

To Find the Prevalence of Hearing Impairment by Brainstem Evoked Response Audiometry in High Risk Neonates Attending a Tertiary Care Hospital in Their Follow up Visit

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Original Research Article

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Article History

Received: 11.11.2018

Accepted: 21.11.2018

Published: 30.11.2018

DOI:

10.36347/sjams.2018.v06i11.061



Abstract: Over 5% of the world's population or 466 million people have disabling hearing loss (432 million adults and 34 million children) as per World Health Organization report. Aim: The aim of our study was to find the prevalence of hearing impairment by Brainstem Evoked Response Audiometry (BERA) in high risk neonates admitted in tertiary care hospital in their follow up visit. The high risk neonates were tested for hearing by using portable Transient Evoked OtoAcoustic Emissions (TEOAE) before discharge from the hospital; follow up TEOAE performed after four weeks in study babies where initial testing gave refer response. Babies who tested refer on the follow-up, were subjected for BERA testing and involvement of central neuropathy and hearing impairment were studied. Among 124, 47(37.9%) babies were preterm, 36(29.0 %) babies were very low birth weight, 23(18.5%) babies were having perinatal asphyxia, 11(8.9%) babies had hyperbilirubinemia requiring exchange transfusion, 7 (5.6%) babies had sepsis. In their first hospital visit, among 124 neonates subjected to OAE, 94(75.8%) neonates had both ears pass response and 30(24.2%) neonates had referred response. BERA was done for neonates with refer response even in the second visit and hearing impairment was confirmed. Conclusion: Prevalence of hearing impairment in the high risk neonates are preterm neonates (19.1%), very low birth weight (5.6%), perinatal asphyxia (30.4%), hyperbilirubinemia requiring exchange transfusion (63.6%) and sepsis (14.3%). The involvement of central neuropathy (auditory nerve) was more in neonates with hyperbilirubinemia requiring exchange transfusion than other risk factors. This study suggests that periodic evaluation of high risk babies with simple, non-invasive test, OAE and BERA will help in monitoring the progress of auditory nerve impairment at the earliest which will influence the speech and future communication.

Keywords: Hearing impairment, Brainstem Evoked Response Audiometry, Neonatal Screening.

INTRODUCTION

Over 5% of the world's population or 466 million people have disabling hearing loss (432 million adults and 34 million children) as per World Health Organization report [1]. But the true incidence of varying degree of hearing impairment may be as high as 5:1000. In India, four in every 1000 children suffer from different degrees of hearing loss all over in India. So almost over 100,000 babies are born with hearing defects every year in our country. But the impairment can be either unilateral or bilateral also. If there is any degree of hearing involvement, it should be considered for further evaluation. Early intervention, as

much primitive age as 6 months is the real goal of improving the child's quality of life and career [2, 3].

The assessment of auditory nerve conduction is actually to determine a child's hearing status. But while a screening test is done with the results showing whether a pass or fail to determine the real need for, whether a complete assessment is warranted. Always the screening programs for hearing impairment may be either "universal" or "high risk" population based [4]. Many studies have shown that early auditory deprivation impairs the development of neurological pathway necessary for hearing. The goal for the early identification and intervention is to minimize the

adverse effects and improve the child's speech, language, communication and learning, which will reduce their poor performance in school and give good quality of life. The first months are crucial because normal language development is rapid. Before language expression, the child has experienced over a year of language reception, during which complex intellectual events have occurred. The neonatal and infant screening programs using otoacoustic emission (OAE) and Brain stem Evoked Auditory Response (BERA) have been established and accepted worldwide for this purpose. There are studies showing that, children who have been detected earlier and received intervention have better cognition than those without. Before the implementation of hearing screening program, it was advised to only test those newborn who have significant risk factors for hearing loss. It is indeed a bigger social challenge to provide special education, vocational training and employment to this large population. The root cause of this problem can only be better cleared if available infrastructure is used to streamline the hearing impaired people in regular education, vocational training and employment, by attending to hearing loss on time and instituting appropriate remedial measures. Kemp introduced Otoacoustic Emissions (OAE) measurement for newborn screening. OAE is sensitive, non-invasive, cost and time effective test, making it an ideal screening method [5]. In a normally functioning cochlea, the outer hair cell emits 'echoes' back which are measured as OAE recorded in the external ear canal by a small, sensitive microphone connected to microcomputer[6].

