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Research Article

Hearing Impairment in High-Risk Neonates: Prevalence and Associated Risk Factors in a Tertiary Care Setting in Tripura

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ABSTRACT

Background: Hearing loss is a common, potentially treatable childhood condition, and early detection and timely intervention improve outcomes. Although newborn hearing screening is an important preventive measure, its implementation remains limited in many parts of India. Data on neonatal hearing impairment, particularly from Tripura, are scarce. Therefore, this study aimed to determine the prevalence of hearing impairment among high-risk neonates at a tertiary care hospital.

Aim: To assess hearing impairment in high-risk neonates

Methodology: A hospital-based prospective observational study was conducted over 12 months (January–December 2016) at Agartala Government Medical College, Tripura, in collaboration with the ENT and Paediatrics departments. High-risk neonates <28 days admitted to the NICU were screened using OAE followed by BERA, after obtaining parental consent.

Results: A total of 182 high-risk neonates were enrolled, with male predominance (51.6%). Most participants were from rural areas (62.1%). The most common risk factors were hyperbilirubinemia and maternal aminoglycoside exposure for more than five days (14.8% each), followed by birth asphyxia (9.9%) and septicaemia (8.2%). OAE screening identified 40 neonates (22%) requiring repeat screening; 24 underwent BERA. Hearing impairment was detected in 12 neonates, yielding a prevalence of **6.6%.** Significant associations were observed between hearing impairment and prematurity, hyperbilirubinemia, birth asphyxia, septicaemia, and maternal aminoglycoside exposure.

Conclusion: A 6.6% prevalence of hearing impairment was observed among high-risk neonates. Significant risk factors included prematurity, hyperbilirubinemia, birth asphyxia, septicaemia, and maternal aminoglycoside use, highlighting the importance of targeted newborn hearing screening.

Keywords: Otoacoustic emission (OAE), Brainstem evoked response audiometry

INTRODUCTION

Hearing impairment is one of the most critical sensory disabilities, often associated with profound social, psychological, and developmental consequences. Failure to identify congenital or acquired hearing loss in children early can lead to lifelong challenges, including delays in speech and language development, poor academic achievement, behavioural difficulties, and impaired personal-social interactions.[1]

Hearing plays a fundamental role in acquiring speech and language. When hearing is impaired, especially during early childhood when critical language development occurs, affected children are at a significant disadvantage compared to their peers. This disadvantage can extend across multiple domains—social, emotional, educational, and even economic—ultimately affecting their overall quality of life.[2,3] Importantly, hearing loss is a common and often treatable condition in childhood, particularly when it is diagnosed early and appropriate interventions are implemented in a timely manner.[4]

Globally, an estimated 0.5 to 6 per 1,000 neonates and infants are born with congenital or early-onset sensorineural deafness or severe-to-profound hearing impairment. Such impairment can significantly hinder a child's ability to thrive if not addressed promptly. Early identification is therefore critical to ensuring that affected children receive the necessary support, including auditory rehabilitation and educational resources, to achieve outcomes comparable to those of their hearing peers. While targeted or high-risk screening approaches may be used, they have a notable limitation—nearly 50% of children with hearing loss may be missed using these methods alone. Consequently, universal newborn hearing screening (UNHS) has emerged as an indispensable strategy in early detection. UNHS ensures that all newborns, regardless of perceived risk, are assessed

for hearing ability, thereby enhancing the likelihood of early diagnosis and intervention, and ultimately improving long-term outcomes for children with hearing impairment.[5–7]

Although newborn hearing screening is recognised as a critical health measure, its implementation remains limited in many regions of India. Furthermore, there is a paucity of research on the prevalence of neonatal hearing impairment at the national level, and data from the state of Tripura are particularly scarce. In light of this gap, the present study aims to determine the prevalence of hearing impairment among high-risk neonates at a tertiary care hospital and to identify the risk factors associated with hearing loss in this population.

MATERIALS AND METHODS

This hospital-based prospective observational study was conducted over a 12-month period, from January to December 2016, at Agartala Government Medical College, a tertiary care institution in Tripura, India. The study involved collaborative efforts between the Departments of Otorhinolaryngology (ENT) and Paediatrics. Parents or guardians were counselled and given information about the OAE screening test and the subsequent BERA test.

The sample size was calculated using the formula n=Z2pq/d2, where p=13.7%, which was the prevalence of hearing loss reported in an Indian study.[8] With a 95% confidence interval and 5% precision, the minimum required sample size was 182. Neonates whose parents provided consent were included in this study.

Inclusion and Exclusion Criteria

Inclusion Criteria

- Neonates aged < 28 days with one or more high-risk factors.
- Neonates whose parents or legal guardians provided written informed consent for participation.

