

# Screening for Hearing Impairment in High Risk Neonates: A Hospital Based Study

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## ABSTRACT

**Background:** Hearing loss very early in life can have multiple deleterious effects on the new born most commonly being related to attainment of speech and language. Also, it can affect social, emotional and academic achievement of the child. Early identification of hearing impairment has been shown to improve prognosis and hence screening programs have been widely and strongly advocated.

**Aims and Objectives:** To estimate the incidence of neonatal hearing loss in high risk neonates admitted in tertiary level teaching hospital and to determine the risk factors predictive of hearing impairment in them.

**Materials and Methods:** It was a prospective study over a period of one year. We screened high risk neonates for hearing impairment admitted to NICU using Brain stem Auditory Evoked Response (BAER). The morphology of the response and wave and interwave latencies was examined in respect to age-appropriate forms. Follow up BAER after one month was performed in cases where initial BAER was abnormal. Babies who tested abnormal on the follow-up were referred for detailed audiology diagnostic work up.

**Results:** A total of 200 cases comprising 118 males (59%) and 82 females (41%) were enrolled. On initial BAER testing, 18 (15.25%) males and 14 (17%) female neonates had hearing

loss. Whereas 7 males (70%) and 3 females (30%) had hearing loss out of the total 10 hearing loss cases in the Follow up-BAER testing.

Two out of the 6 neonates with birth weight <1500g had hearing loss in the follow up of BAER testing. Use of ototoxic medications, hyperbilirubinemia requiring exchange transfusion, perinatal asphyxia and bacterial meningitis were the major risk factors occurring in 45%, 30% and 26% and 10%. Five neonates had unilateral hearing loss and the rest five (5%) had bilateral impairment. Meningitis was the significant independent clinical risk factors for predicting hearing impairment in high risk neonates. The risk of BAER increased cumulatively with BAER abnormality rate of 4.2%, 22.2% and 33.3% with one two and three risk factors respectively.

**Conclusion:** The overall incidence of hearing loss in initial BERA testing was 16%, in males it was 15.25% in males and in 17% in females, only 62.5% of neonates had a persistent abnormal BAER, with male gender a significant risk factor for this. The incidence of hearing loss increased with number of 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. Thus, a targeted approach for hearing screening may be more feasible in resource limited settings.

**Keywords:** BAER, Hearing loss, Meningitis, Perinatal asphyxia

## INTRODUCTION

Hearing is a vital part of newborn's contact with his environment and is crucial for the development of speech and language [1]. Most crucial time for this speech and language development is the first year of life [2]. Hearing loss very early in life can have multiple deleterious effects on the new born most commonly being related to attainment of speech and language. Also, it can affect social, emotional and academic achievement of the child. Even mild or unilateral involvement may have detrimental effect on the development and on school performance [3] of a young child. The severity of these hearing disabilities is generally related to the length of time the hearing loss is left untreated. Hence the policy of 'wait and watch' cannot be adopted with hearing impairment, hoping that the child will grow out of it [4]. Early identification of hearing impairment improves prognosis, hence screening programs have been widely and strongly advocated [3].

Significant hearing loss is one of the most common major abnormalities present at birth and if left untreated, will impede speech, language and cognitive development [5]. The incidence of significant bilateral hearing loss in neonates is 1-3 cases per 1000 live births and 2-4 per 100 infants surviving neonatal intensive care [6]. Data from the Colorado newborn screening programs suggest that if hearing impaired infants are identified and treated by 6 months of age. These children (with the exception of those with bilateral

profound impairment) should develop the same level of language as their age-matched peers who are not hearing impaired [3]. Thus early intervention enhances the potential of most hearing impaired children to become adults who are fully independent, participating and contributing members of society [4].

Screening programs for hearing impairment may be either "universal" or "high risk" population based [7]. The problem with using high risk criteria to screen is that 50% of cases of hearing impairment will be missed, either because the infants are hearing impaired but do not meet any of the high risk criteria, or because they develop hearing loss after the neonatal period. Hence, the American Academy Of Paediatrics endorses the goal of universal detection of hearing loss in infants before 3 months of age [3]. Until mandatory screening programs are established universally, many hospitals will continue to use high risk criteria to screen for hearing loss [3]. The screening of infant at risk is selective and considered as first step towards introduction of universal hearing screening [8].

