part in the study. On admission a detailed history was taken and baby was subjected to a thorough clinical examination including staging of bilirubin encephalopathy if present.

The findings were recorded on a proforma especially designed for the study. Estimation of serum bilirubin level with direct and indirect fraction was done by modified Jendrassik and Grof method. All babies were subjected to BAER test using Neuroperfect EMG/NCV/EP system (manufactured by Medicaid systems, Chandigarh). The system consist of stimulus generator, electrodes, preamplifiers, differential amplifications and common mode rejection, filters, signal averager with on artefact rejection system, display and print device. BAER was done in a quiet room with appropriate acoustic attenuation and electric shielding of the environment to prevent electric artefacts from other equipments. Babies were tested after feed preferably in sleep state and using sedatives like chloral hydrate so that he may remain still and relaxed to prevent muscle interference during recording. A pulse or acoustic transient (click) was generated through stimulus generator which was of instantaneous onset and brief in duration (0.1 millisecond).

Test was done using 70 dB clicks at 11 Hz presented monoaurally, more close assessment was done using 30 dB clicks at 61 Hz. Recording was done via silver coated electrodes on the surface of the scalp placed over ears, mastoid process and vertex (a point equidistance between right and left ear canals on the coronal plane and equidistance between nasion and inion on the sagittal plane).

Preamplifiers amplifies signals to 100000 times, background noise and unnecessary information were filtered by filters. Signal average converts the analogue electrical activity into a series of numerical values by summing up usually 1000 to 2000 stimuli. BAER waveform consists of five to seven waves or peaks appearing within 8 to 10 milliseconds each of which represents a neuroelectrical activity at some site in the auditory pathway as follows- wave I (distal end of cochlear nerve), wave II (cochlear nucleus), wave III (superior olivary complex), wave IV (lateral lemniscus), V (inferior collicullus), wave VI and VII (neural generators). These waves appear at intervals of approximately one millisecond in normal subjects, delayed latency indicates impaired conduction while prolonged interpeak latency localizes site of lesion. Data collected was subjected to standard statistical analysis using Chi Square test where $p<0.05$ were taken as significant.

## RESULTS AND DICUSSION

A total of 100 term neonates were studied, out of which 80 were cases and 20 controls. Out of 80 cases 56 were males and 24 females. Birth weight of term neonates has not been found to be statistically significant in relation to BAER abnormality ($p>0.05$). Majority of cases were having physiological jaundice ranging peak serum bilirubin of < 15mg/dL (Singh, 2004a ; Srivastava, Bhalla and Arora, 1972) in 41.25% (n=33). No abnormal BAER was found in term neonates with serum bilirubin of < 5mg/dL. Progressive increase in abnormal BAER was seen with increase in serum bilirubin levels of more than ≥ 5mg/dL which was found to be statistically significant ($p<0.05$) but BAER abnormality on the left side specifically Wave II, III & IV did not showed any statistical significance ($p=0.069$). DSPT was given to 55% (n=55) cases, Double Surface Phototherapy (DSPT) + Double Volume Exchange Transfusion (DVET) was required in 10% (n=8) cases. In 45% (n=36) cases no intervention was required. In 5% (n=4) cases bilirubin encephalopathy was present and all were in stage 2. Abnormal BAER was present in babies having peak serum bilirubin level of ≥ 5mg/dL. Abnormal BAER was localized to right side in 34.09% (n=15) cases, left side in 11.36% (n=5) cases. Bilateral abnormal BAER was observed in 54.54% (n=24) cases (Fig. 1).

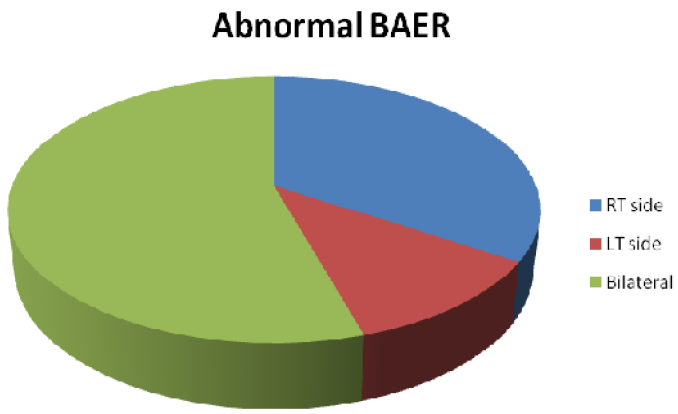


**Fig. 1:** Percentage of BAER abnormality.

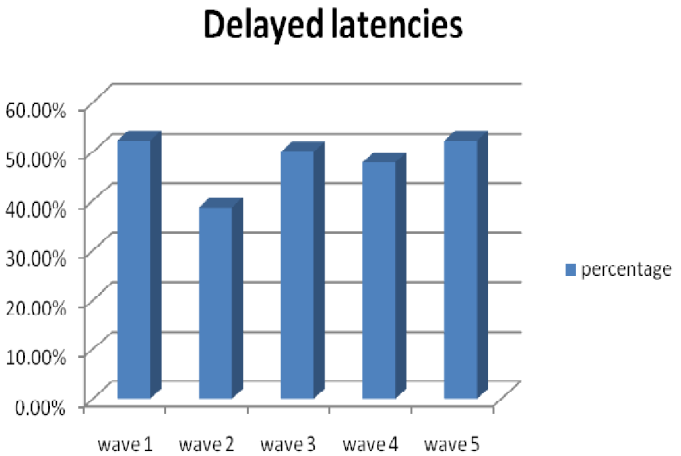


**Fig. 2:** Percentage of delayed latencies in abnormal BAER

Delayed latencies were observed in 52.27% (n=23) in wave 1 and wave 5, followed by 50% (n=22) in wave 3, wave 4 has delayed latency in 47.72% (n=21) cases, wave 2 was least affected in 38.63% (n=17) cases (Fig. 2). Maximum of 75% (n=33) cases were having prolonged interpeak latency 3-5, followed by prolonged interpeak latency 1-3 in 61.36% (n=27) cases, Least affected was interpeak latency 1-5 in 52.27% (n=23) cases (Fig. 3).