Significant hearing loss is one of the most common health problems present at birth. If undetected, will impede speech, language, and cognitive development. Early detection, intervention, treatment and rehabilitation prevent the consequences of neonatal hearing impairment. The statement of the Joint Committee on Infant Hearing, supported by the American Academy of Pediatrics (AAP), endorses the goal of universal detection of hearing loss in infants before 3 months of age, with appropriate intervention no later than 6 months of age. Infant distraction test has the disadvantage that it cannot be performed until 6 months of age [7]. Lack of appropriate development of central auditory system, even if not expressed in so obvious manner as sensitivity loss, may reduce the degree of redundancy in encoding by the central nervous system.

AIM AND OBJECTIVES

The aim of this study was to find the prevalence of impairment of hearing in the high risk neonates who come under inclusion criteria and to plan in future for recognition of the impairment in the auditory nerve at the earliest. The objective is to use Brainstem Evoked Response Audiometry as a tool to assess conduction in auditory pathway in high risk neonates. The early detection leading to early

intervention, improving speech and language acquisitions.

MATERIALS AND METHODS

This study was a descriptive study done in a tertiary care hospital. The study was done over a period of one year and one month from September 2017 to September 2018. Institutional Ethical Committee permission was obtained. Informed written consent was taken from the parents in their own language after explaining to them, the clear purpose of the study. A sample of the study group comprised of 124 neonates in the age between 1 and 28 days selected randomly who were considered to be high risk babies as they were admitted for the following causes in NICU, in the Newborn ward.

Inclusion Criteria

Age group – 1 to 28 days, both gender, premature babies, very low birth weight (<1500grams), perinatal asphyxia determined by APGAR less than 7 at 5 minutes, hyperbilirubinemia requiring exchange transfusion, culture positive neonatal sepsis.

Exclusion Criteria

Acutely ill infants, neonates on ototoxic drugs, metabolic diseases, cardiac or renal disorders and birth injuries

The complete history and clinical examination including otoscopy was done thoroughly for all 124 high risk infants. The babies will be subjected to otoacoustic emissions OAE (I) before their discharge from our hospital. If the initial screening result falls under refer criteria, repeat OAE (II) after 4 weeks is suggested and those detected refer in OAE (II) will be subjected to BERA during their follow up visit.

The otoscopic exam is performed by gently pulling the auricle upward and backward. In children, the auricle should be pulled downward and backward. This process will move the acoustic meatus in line with the canal. Hold the otoscope like a pen/pencil and use the little finger area as a fulcrum. This prevents injury if the study babies turn suddenly. The complete inspection of the external auditory canal and evaluation of tympanic membrane done. Since an intact tympanic membrane is necessary for conducting cochlear echoes, otoscopic examination is a must before OAE testing.

The neonatal hearing screening was carried out by portable transient evoked automated otoacoustic emissions (OAE). OAE was carried out in both ears using a portable device – EROSEAN – MAICO Ltd which uses click stimuli involving frequency bands between 1,500 Hz and 3,800 Hz. The click is presented at an intensity of 75 to 85 dB SPL. The response was considered positive (passed) when the otoacoustic emissions captured were 6 dB higher than the noise. No further tests are to be done for neonates who have their

otoacoustic emissions under pass criteria. The parents of newborns who had met the pass criteria were informed regarding the delayed-onset hearing impairment and follow-up of their children regarding hearing loss was very clearly recommended.