The currently acceptable methods for physiologic hearing screening in newborns are Brainstem Auditory Evoked Response (BAER) and evoked otoacoustic emissions (EOAEs). BAER measures the electroencephalographic waves which are produced in response to click sounds of three electrodes placed on the infant's scalp by the auditory system [6]. This has been recommended for newborn hearing assessment because it is objective, correlates well with

hearing, can detect mild and moderate hearing losses as well as severe to profound losses, permits ear specific information, has good performance statistics (sensitivity and specificity), is stable over time, is unaltered by sleep/ sedation as the response is physiological, and can be done at any age [4]. EOAEs and BAER provide the assessment of function at various levels of the ear as shown below [Table/Fig-1].

Auditory Structure	EOAEs	BAER
Outer ear	Yes	Yes
Middle ear	Yes	Yes
Inner ear	Yes	Yes
Auditory nerve	No	Yes
Auditory brainstem	No	Yes

[Table/Fig-1]: Assessment of the Auditory System by EOAEs and BAER [9]

The BAER occurs as a result of synchronous neural activity originating in the auditory nerve and brainstem pathways which usually arises in first 10 milliseconds of stimulus. It is produced by giving a click stimulus through headphones and recorded via surface electrodes applied to locations on the skull [10]. The responses are recorded as a graphic display with vertex positive peaks noted and designated as waves I-V. In infants waves I,III,V are easily identifiable. The absolute latencies as well as interpeak latencies are higher than adults. It is always prudent to record the response for at least 15 milliseconds instead of 10 milliseconds that is done for adults [11]. The waves are described in terms of amplitude and latency; the units used for them are milliseconds and micro volts, respectively [12]. The most prominent component of the response pattern is the wave V [6]. The five waveform peaks give information regarding hearing sensitivity for each ear [7]. It is worthwhile to mention here that BAER tests only electrophysiological integrity of auditory pathway from cochlea to midbrain and not a test for hearing per se, since it does not test conscious perception of sound [11].

## AIMS AND OBJECTIVES

To estimate the incidence and to determine the risk factors predictive of hearing impairment in high risk neonates admitted in a tertiary care hospital.

## MATERIALS AND METHODS

### Study design

It was a hospital based prospective study under taken in the Department of Paediatrics, Government Medical College Srinagar, at GB Pant Hospital, a tertiary care referral hospital. The study was done over a period of one year from August 2009 to July 2010. Ethical committee clearance was given by the hospital ethical committee. Informed consent was taken from the parents and the guardians after explaining to them the purpose of the study.

### Sampling frame

The sample size of the study group comprised of the 200 neonates between the age of 7 and 28 days selected by simple random sampling method who were considered to be high risk patients as described below for hearing loss:

1. Family History of hereditary childhood sensorineural hearing loss.
2. Intrauterine infections (TORCH).
3. Craniofacial anomalies, including those with morphologic abnormalities of the pinna and ear canal.
4. Birth weight < 1500 g.
5. Hyperbilirubinemia at a serum level requiring exchange transfusion.
6. Ototoxic medications, including but not limited to the

aminoglycosides, used for more than five days or multiple courses or in combination with loop diuretics.

7. Bacterial meningitis.
8. Apgar scores of less than four at one minute or less than six at fifth minute.
9. Needing mechanical ventilation for more than five days.
10. Stigmata or other findings associated with a syndrome known to include sensor neural and/or conductive hearing loss.

Neonates with one or more of the above risk factors were screened for hearing impairment using Brainstem Auditory Evoked Response (BAER) before the age of 3 months using the Medlec Synergy (USA).

## Procedure for Brainstem Auditory Evoked Response (BAER)

Most children less than four months of age slept for long enough period of time after feeding to allow a BAER to be done. As the BAER results are not affected by sedation or general anaesthesia for neonates who were awake, a 20mg/kg of triclofos was given orally for sedation. The morphology of the response and wave and interwave latencies was examined in respect to age-appropriate forms. An initial test using a stimulus intensity of 70 dB was done. Failure to produce wave V indicated hearing impairment. If wave V was present, repeated tests at sequential reductions of 10 dB established the hearing threshold. Intensity of 30dB was taken as normal threshold for wave V. Subsequently, the latency-intensity curve of wave V was studied, in addition to V-I interpeak interval. In sensorineural hearing impairment the latency-intensity curve of wave V shifted to the right and the slope became steeper. Follow up BAER after one month was performed only in those cases where initial BAER was abnormal. Babies who tested abnormal on the follow-up were referred for detailed audiology diagnostic work up.

## STATISTICAL ANALYSIS

The data obtained was tabulated and the variables were analyzed for their association with the outcome by applying the Fisher's exact test, Chi-square test, correlational analysis and calculation of p-value and Odd's ratio. The statistical package for social sciences (SPSS) software program 10.0 and Graph Pad InStat were used.