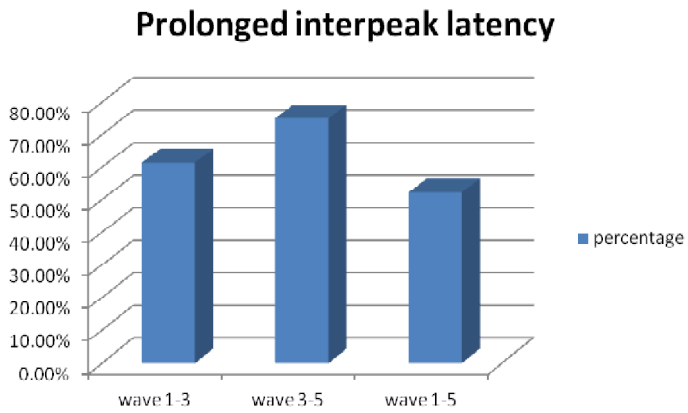


**Fig. 3:** Percentage of prolonged interpeak latencies.

Bilirubin encephalopathy is still a challenge with respect to its exact pathogenesis, preventive, therapeutic and follow up protocols (Wood, Marcomik and Marson, 1988). New assessment tools have been sought to identify factors that could be used to predict impending encephalopathy or to identify subtle findings that could be reversed (Garg and Krishak, 2005).

BAER has been suggested as a tool that could identify or predict early effects of hyperbilirubinemia on the central nervous system. Studies have regularly correlated increased bilirubin concentration with changes in amplitude and latency of these response (Madan, MacMohan and Stevenson, 2004).

In the present study BAER have been studied in 100 neonates, 80 with clinical jaundice having different levels of serum bilirubin taken as cases and 20 with no detectable clinical jaundice taken as controls.

Jaundice is the commonest abnormal physical finding during first week of life. Over two-third of newborn babies develop clinical jaundice and by adult standards almost all newborn babies are jaundiced during early days of life (Singh, 2004b). In the present study majority of cases had physiological jaundice and duration was 5 days. A similar study in past showed 4 days to be the duration of jaundice in majority of cases (Behjati-Ardakani et al., 2006).

In this study serum bilirubin of more than 30 mg/dl was observed in 5 babies, out of which 4 (80%) had bilirubin encephalopathy. In a previous study no newborns with serum bilirubin levels above 25 mg/dl developed bilirubin encephalopathy although some neurological abnormalities were noted in 17% of the cases (Newman et al., 2006). This is important because mild degree of hearing loss in otherwise normal child are not easily diagnosed but can cause developmental and educational delay. The BAER consist of five to seven waves or peaks appearing within 8 to 10 milliseconds. Each of these waves represents a neuroelectrical activity generated by the neural generators at some site in the auditory pathway between the cochlea and the brainstem. These waves peaks appear at an intervals of approx 1 millisecond in normal subjects. Delayed latency indicates impaired conduction in the auditory pathway and prolonged interpeak latencies localizes the site of lesion.

In the present study abnormal BAER was observed in 44 (55%) cases out of these 24 babies had bilateral abnormality which was followed by right sided abnormality in 15 and left sided in 5 babies. Lateralization indicates unilateral lesion.

The present study recorded BAER at serum bilirubin level from as low as 10 mg/dl till as high as 20 mg/dl after intervention. The probability of abnormal BAER increases with increasing serum bilirubin levels and was statistically significant ($p<0.05$). A previous study observed 56% babies having abnormal BAER in 25 subjects with serum bilirubin requiring exchange transfusion (Gupta, Raj and Anand, 1990). The present study indicates the importance of performing BAER in babies with lower serum bilirubin as indicated by abnormal BAER in 6 out of 30 babies (20%) with serum bilirubin less than 10 mg/dl after intervention.

Latency of wave 1 and wave 5 was equally affected in majority of abnormal BAER (23 out of 44 cases). Least affected was wave 2 in 17 cases. Interpeak latency 3-5 was the most common IPL affected in 20 out of 44 cases. Overall most common BAER abnormality was prolongation of IPL 3-5, followed by IPL 1-3. Overall least affected was Latency of wave 2. Previous studies have demonstrated the various abnormalities in latencies and interpeak latencies but did not quantify the various abnormalities (Tan, Skurr and Yip, 1992 ; Sharma et al., 2006). One study demonstrated decrease in latencies of waves I, II, V and interpeak latency 1-5 after exchange transfusion in six infants (Kuriyama et al., 1986).

## CONCLUSION

BAER abnormalities in neonatal jaundice are not related to birth weight in term babies. BAER abnormalities are common in babies with serum bilirubin as low as 5mg/dL. Bilateral abnormalities are more common followed by right sided. Delayed latencies in wave 1 and wave 5 and prolonged interpeak laency in wave 3 - 5 are more common.

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