Exclusion Criteria

- Neonates aged > 28 days at the time of screening.
- Critically ill neonates requiring immediate referral to a higher centre for urgent medical intervention.
- Neonates who died before the screening process could be completed.
- Neonates who were discharged before completion of assessment and were subsequently lost to follow-up.
- Neonates whose parents or legal guardians did not provide consent for participation.

Otoacoustic emissions (OAEs) are sounds produced by outer hair cells within a functioning cochlea when stimulated by external sounds. These emissions can be measured using a probe with speakers and a microphone in the ear canal. OAEs indicate outer hair cell function in the cochlea and provide insight into auditory health. In screening, results are PASS or REFER, requiring 3 out of 4 frequencies in the speech range for a PASS. A PASS indicates a low chance of significant auditory disorder requiring amplification. A REFER result indicates the test criteria were not met due to noise, hearing loss, or poor testing. Infants who REFER may be rescreened before referral to audiology for thorough testing to rule out permanent hearing loss. The auditory brainstem response (ABR) is an objective method used to evaluate the function of the auditory pathway, extending from the auditory nerve to the midbrain. It is considered the definitive standard for diagnosing and verifying hearing loss in infants who do not pass their newborn hearing screening using the OAE test.

All the eligible neonates were enrolled in this study after obtaining informed written consent from their parents. Data on each neonate were systematically collected using a predesigned proforma. The structured proforma included demographic and clinical information such as gestational age, family history of congenital hearing loss, consanguinity, and known risk factors for neonatal hearing impairment. These risk factors included hyperbilirubinaemia, exposure to aminoglycosides, birth asphyxia, septicaemia, meningitis, transient tachypnoea, maternal rubella, and syphilis. A two-stage screening protocol was applied, with TOAE as the first screen, followed by ABR for those who failed the TOAE screen. Selected neonates were first screened with the TOAE test. Based on the results, they were classified as PASS or REFER. A PASS indicates a low chance of significant auditory disorder. A REFER result indicates that the test criteria were not met due to hearing impairment or any test-related error. If an abnormal/REFER OAE was detected, it was repeated at 6 weeks on the 1st immunisation visit. If it was again abnormal, BERA was done for confirmation, followed by full audiological evaluation and remediation with hearing aids. The results of OAE and BERA tests were also recorded in the proforma.

The collected data were entered into a Microsoft Excel spreadsheet and subsequently analysed using IBM SPSS. Categorical variables were described using frequencies and percentages, while continuous variables were represented by mean and standard deviation. Associations between risk factors and hearing loss were assessed using the chi-square test or Fisher's exact test, as appropriate. A p-value of <0.05 was considered statistically significant.

RESULT

A total of 182 neonates were enrolled in the study, with a slight male predominance (51.6%). At screening, 58 neonates (31.9%) were aged ≤7 days, 67 (36.8%) were 8 to 14 days, 39 (21.4%) were 15 to 21 days, and 18 (9.9%) were older than 21 days. More than half of the participants (53.3%) belonged to non-tribal communities, and the majority (62.1%; n=113) were from rural areas (Table 1).

The majority, 160 (87.9%), were born at term, while 22 (12.1%) were preterm. Regarding birth weight, 136 (74.7%) neonates had a normal birth weight, whereas 46 (25.3%) were classified as having low birth weight (LBW) (Table 2).

Several risk factors associated with hearing impairment were noted in the neonates. Hyperbilirubinemia and exposure to aminoglycosides (>5 days) were each reported in 27 (14.8%) cases. Birth asphyxia was documented in 18 (9.9%) neonates, and septicaemia in 15 (8.2%). A history of meningitis was present in 9 (4.9%) cases. Both consanguinity and transient tachypnoea were reported in 6 (3.3%) neonates each. Additionally, maternal rubella was noted in 3 (1.6%) cases. There was no history of syphilis (Figure 1).

As shown in Figure 2, out of 182 neonates screened using OAE, 142 (78.0%) passed the first test, while 40 (22.0%) were referred for a second OAE. Among those referred, 16 (40.0%) passed, and 24 (60.0%) required further evaluation with BERA. Of the 24 who

Table 1: Basic characteristics of sample

Variables	*Sub-group*	*Frequency*	*Percentage*
Gender	Male	94	51.6
	Female	88	48.4
Age-group	≤7 days	58	31.9
	8–14 days	67	36.8
	15–21 days	39	21.4
	>21 days	18	9.9
Ethnicity	Tribal	85	46.7
	Non-tribal	97	53.3
Locality	Urban	69	37.9
	Rural	113	62.1
Total		182	100.0

