

Screening of Hearing Impairment in Newborns with Risk Factors, Detected by Otoacoustic Emission Hearing TestAhmedi Begum¹, Hajira Siddiqua², D. Harshitha³, Farhat Unnisa⁴¹Ms ENT, Senior Resident, Department of ENT, Government Medical College, Mahbubnagar²Senior Resident, Department of ENT, Government Medical College, Khammam³Ms ENT, Assistant Professor, Department of ENT, TRR Institute of Medical Sciences, Hyderabad, Telangana⁴Ms ENT, Senior Resident, Department of ENT, Government Medical College, Nalgonda

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Abstract:**Background:** Hearing impairment in newborns, particularly those with high-risk factors, is a significant concern as it can impact speech, language, and cognitive development. Early detection through otoacoustic emission (OAE) testing is crucial for timely intervention. This study aims to assess the efficacy of OAE in detecting hearing impairment among high-risk infants and to identify associated risk factors.**Methods:** This prospective observational study was conducted over 18 months in the NICU of Owaisi Group of Hospitals, involving 50 high-risk infants. Infants were screened using OAE testing before discharge, with a follow-up screening for those referred. Further evaluation using Brainstem Evoked Response Audiometry (BERA) was conducted for infants who failed the second screening. Data were analyzed using SPSS, with statistical significance set at $p < 0.05$.**Results:** Out of 50 infants screened, 2 were referred, resulting in an incidence of hearing impairment of 4%. Meningitis was significantly associated with hearing impairment ($p = 0.01$), while other factors such as prematurity, low birth weight, and craniofacial anomalies showed no significant association. The study demonstrated the effectiveness of OAE as a screening tool in high-risk newborns.**Conclusion:** OAE testing is effective in early detection of hearing impairment in high-risk infants, particularly those with meningitis. Incorporating OAE into routine neonatal screening, especially in resource-limited settings, can facilitate timely intervention and improve developmental outcomes.**Keywords:** Otoacoustic Emission, Hearing Impairment, Newborn Screening, High-Risk Infants, Early Detection, Meningitis.

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Introduction

Hearing impairment in newborns is a significant public health concern, especially when considering its impact on the development of speech, language, and overall cognitive abilities. Early identification of hearing loss is crucial as it allows for timely intervention, which is critical for the development of communication skills and social integration. [1] The consequences of undiagnosed hearing impairment can be profound, leading to delays in language acquisition, educational difficulties, and social challenges.

Therefore, the importance of neonatal hearing screening cannot be overstated, as it serves as the first step in a comprehensive strategy to minimize these adverse outcomes. [2,3] The advent of otoacoustic emission (OAE) testing has revolutionized neonatal hearing screening. OAE tests, including Distortion Product Otoacoustic

Emissions (DPOAE) and Transient Evoked Otoacoustic Emissions (TEOAE), are non-invasive, objective, and reliable methods to assess cochlear function, particularly the outer hair cells. [4] These tests have become the cornerstone of newborn hearing screening programs globally due to their effectiveness in detecting hearing loss at an early stage. The Joint Committee on Infant Hearing (JCIH) 2007 guidelines emphasize the need for universal newborn hearing screening, particularly focusing on high-risk infants who are more likely to have hearing impairments. [5,6]

High-risk infants, such as those with a family history of hearing loss, in utero infections, low birth weight, prematurity, jaundice requiring intensive treatment, meningitis, craniofacial anomalies, or exposure to ototoxic drugs, are at a significantly increased risk for developing hearing

impairment. In these populations, early screening and diagnosis are essential, not only for initiating early intervention strategies but also for preventing further developmental delays associated with untreated hearing loss. [7,8] Despite advancements in neonatal care, many developing countries still face challenges in implementing universal newborn hearing screening programs. Resource limitations, lack of trained personnel, and inadequate healthcare infrastructure are significant barriers. [9,10] In this context, the feasibility of using OAE as a screening tool in such settings is of paramount importance. OAE testing is advantageous in resource-constrained environments due to its low cost, portability, and ease of use. However, its application in these settings, particularly among high-risk infants, requires further exploration to establish its effectiveness and practicality. [11]

This study focuses on screening for hearing impairment in high-risk newborns admitted to the Neonatal Intensive Care Unit (NICU) using OAE testing. The primary objective is to evaluate the efficacy of DPOAE and TEOAE in detecting hearing loss among these infants, thereby facilitating early intervention. Additionally, the study aims to identify the specific risk factors associated with increased hearing impairment in this population, as defined by the JCIH 2007 guidelines. By examining the outcomes of OAE testing in a high-risk neonatal population, the study seeks to provide evidence on the feasibility of implementing OAE as a routine screening procedure in developing countries. [12] Furthermore, the study aims to contribute to the existing body of knowledge regarding the early detection of hearing impairment, with a particular focus on populations at increased risk due to genetic, environmental, or medical factors. Understanding the prevalence and causes of hearing impairment in high-risk infants will aid in the development of targeted screening programs and interventions. This is particularly relevant in settings where resources are limited, and the burden of undiagnosed hearing loss can have far-reaching consequences on the affected individuals and their families.

