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Incidence of Hearing Impairment in High-Risk Newborns

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Abstract:
Background and objectives: *Hearing loss is a significant morbidity in at risk neonates. The study evaluated the incidence in such high-risk graduates of a tertiary level III NICU in India.*
Methods: *138 neonates with various comorbidities admitted in hospital were evaluated with OAE (Oto-acoustic Emission) and BERA (Brainstem Evoked Response Audiometry) at 3 months if required.*
Results: *8 neonates had hearing loss with equal sex predilection. 4 neonates each had unilateral or bilateral hearing loss. Only congenital anomalies were determined to be a significant contributing risk factor.*
Conclusion: *Hearing impairment in high-risk neonates was 5.8% (8 patients). Both genders and bilateral and unilateral hearing loss had equal distribution. Sepsis, prematurity, NICU stay more than 5 days and hyperbilirubinemia were most common risk factors, however, only congenital anomalies had statistically significant association with hearing loss (p-value 0.021).*
Key words: *BERA, developmental delay, OAE, prematurity, Sensorineural hearing loss*

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I. INTRODUCTION

Hearing is indispensable in achieving language milestones to build up cognitive skills. It helps the developing child to learn and recognize sounds and internalize the concepts. Hearing loss in infancy can be disturbing and can prevent normal educational and social development.[1]Screening of hearing impairment at birth is not been emphasized in most of the centers in India at the moment. The incidence of congenital hearing loss in neonatal population is observed to be higher than the combined incidence of all other metabolic conditions screened for with the blood tests.[2]In Indian population, 5-15% of high-risk neonates are prone to hearing loss as compared to 1-2 out per thousand normal newborns born without risk factors.[3]The prevalence range is 0.09 to 2.3% in low risk to as high as 3 to 14.1% in high-risk population. Moreover, the average age at which it is usually detected is currently 24-30 months.[4] Nearly half patients of congenital hearing loss have genetic defects.

About 50% of hearing defects can be detected in screening based exclusively on hearing risk criteria. Early detection and intervention at younger age is crucial for future speech, language and cognitive development of the newborns. Introduction of high-risk neonatal screening, aimed at detecting hearing loss within 3 months and intervention within 6 months will end in a better language development of newborns.[5,10]

Hearing evaluation can be done either by Transient evoked Otoacoustic emission (TEOAE) or by Automated Auditory Brainstem Response (AABR). Ideally all infants have to be screened for congenital and neonatal onset hearing loss prior to the discharge from the hospitals where they were born. If unfeasible due to financial constraints, then infants with the risk factors should be screened in subsequent visits.[18]High risk newborns have much higher rates of hearing impairment and constitute about 50 percent of all newborns with hearing loss at birth. As a consequence of screening only high-risk neonates, approximately only one in ten newborns are screened, and about half of all hearing-impaired infants are detected at birth.[19]This study was done as very few studies in this domain have been carried out in India.

II. MATERIAL AND METHODS

This cross-sectional observational study was conducted at Department of Pediatrics of a Tertiary Care Hospital of Armed forces from August 2018 to Mar 2020 after due approval from the Institute Ethics Committee. High risk neonates admitted to NICU of Tertiary Care Hospital of the Armed Forces were considered for the study.
Study Design:cross-sectional observational study

Study Location: This was a tertiary care teaching hospital-based study done in Department of Pediatrics of a Tertiary Care Hospital of Armed forces from August 2018 to Mar 2020 after due approval from the Institute Ethics Committee.

Study Duration: August 2018 to Mar 2020 .

Sample size: 138 patients.

Sample size calculation: Previously researches have performed studies on incidence of hearing impairment in high-risk neonates. The incidence found in articles ranges 5.9% to 16%. Therefore, assuming (p)=10% as the incidence of hearing impairment in high-risk neonates with 5% margin of error, the minimum required sample size at 5% level of significance is 138 patients.

Formula used:

$$n = \frac{Z^2_{\alpha/2}\, pq}{d^2}$$

$$= \frac{1.96 \times 1.96 \times 0.10 \times 0.90}{0.05 \times 0.05}$$

$$= 138.30$$

Where, p is the observed hearing impairment in high-risk neonates

q = 1 - p

d is the margin of error

$Z_{\alpha/2}$ is the ordinate of standard normal distribution at α% level of significance.