BERA is an objective way of eliciting brain stem potentials in response to audiological click stimuli. Even though BERA provides information regarding auditory function and sensitivity, it is not a substitute for other methods of audiological evaluation. It should be always viewed in conjunction with other audiological investigations. It was recorded by Intelligence Hearing System - BERA in our hospital. Recording done in a quiet semidarkened room. Procedure: The stimulus is in the form of click transmitted to the ear via a transducer placed in the insert ear phone or head phone. The wave forms of impulses generated at the level of brain stem are recorded by the placement of electrodes over the scalp. Electrode placement: The hairs of the babies are kept oil free by instructing their mother clearly. The babies to have shampoo bath before coming for investigation. The standard electrode configuration for BERA involves placing surface electrodes over the vertex of the head, and over the ear lobe or mastoid prominence. One more earthing electrode is placed over the forehead. This earthing electrode is important for proper functioning of preamplifier. Since the potentials recorded are in far field, well displaced from the site of impulse generation, the wave forms recorded are very weak and they need to be amplified. This amplification is achieved by improving the signal: noise ratio. To improve signal to noise ratio: Three parallel approaches are designed to achieve this goal. Filtering: This is

employed to reduce the recording bandwidth so that only the important components of the signal generated are recorded. Repeated stimulation: This is done with synchronous time domain averaging to increase the amplitude of the components of the signal. In real time situations these two can be achieved by connecting the recording electrodes to a preamplifier, with appropriate filter settings. Polarity alteration: By altering the polarity of impulses recorded, the artifacts are cancelled making the brain stem waves stand out. Monoaural auditory stimulus delivered through earphones and contralateral ear masked with pure white noise. Responses to 2000 clicks were averaged. In auditory brain stem evoked response audiometry, the impulses are generated by the brain stem. These impulses when recorded contain a series of peaks and troughs. The measured recording is a series of six to seven vertexes positive peaks (vertex positive) are referred to by the Roman numerals I – VII. Measurement of BERA produced by a series of clicks at 45, 90 and 110 dB NHL was made via three scalp electrodes, an averaging computer, and a printer.

STATISTICAL ANALYSIS

The data obtained was tabulated and the variables were analyzed for their association with the outcome by using SPSS 16 and Sigma Stat 3.5 Version. The frequencies, percentages, mean with standard deviation and p values derived by applying the Chi-square test, one way ANOVA and Student t test.

RESULTS

Our study included 124 high risk babies who fulfilled inclusion criteria comprising 55 males (44.4%) and 69 females (55.6%) were enrolled and studied.

Table-1: Oto Acoustic Emission (OAE) responses of High risk infants during their first and second visit

Visits	OAE – I (n=124)	OAE -II
Pass	94	2
Refer	30	27
Defaulter	0	1

In the first visit, with 124 neonates OAE was tested in both the ears. 94(75.8%) neonates had both ears pass response, while 30(24.2%) neonates had refer response. 1 neonates did not appear for follow up visit.

2nd OAE was tested after 4 weeks of initial testing. Out of 29 neonates who visited the second time, 27 had referred response and 2 neonates had pass response (Table 1).

Table-2: Prevalence of Hearing Impairment in High risk neonates

Risk factors	Babies participated in the study (n=124)	Babies having hearing impairment in BERA	Hearing Impairment Prevalence (%)
Preterm	47	9	19.1
Very Low Birth Weight(<1500grams)	36	2	5.6
Asphyxia	23	7	30.4
Hyperbilirubinemia requiring exchange transfusion	11	7	63.6

Neonatal Sepsis	07	1	14.3
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BERA was done only for neonates with refer response even in the second visit and hearing impairment was confirmed in 9 (19.1%) preterm neonates, 2 (5.6%) very low birth weight neonates, 7 (30.4%) perinatal asphyxia babies, 7 (63.6%) hyperbilirubinemia requiring exchange transfusion babies and 1 (14.3%) sepsis babies (Table 2).

DISCUSSION

In this study 124 at risk neonates were screened for hearing loss using OAE. 30 neonates tested abnormal in the initial screening procedure, which could be confirmed in 26 infants (21%) on follow-up. This implies a significant increase in hearing impairment in high risk neonates. Similar results have been obtained in the studies done by A Zamani *et al.* (8%) and Alwan M Maisoun *et al.* (13.5%) [8]. However, Christiane Meyer *et al.* found hearing impairment in 5.3% [9]. AL-Harbi M *et al.* found sepsis/meningitis and intraventricular haemorrhage as significant risk factors for hearing impairment [10]. Christiane Meyer *et al.* reported craniofacial anomalies, familial hearing disorders and bacterial meningitis as significant factors associated with pathologic BAER [9]. Similar findings were reported by AL-Harbi M *et al.* and KY Chan *et al.* [10, 11].