## OBSERVATIONS AND RESULTS

A total of 200 cases comprising 118 males (59%) and 82 females (41%) were enrolled and studied. Eighteen (15.25%) males and fourteen (17%) females had hearing loss (initial BAER testing). A total of 20 neonates 14 males and 6 females had hearing loss

RISK FACTOR	n	%
Family history of hearing impairment	0	0
Intrauterine infections( TORCH)	4	2
Craniofacial anomalies including those with morphologic abnormalities of the pinna and ear canal	10	5
Hyperbilirubinemia at a serum level requiring exchange transfusion	60	30
Ototoxic medications, including but not limited to the aminoglycosides, used for more than five days or multiple courses or in the combination with loop diuretics	90	45
Bacterial meningitis	20	10
Birth weight<1500g	10	7
Apgar scores of less than 4 at one minute or less than 6 at fifth minute	52	26
Needing mechanical ventilation for more than 5 days	10	5
Stigmata or other findings associated with a syndrome known to include sensor neural and/or conductive hearing loss	6	3

[Table/Fig-2]: Distribution of risk factors for hearing loss in study population

on follow up BAER Hearing loss had no statistical relationship with gender ( $p=0.17$ ).

The major risk factors for hearing loss are enumerated in [Table/Fig-2]. The use of ototoxic medications, hyperbilirubinemia requiring exchange transfusion and perinatal asphyxia were the major risk factors occurring in 45%, 30% and 26% at risk neonates respectively. Bacterial meningitis was present in 10% of neonates. None of the study neonates had family history of hearing loss. One hundred and

Risk factor	Normal BAER (168 patients)		Pathologic BAER (32 patients)		p-values
	n	%	n	%	
Familial hearing loss	0	0	0	0	-
Torch infection	4	2.38	0	0	1.00
Ototoxic medication	74	44.05	16	50	0.7856
Birth weight<1500g	6	3.5	4	12.5	0.311
Mechanical Ventilation>5 days	6	3.57	4	12.5	0.179
Craniofacial anomalies	6	3.57	4	12.5	0.179
Meningitis	16	9.5	4	25	0.05
Hyperbilirubinemia	40	23.80	20	31.25	1.00
Stigmata and/ or syndrome associated with hearing loss	2	1.19	4	12.5	0.065
APGAR score<4at 1min and <6 at 5 min	48	28.57	4	12.5	0.227

**[Table/Fig-3]:** Distribution of risk factors in neonates with Normal and Pathologic BAER (initial BAER testing)

Risk factor	Normal BAER (180 patients)		Pathologic BAER (20 patients)		p-values
	n	%	n	%	
Familial hearing loss	0	0	0	0	-
Torch infection	4	2.22	0	0	1.00
Ototoxic medication	78	43.33	12	60	0.34
Birth weight<1500g	6	3.3	4	20	0.144
Mechanical Ventilation>5 days	10	5.55	0	0	1.00
Craniofacial anomalies	6	3.33	4	20	0.07
Meningitis	12	6.66	8	20	0.008*
Hyperbilirubinemia	56	31.11	4	20	0.718
Stigmata and/ or syndrome associated with hearing loss	2	1.11	4	20	0.025*
APGAR score<4at 1min and <6 at 5 min	52	28.88	0	0	0.059

**[Table/Fig-4]:** Distribution of risk factors in neonates with Normal and Pathologic BAER (follow-up BAER testing)

forty patients had 1 risk factor, 54 patients had 2 risk factors and 6 patients had 3 risk factors for hearing loss.

From the above [Table/Fig-3,4] it is evident that meningitis ( $p=0.008$ ) and stigmata and /or syndrome associated with hearing loss ( $p=0.025$ ) were the significant independent clinical risk factors for predicting hearing impairment in high risk neonates. Similarly neonates with craniofacial anomalies ( $p=0.07$ ) had around five times greater risk of hearing loss as compared to those who did not have this risk factor. Transient BAER abnormalities were observed in six neonates as follow-up response was normal. These included three infants with hyperbilirubinemia, one received mechanical ventilation for six days and another two had perinatal asphyxia and also needed mechanical ventilation for >5 days.

[Table/Fig-5] shows that neonates with stigmata and/syndrome associated with hearing loss, meningitis and craniofacial anomalies were positively correlated with hearing impairment.

Risk factor	Correlational analysis R	p-value
Stigmata and/ or syndrome associated with hearing loss	6.66	0.025
Meningitis	4.00	0.008
Craniofacial anomalies	4.00	0.07
Birth weight<1500g	3.33	0.144
Ototoxic medication	1.00	0.34

**[Table/Fig-5]:** Correlational analysis of the risk factors with abnormal BAER on follow-up

No of risk factors present	Normal BAER (180 patients)	Abnormal BAER (20 patients)
One, n=140	134	06
Two, n=54	42	12
Three, n=6	04	02

**[Table/Fig-6]:** Abnormal BAER response in relation to the number of risk factors present

Neonates with single, two and three risk factors had BAER abnormality rate of 4.28%, 22.2% and 33.3% respectively [Table/Fig-6].