Table 2: Distribution of pregnancy-related factors

Variables	*Sub-group*	*Frequency*	*Percentage*
Pregnancy	Term	160	87.9
	Preterm	22	12.1
Birth weight	Normal	136	74.7
	LBW	46	25.3

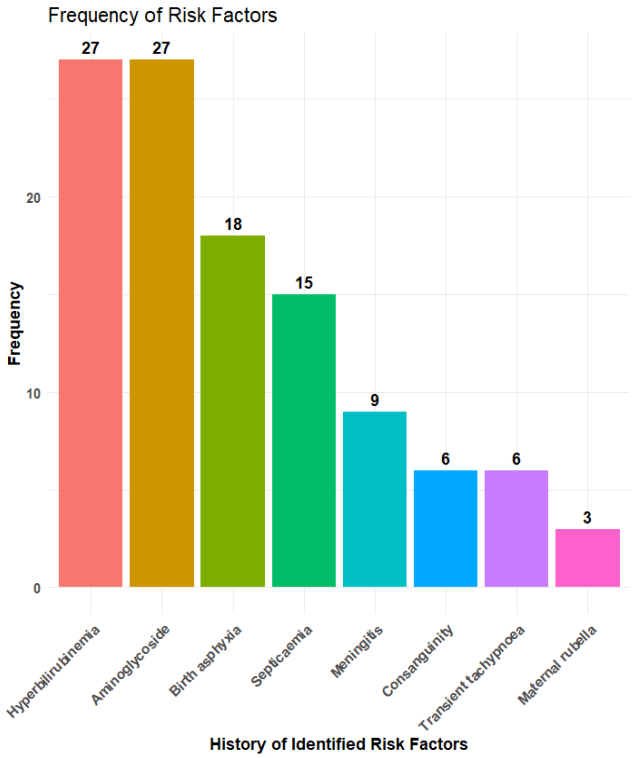


Figure 1: Distribution of presence of risk factors

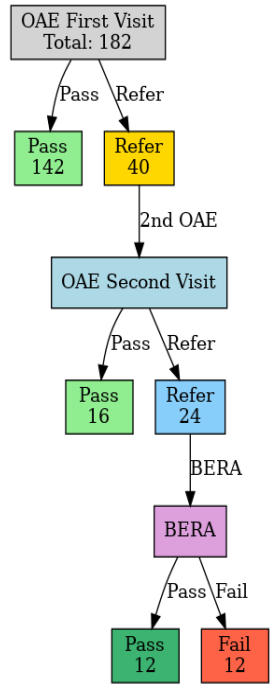


Figure 2: Schematic flow-chart showing screening results

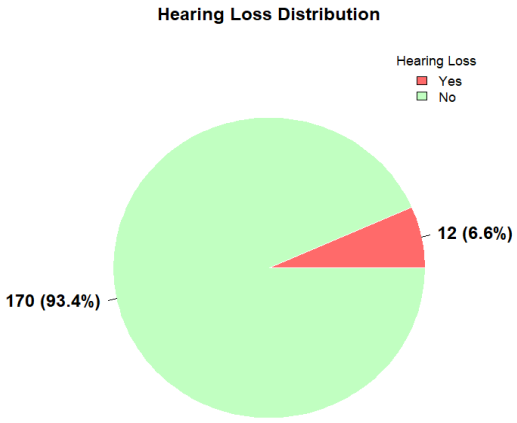


Figure 3: Prevalence of hearing impairment

underwent BERA, 12 (50.0%) passed, and 12 (50.0%) failed. The observed prevalence of hearing impairment among the participants was 6.6% (Figure 3).

A chi-square test or Fisher's exact test was used to assess the association between demographic and clinical risk factors and the presence of hearing loss. Statistically significant associations were observed with preterm birth ($p < 0.001$), history of hyperbilirubinemia ($p = 0.003$), birth asphyxia ($p < 0.001$), septicaemia ($p < 0.001$), and maternal aminoglycoside use for more than 5 days ($p = 0.003$). No significant associations were found for the remaining variables.