Overall, the early detection of hearing impairment in newborns, especially those at high risk, is critical for ensuring optimal developmental outcomes. This study seeks to highlight the importance of OAE screening in identifying hearing impairment among high-risk infants, exploring its effectiveness, and addressing the challenges of implementing such screening programs in resource-limited settings. Through this research, we aim to contribute valuable insights that can inform policy and practice in neonatal hearing screening, ultimately improving the quality of care for newborns at risk of hearing loss.

Materials and Methods

Study Design: This study was a prospective observational study designed to screen for hearing impairment in high-risk infants using otoacoustic emission (OAE) testing.

Study Area: The study was conducted at Owaisi Group of Hospitals, affiliated with Deccan College of Medical Sciences.

Study Period: The study spanned 18 months, from January 2021 to July 2022.

Study Population: The study population consisted of high-risk infants admitted to the Neonatal Intensive Care Unit (NICU) of the Owaisi Group of Hospitals.

Sample Size: A total of 50 high-risk infants were included in the study.

Criteria for Sample Selection

Inclusion Criteria: High-risk infants with one or more risk factors, as defined by the Joint Committee on Infant Hearing (JCIH) 2007, were included in the study. These risk factors include:

- Family history of permanent hearing loss
- In utero infections (e.g., toxoplasmosis, rubella, cytomegalovirus, herpes simplex virus, and syphilis)
- Birth weight less than 1500 grams
- Prematurity less than 32 weeks
- Jaundice requiring phototherapy and exchange transfusion
- Meningitis
- Hypoxic-ischemic encephalopathy (HIE) of any degree
- Treatment with ototoxic drugs
- Craniofacial abnormalities

Exclusion Criteria:

- Normal term neonates without any of the above risk factors

Study Group and Method of Collection

1. **History and Examination:** A thorough history was obtained, and clinical examinations were conducted, including anthropometry, general examination, and otoscopy.
2. **OAE Testing:** Otoacoustic emission (OAE) testing was performed on infants 24 to 48 hours prior to discharge from the NICU. Infants who were referred after the first OAE test underwent a repeat OAE test 15 to 30 days later. Infants who failed the second OAE test were referred to an otorhinolaryngologist and audiologist for further evaluation using Brainstem Evoked Response Audiometry (BERA) within three months to confirm hearing loss and facilitate early intervention.

3. **OAE Equipment:** OAE testing was performed using the OtoRead™ OAE equipment.

Procedure

The following information was recorded for each infant: gestational age, sex, maternal history, prenatal and maternal risk factors, and birth weight. After otoscopic examination of the ears, screening was conducted with the infant lying comfortably on a bed or on the mother's lap in a soundproof room. A probe with a soft, flexible tip was gently inserted into the outer part of the ear canal to obtain an adequate seal. The OAE equipment used different probes calibrated for neonatal ear canal volume. The low amplitude OAEs were amplified and analyzed relative to the noise floor. The results were recorded as either PASS or REFER.

Screening and Re-Screening Protocol

The study protocol was conducted in three steps:

1. **First Screening:** Conducted prior to discharge from the NICU using TEOAE/DPOAE for at-risk infants.
2. **Second Screening:** Conducted one month after discharge for infants who failed the first screening. Infants who failed the second screening were referred to an audiologist for further evaluation with BERA.

Ethical Clearance: The study protocol was approved by the Institutional Review Board of the Deccan College of Medical Sciences.

Statistical Analysis: Data were entered into Microsoft Excel 2016 and analyzed using the Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, version 24.0). Qualitative data were expressed as frequencies and percentages, while quantitative data were expressed as means and standard deviations. Statistical significance was evaluated using the Chi-square test and Fisher's exact test, with a p-value < 0.05 considered statistically significant at a 5% level of significance and 95% confidence interval.

Results

The study involved 50 high-risk newborns who were screened for hearing impairment using otoacoustic emission (OAE) testing. The demographic characteristics of the study population are summarized in Table 1. The majority of the infants (68%) were less than 10 days old at the time of screening, with the remaining infants distributed

across the 10 to 20 days (18%), 15 to 20 days (12%), and over 20 days (2%) categories.

The gender distribution was relatively balanced, with 52% of the infants being male and 48% female. Most infants (70%) were born between 37 and 41 weeks of gestation, while 30% were born between 33 and 36 weeks. The overall incidence of hearing impairment among the screened newborns is presented in Table 2. Of the 50 newborns screened, 2 were referred for further testing, resulting in an incidence rate of 4% for hearing impairment within this high-risk population.