In our study preterm, perinatal asphyxia and hyperbilirubinemia were the major risk factors in study neonates, which is consistent with the study conducted by A Zamani *et al.* [8]. In the study by Christiane Meyer *et al.* ototoxic medication and birth weight <1500gm were the major risk factors [9]. The difference can be attributed to the relatively low survival rate of low birth infants in our set-up.

In our study 7 out of 11 neonates with hyperbilirubinemia requiring exchange transfusion had abnormal BERA which is supported by the study conducted by A Zamani *et al.* [8], hyperbilirubinemia was the main cause of hearing loss. The transient BERA abnormalities in infants with hyperbilirubinemia have been earlier reported by VK Agrawal *et al.* [12]. Infant hearing screening was started in the USA more than 30 years ago by using behavioral audiometric 'arousal' technique. The abnormalities of BERA were described in earlier studies clearly [13]. Most of the earlier reference studies have shown the transient nature of the bilirubin encephalopathy in almost all the infants, after therapy but we observed reversal of abnormalities in most but not all after phototherapy and/or exchange transfusion. However persistent abnormality in a few patients was also documented by others [14]. The disorders which brought the babies to the intensive care unit are almost all predisposing for hearing impairment probably because they all induce a certain amount of hypoxia to the cochlea and to the brainstem. The unconjugated bilirubin can easily cross the blood-brain

barrier which leads to neuronal cellular injury by inhibiting mitochondrial enzymes, disturbs the DNA synthesis which induces DNA-strand breakage results in inhibition of protein synthesis and phosphorylation. Bilirubin also inhibits the uptake of tyrosine, a marker of synaptic transmission. Also, bilirubin has been found to inhibit the function of N-methyl-D-aspartate receptor ion channels which indicates bilirubin can interfere with neuroexcitatory signals and impair nerve conduction specifically in the auditory nerve [15].

High rates of false positives and false negatives were detected, according to the Joint Committee on Infant Hearing, and recommended the alternative use of audiometry tests for infants with high-risk criteria. Low sensitivity and specificity in conventional screening procedures such as the arousal technique apparatus render the technique suitable for screening only and not for diagnostic procedures. In 1988 Screening for hearing impairment in infancy in most districts in the United Kingdom was done with infant distraction test (IDT) at 7 to 8 months of age, a targeted high risk babies Johnson *et al.* reported the distraction test was sensitive (91%) but non-specific (82%) in the high-risk population. The effectiveness of the screening program was limited. Recently, the use of TEOAEs together with BERA was shown to be reliable and high sensitivity and specificity in universal hearing screening programs [16]. This study represents a first baby step attempt for implementing newborn hearing screening program in our hospital.

Limitations of Study

Small sample size is one of the limitations in our study. Further studies are needed with larger sample size to more accurately highlight the importance of hearing assessment in high risk newborn babies. Furthermore, other risk factors, malformations, ototoxic drug administration could not be evaluated.

CONCLUSION

To conclude, prevalence of hearing impairment in at risk neonates are hyperbilirubinemia requiring exchange transfusion (63.6), perinatal asphyxia (30.4%), sepsis (14.3%), preterm neonates (19.1%) and very low birth weight (5.6%), Hence emphasizes the importance of screening for hearing impairment in such high risk newborns and their sequential evaluation. The prevalence of hearing impairment was more in neonates with hyperbilirubinemia requiring exchange transfusion than other risk factors. The study highlights that although universal hearing screening programs are warranted; most newborns with a detected hearing loss can be identified based on the risk factors. A correct and early diagnosis of hearing loss is mandatory to prevent permanent consequences with the spread of hearing

screening programs is the optimal solution to reach the goal.

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