DISCUSSION

This prospective observational study evaluated the prevalence of hearing impairment and associated risk factors among high-risk

neonates admitted to a tertiary care hospital in Tripura, India. A total of 182 neonates meeting the inclusion criteria were enrolled. All participants underwent initial hearing screening using otoacoustic emissions (OAE), and those who failed on two successive occasions were subsequently evaluated with brainstem evoked response audiometry (BERA) for diagnostic confirmation. The observed prevalence of hearing loss in this study was 6.6%, which aligns with prior research conducted in similar high-risk neonatal populations in India. For example, Dhande *et al*. reported a sensorineural hearing loss (SNHL) incidence of 3.76%, while Hardani *et al*. observed a prevalence of 5.09% for various types of hearing impairment among neonates.[9,10] In contrast, some studies reported lower prevalence rates, such as Siddique *et al*. and Singh *et al*., who found 2.07 per 1,000 newborns with hearing loss in a universal screening context.[11,12] Rawat *et al*., focusing on high-risk neonates, reported a prevalence of 18.3 per 1,000 live births, which is slightly lower than the current study's findings.[13]

These discrepancies may be due to differences in study population (universal vs high-risk screening), methodological variations in screening and diagnostic protocols (single-stage vs two-stage OAE with BERA confirmation), test timing, sample size, and regional differences in perinatal care. Notably, studies that employ universal screening among all neonates tend to report lower prevalence rates compared to studies focusing on high-risk infants, where the burden of perinatal complications known to affect auditory function is higher.

This study identified several significant risk factors associated with neonatal hearing impairment, including preterm birth, hyperbilirubinemia, birth asphyxia, septicaemia, and maternal use of aminoglycosides. These findings are consistent with existing literature and underscore the multifactorial aetiology of congenital and early-onset hearing loss. Preterm birth emerged as a major contributor, which is in line with the findings of Bielecki *et al*., who reported a strong association between prematurity and auditory dysfunction. The immaturity of the auditory system in preterm infants, along with increased vulnerability to hypoxic events, metabolic disturbances, and exposure to intensive care interventions, may explain this elevated risk.[14]Hyperbilirubinemia was another prominent risk factor observed in this study. Elevated bilirubin levels are known to exert neurotoxic effects, particularly affecting the auditory pathways, including the cochlear nuclei and auditory brainstem. This association is well documented in studies by Bielecki *et al*. and Pradhan *et al*., the latter noting a particularly high risk in neonates requiring exchange transfusion.[7,14] Birth asphyxia and neonatal septicaemia were also significantly associated with hearing loss. These conditions can cause hypoxic-ischemic injury or direct neuroinflammatory damage to the auditory structures. Pradhan *et al*. similarly reported birth asphyxia and mechanical ventilation as major risk factors, reinforcing the role of perinatal hypoxia and critical illness in auditory impairment.[7] Maternal exposure to aminoglycosides and neonatal ototoxic medication use were also noted as significant contributors. Aminoglycosides are well-known for their cochleotoxic potential, especially in genetically susceptible individuals, and their use during pregnancy or neonatal treatment warrants careful monitoring. This observation is supported by Pradhan *et al*., who reported ototoxic drug exposure as a significant predictor of hearing loss.[7] Comparative findings from Siddique *et al*. identified additional risk factors including congenital anomalies, viral or bacterial infections, and prolonged NICU stay, many of which may be interlinked with the high-risk conditions observed in our cohort.[11] Raju *et al*. added to this by highlighting maternal age >35 years, low birth weight, and teenage pregnancy—factors that may compromise perinatal outcomes and indirectly affect auditory development.[15] Likewise, Kunnath *et al*. noted associations with pregnancy-induced hypertension, premature labour, low birth weight, and small-for-gestational-age infants, all of which may predispose neonates to complications that impair auditory function.[16] The convergence of findings across these studies supports the importance of early and targeted screening protocols in neonates with identifiable perinatal risk factors. Early identification and intervention are critical in mitigating long-term developmental delays associated with undiagnosed hearing loss.

This study provides valuable data on the prevalence and risk factors of neonatal hearing impairment in Tripura, addressing a significant gap in regional literature. However, as a single-centre study conducted at a tertiary care hospital, the generalisability of the findings may be limited. Additionally, although the sample size was based on prior prevalence estimates, a larger cohort would enhance the robustness of the results and enable more detailed subgroup analyses.

CONCLUSION

This study assessed the prevalence and risk factors of hearing impairment among high-risk neonates in a tertiary care setting in Tripura, India, using a two-stage screening approach comprising otoacoustic emissions (OAE) and brainstem evoked response audiometry (BERA). A hearing impairment prevalence of 6.6% was observed, with significant associations identified for preterm birth, hyperbilirubinaemia, birth asphyxia, septicaemia, and maternal aminoglycoside use. The findings support implementing universal newborn hearing screening, particularly among high-risk groups, and contribute region-specific data to inform early detection and intervention strategies. The single-centre design and limited sample size may affect generalisability, underscoring the need for larger, multicentre studies to validate and expand upon these findings.

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CONSENT

Ethical approval was obtained from the institutional ethics committee. Written informed consent for medical procedures and the use of the patient's medical information in this study was obtained from the patient's legal guardian/informant for publication.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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