Subjects & selection method: All high-risk neonates admitted to NICU of the Tertiary Care Hospital of the Armed Forces over a period of 18 months were considered for the study.

Inclusion criteria:

1. Family history of congenital or delayed onset childhood sensorineural hearing loss.
2. Maternal infection TORCH group.
3. Congenital anomalies (craniofacial abnormalities).
4. Neonates with birth weight less than 1500 g.
5. Pathological hyperbilirubinemia
6. Prematurity.
7. Sepsis.
8. Ototoxic drugs (infant and mother).
9. NICU stay more than 5 days.
10. Birth asphyxia.
11. Neonatal seizures.

Exclusion criteria:

1. High risk infants whose parents did not give consent for study.
2. Infant on ventilators who were critically ill during the timeline of study

Statistical analysis

The purpose of the study and the procedures was explained to the parents/guardian first. Written consent was obtained by signature or thumb print. Parents/guardian who gave consent for his/her baby was considered for the study. Then as per inclusion and exclusion criteria, neonates were selected for the study. High risk neonates admitted in NICU of hospital were selected for study. Complete prenatal and postnatal history were taken. Then OAE was performed before discharge = if fails then retest after 4 weeks was done. If it fails again then BERA was performed at 3 months age.Findings were noted as per proforma after which data analysis and statistical calculations was made.

III. RESULT

During this study, 138 high risk neonates were screened in the hospital. The age of neonates included in the study group ranged between 1 to 28 days (Mean ± SD, 15.79 ± 13.34). Mean age of male neonates were 15.78 days as compared to female neonates which is 14.97. Seventy-two patients (52.2%) were male and sixty-six patients (47.8%) were female. The maternal age of the study group ranged between 20 to 50 years (mean, 27.9 ± 5.6). The most common mode of delivery was LSCS 55.1% and rest was normal vaginal delivery 44.9%. Weight of the baby at birth varied between 715 to 3750 grams (mean, 1971 ± 748 grams).

Table 1: Demographic parameters of Maternal and neonatal study population.

Variables	Parameters	
Neonatal age	**Mean**	**SD**
Male (N=72)	15.78	13.38
Female (N=66)	14.97	13.42
Birth weight		
Male (N=72)	1.962	0.742
Female (N=66)	1.867	0.746
Maternal age (years)	**Number**	**Percentage**
<20	3	2.2
21-30	103	74.6
31-40	27	19.6
>40	5	3.7
Risk factors		
Prematurity	50	36.2
NICU stay > 5 days	48	34.7
VLBW	19	13.8
Sepsis	57	41.3
Ototoxic drug use	16	11.6
Birth asphyxia	10	7.3
Neonatal seizures	0	0
Maternal TORCH inf	0	0
Congenital anomalies	3	3.1
Hyperbilirubinemia	39	28.2
F/H of hearing loss	0	0

1. Distribution of Risk Factors and Hearing Loss Among High-Risk Infants.

Sepsis, prematurity, NICU stay of more than 5 days and hyperbilirubinemia were the most common risk factors observed, contributing to 41.3%, 36.2%, 34.7% and 28.2% of the study population respectively. 3 patients had craniofacial anomaly. There were no cases of neonatal seizures, TORCH was reported (Table 1). None of these patients had the intrauterine infections, neonatal seizures, history of TORCH infection, family history of hearing loss, or syndromes known to be associated with hearing loss.

Table 2 - Risk factors (single patient may have more than one symptom):

Risk Factor	Number	Percentage	Hearing loss	Percentage	p-value
Prematurity	50	36.2	4	8	0.68
NICU stay > 5 days	48	34.7	7	14.6	0.47
VLBW	19	13.8	3	15.7	0.51
Sepsis	57	41.3	4	7	0.69
Ototoxic drug use	16	11.6	1	6.2	0.62
Birth asphyxia	10	7.3	0	0	-
Neonatal seizures	0	0	0	0	-
Maternal TORCH inf	0	0	0	0	-
Congenital anomalies	3	3.1	1	33.3	**0.021***
Hyperbilirubinemia	39	28.2	1	2.5	0.76
F/H of hearing loss	0	0	0	0	-

*P<0.05 is statistically significant (chi square test)