## DISCUSSION

This study represents an initial attempt for implementing new-born hearing screening program in our hospital. In this study 200 at risk neonates were screened for hearing loss using BAER. Thirty two neonates tested abnormal in the initial screening procedure, which could be confirmed in 20 infants (10%) on follow-up. This implies a 50 fold 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%) [13,14]. However, Christiane Meyer et al., found hearing impairment in 5.3% [15]. The higher incidence in our study could be due to smaller sample size or because of severity of illness in our study population

Meningitis and stigmata and/syndrome associated with hearing loss were independent risk factors for hearing loss ( $p$ -values of 0.008 and 0.025, respectively). M AL-Harbi et al., found sepsis/ meningitis and intraventricular haemorrhage as significant risk factors for hearing impairment [16]. Christiane Meyer et al., reported craniofacial anomalies, familial hearing disorders and bacterial meningitis as significant factors associated with pathologic BAER [15]. Similar findings were reported by AL-Harbi M et al., and KY Chan et al., [16,17].

In our study use of ototoxic medications and hyperbilirubinemia were the major risk factors in study neonates, which is consistent with the study conducted by A Zamani et al., [13]. In the study by Christiane Meyer et al., ototoxic medication and birth weight <1500gm were the major risk factors [15]. The difference can be attributed to the relatively low survival rate of low birth infants in our set-up. Higher percentage of hyperbilirubinemia requiring exchange transfusion in our study is due to poor follow-up of neonates with blood group incompatibilities.

In our study, two out of the five neonates who required mechanical ventilation for more than five days had abnormal BAER response initially. On follow-up normal response was recorded in both the two infants. This transient abnormality can be due to the presence of middle ear effusion seen in ventilated babies. Similar findings have been reported by Hulya Bilgen et al., [18].

In our study abnormal BAER response was recorded initially in ten out of sixty neonates with hyperbilirubinemia as risk factor. However, on follow-up hearing impairment was confirmed in only four. Hence, hyperbilirubinemia was not a significant risk factor for hearing impairment. In the study conducted by A Zamani et al., [13], hyperbilirubinemia was the main cause of hearing loss. The difference

can be attributed to the timely intervention in the form of exchange transfusion at our place, thus preventing the auditory damage. The transient BAER abnormalities in infants with hyperbilirubinemia has been earlier reported by VK Agrawal et al., [19]. The two infants with BAER abnormalities had features of kernicterus on follow-up.

In our study two neonates out of 26, who had perinatal asphyxia as the risk factor, had abnormal BAER response initially, but tested normal on follow-up which is in accordance with earlier study conducted by PK Misra et al., [20]. Both the studies have shown that transient neurological abnormalities can be seen in infants with mild to moderate asphyxia.

In our study aminoglycosides were used for more than 5 days in 90 neonates making up 45% of the total study infants. This high percentage could be attributed to the high risk of sepsis in our NICU. Out of these 90 neonates, aminoglycoside use was the only risk factor in 32 neonates and none showed any BAER abnormality. This reflects the use of aminoglycosides in proper dosages given at proper intervals such that the drug concentration in blood remained below the toxic level. Fifty six neonates had aminoglycoside use accompanied with other risk factors and 6 out of these showed BAER abnormalities ( $p=0.34$ ). Similar findings have been reported by Christiane Meyer et al., [15].

In our study, six neonates with BAER abnormalities had only one risk factor, 12 neonates had two risk factors and 2 neonates had maximum of three factors. This reflects the fact that multiple risk factors cause these neonates to be admitted in NICU. BAER abnormality rate increased from 4.2% for one risk factor to 33.3% in neonates with three risk factors. As the number of risk factors per neonate increased, the probability of being hearing impaired also increased which is in accordance with the study conducted by Pimol Srisuparp et al., [21] and A Zamani et al., [13].

## LIMITATIONS OF THE 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.

## CONCLUSION

To conclude, our data indicates a high incidence of hearing impairment in NICU graduates and identifies various risk factors for neonatal hearing loss. Use of ototoxic medications, hyperbilirubinemia requiring exchange transfusion, perinatal asphyxia and bacterial meningitis were the major risk factors for hearing loss. Hence emphasizes the importance of screening for hearing impairment in such high risk newborns. 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. Thus, a targeted approach for hearing screening may be more feasible in resource limited settings.

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