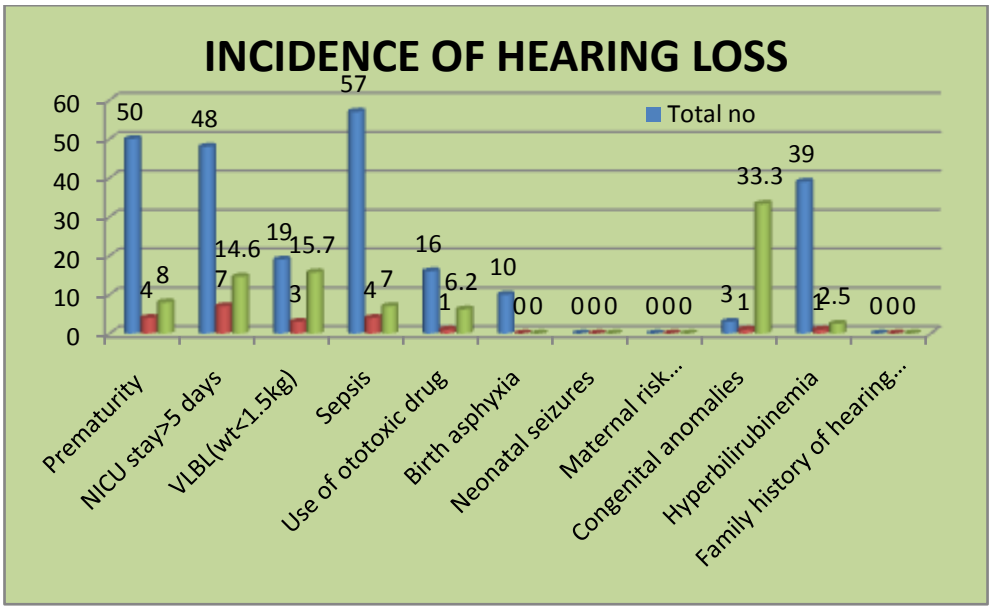

Fig 1- Hearing defects and risk factors (single patient may have > symptom).

24 patients have given false OAE on first screening of which 13 patients passed it in second screening done after 4 weeks. Rest 11 of them were referred for BERA. Only three patients' passes BERA, rest 8 have hearing impairment which accounts for 5.8 % of the study group, p = 1 which is statistically not significant. Of these there is equal distribution of sex, 50 % for male and female both. (Table 3).Out of diagnosed 8 patients with hearing defects 4(2.9%) have bilateral and 4 (2.9%) have unilateral hearing impairment, right being more common then left ear. The p value s 0.24 which is statistically not significant. (Table 4).

Table 3- Incidence of Hearing Defects

	Number		Total Number (Percentage)	P value ($\chi 2$ test)
	Male	Female		
Total	**4**	**4**	**8(5.8%)**	
Bilateral	**2**	**2**	**4(2.9%)**	**P=1 (x^2=0)**
Unilateral	**2**	**2**	**4(2.9%)**	
Left	**0**	**1**	**1(0.7%)**	**P=0.24 (x^2=1.33)**
Right	**2**	**1**	**3(2.2%)**	

P<0.05 is statistically significant

IV. DISCUSSION

Hearing is vital for achievement of verbal and social communication by an infant. Hence, the purpose of early diagnosis of hearing impairment is to achieve better verbal and social communication.[3] Previous Indian studies report a high incidence of 5-15% of high-risk neonates being prone to hearing loss.[7] **Downs and Yoshingata- Itano** have reported the beneficial effects of early diagnosis of hearing impairment in neonates on the normal development of speech. They concluded that the diagnosis of hearing loss before 6 months of age is of critical importance, and this can be done by universal newborn hearing screening.[2]

In our study out of 138 neonates screened, 24 patients have given false OAE on first screening of which 13 patients

passed it in second screening done after 4 weeks. Rest 11 of them were referred for BERA. Only three patients' passes

BERA, rest 8 have hearing impairment which accounts for 5.8 % of the study group. This incidence of hearing impairment in high-risk neonates in our study was similar to previous reported studies done by **Vashistha et al.[6], Zamani et al.[7] Kumar et al.[10] and Maisoun et al.[12].** The hearing loss had equal distribution

amongst both genders. 2 neonates of each gender had bilateral hearing loss; same was seen for unilateral hearing loss too, with right sided hearing loss being more common then left. The p value was determined at 0.24 which was statistically not significant. Previous reports also did not find any significant statistical relationship of hearing loss with sex.[7, 10, 11]**Meyer et al. [36]** reported almost equal incidence of unilateral (3.2 %) and bilateral (2.05 %) hearing impairment, similar to our study. In contrast, **Piper et al.[37]** reported a predominance of bilateral hearing loss.

VLBW neonates, NICU stay of more than 5 days and prematurity were the most common risk factors contributing to 33.3%, 15.7%, 14.6% and 8% of neonates with hearing loss. There were 50 neonates born premature in our study, out of which 4 had hearing loss; p value was 0.68 which is statistically not significant. **Vashistha et al.**[6] in her study reported prematurity as a risk factor in 17.02 % of hearing loss cases. Forty-eight neonates were in NICU >5 days, out of which 7 (14.6%) neonates didn't pass the screening, having p value is 0.47 and hence not statistically significant. **Vashistha et al.[6]** reported a prevalence of hearing impairment of 20.68 % in neonates admitted in NICU for more than 5 days. Similar study was done by **Zamani et al.[7]**in which 16% had hearing loss out of the 25 cases who were hospitalized in NICU.

Three neonates with craniofacial malformation were screened in our study out of which one neonate had hearing loss, comprising of 33.3 % hearing loss among the group with a statistically significant p value of 0.021. Studies done by **Fakhraei et al.[5]**and **Vashistha et al.[6] also** have reported 40 % and 25% hearing loss respectively in neonates with craniofacial anomaly. The study by **Zamani et al.[7]** also demonstrated significant correlation between craniofacial anomaly and hearing loss.

Nineteen neonates with VLBW were screened by OAE. 6 (30%) neonates were referred for second OAE. Of these only 1 neonate passed the second OAE and rest were referred for AABR in which 3 (15.7%) neonates had hearing impairment. **Zamani et al.[7]** in his study found that hearing loss is seen in 17% of the VLBW patients which closely resembles our study. **Cristobal et al**[39] in his review stated that the rate of sensorineural hearing loss among patients with VLBW is 2–5%, in our study we found it to be 15% which closely resembles the study done by **Vashistha et al. [6] in** which the incidence is 17%. A study by **Christine Ohl et al[22]**who showed very low birth weight is not a risk factor for hearing impairment. Another study by **Kramer et al[35]** and **Hess et al**[38] also concluded that VLBW was not a predictor of hearing impairment which is as opposite to our study.

Fifty-seven neonates diagnosed with sepsis were screened, out of which 4 (7%) neonates didn't pass the screening. **Aiyer et al[9]**in his study screened 18 neonates with septicemia and meningitis both and found that hearing loss occurs in 4 (22.2%) neonates. **Wroblewska-Seniuk et al[43]** in his study has shown that SNHL is observed in 5.3% and conductive hearing loss was seen in 12.5 % which is close to our study. Whereas study by **Vashistha et al.[6]**found no correlation between sepsis and hearing loss. Sixteen babies who received ototoxic drugs for septicemia were screened in our study out of which one was found to have hearing loss. Hence it accounts for 6.2 % of hearing loss among high-risk group. **Finckh Kramer U et al[35]** and **Hess M et al[38]** concluded that aminoglycosides are not an important risk factor. No positive correlation between birth asphyxia and hearing loss in the present study which was same as shown by study done by **Maqbool et al.[11]**There were thirty-nine neonates with hyperbilirubinemia out of which only one (2.5%) neonate had hearing impairment. The study by **Mirajkar et al.[44]**showed hearing impairment by BERA analysis was 16%. **Zamani et al.[7]**had done a study in which there was (12.5%) of the 40 cases with hyperbilirubinemia

V. CONCLUSION

The incidence of hearing impairment as measured with OAE and AABR in high-risk neonates was significant being 5.8%. There was equal distribution between both genders and between bilateral and unilateral hearing loss. In unilateral hearing loss right ear was more commonly affected than left ear. Sepsis, prematurity, NICU stay more than 5 days and hyperbilirubinemia were most common risk factors, however, only congenital anomalies had statistically significant association with hearing loss.All the neonates with doubtful OAE test were made to undergo another OAE followed by AABR confirmation to reduce false positive result. However, 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.

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