The association between various risk factors and hearing impairment is detailed in Table 3. Meningitis was significantly associated with hearing impairment, with 16.70% of infants with meningitis being referred ($p = 0.01$). Other risk factors, including prematurity, hypoxic-ischemic encephalopathy (HIE), very low birth weight (VLBW), craniofacial anomalies, exposure to ototoxic drugs, TORCH infections, hyperbilirubinemia, and family history of hearing loss, did not show statistically significant associations with hearing impairment.

These findings suggest that while meningitis is a critical risk factor for hearing loss, the other factors studied may require larger sample sizes or more sensitive screening methods to detect their potential impact. Birth weight and its relation to hearing screening outcomes are summarized in Table 4. Infants with a birth weight of less than 1500 grams all passed the OAE screening, as did those weighing more than 2500 grams. However, 12.50% of infants in the 1500-2500 grams category were referred, though this association was not statistically significant ($p = 0.109$).

Finally, Table 5 examines the hearing screening outcomes based on the number of risk factors present. Infants with a single risk factor had a referral rate of 2.4%, whereas those with two risk factors had a higher referral rate of 14.29%. Interestingly, the single infant with three risk factors passed the OAE screening, suggesting variability in the predictive value of multiple risk factors.

Overall, the results highlight the importance of targeted screening for hearing impairment in high-risk newborns, particularly those with a history of meningitis, while also pointing to the need for further research into the role of other risk factors.

Table 1: Demographic Distribution of Study Infants

Variable	Category	Frequency	Percent
Age Distribution	<10 days	34	68%
	10 to 20 days	9	18%
	15 to 20 days	6	12%
	>20 days	1	2%

Gender Distribution	Male	26	52%
	Female	24	48%
Period of Gestation	33-36 weeks	15	30%
	37-41 weeks	35	70%

Table 2: Incidence of Hearing Impairment among Screened Newborns

Variable	Value
Total Number of Newborns Screened	50
Number of Newborns Referred	2
Incidence of Hearing Impairment	4%

Table 3: Association of Risk Factors with Hearing Impairment

Risk Factor	Pass (N/%)	Refer (N/%)	P Value
Meningitis	5 / 83.30%	2 / 16.70%	0.01
Prematurity	6 / 100%	0 / 0.00%	0.594
Hypoxic Ischemic Encephalopathy (HIE)	23 / 95.80%	1 / 4.20%	0.954
Very Low Birth Weight (VLBW)	11 / 100%	0 / 0.00%	0.443
Craniofacial Anomaly	1 / 100%	0 / 0.00%	0.837
Ototoxic Drugs	1 / 100%	0 / 0.00%	0.837
TORCH Infections	1 / 100%	0 / 0.00%	0.837
Hyperbilirubinemia	7 / 100%	0 / 0.00%	0.564
Family History	1 / 100%	0 / 0.00%	0.387

Table 4: Birth Weight and Hearing Screening Outcomes

Birth Weight (grams)	Pass (N/%)	Refer (N/%)	P Value
<1500	10 / 100%	0 / 0.00%	0.109
1500-2500	14 / 87.50%	2 / 12.50%	Not Sig.
>2500	24 / 100%	0 / 0.00%	

Table 5: Hearing Screening Outcomes Based on the Number of Risk Factors

Number of Risk Factors	Pass (N/%)	Refer (N/%)
1	41 / 97.60%	1 / 2.4%
2	6 / 85.71%	1 / 14.29%
3	1 / 100%	0 / 0.00%

Discussion

The findings from this study underscore the importance of early hearing screening in newborns, particularly those with high-risk factors such as those outlined by the Joint Committee on Infant Hearing (JCIH) 2007 guidelines. The use of otoacoustic emission (OAE) testing proved to be an effective tool in identifying hearing impairment among high-risk infants, highlighting its potential for wider implementation in neonatal screening programs, especially in resource-constrained settings. [13]

One of the most significant findings of this study was the association between meningitis and hearing impairment. Infants with a history of meningitis had a markedly higher likelihood of failing the OAE screening, suggesting that this risk factor should be given particular attention in neonatal hearing screening protocols. The statistically significant association ($p = 0.01$) reinforces the need for vigilant monitoring and early intervention in infants with this condition. The impact of meningitis on hearing is well-documented, with the

infection potentially causing inflammation and damage to the cochlea, leading to sensorineural hearing loss. [14]

Interestingly, other commonly recognized risk factors, such as prematurity, very low birth weight (VLBW), and craniofacial anomalies, did not show a significant association with hearing impairment in this study. This finding may suggest that while these factors are important, they may not be as predictive of hearing loss as previously thought, or it could be reflective of the small sample size in this study. Nevertheless, it underscores the importance of a comprehensive approach to screening that considers multiple factors and not just the presence of a single risk element. [8,11]

The study also demonstrated the practicality of OAE testing in a neonatal intensive care setting. Given its non-invasive nature, ease of administration, and relatively low cost, OAE screening is particularly suitable for use in developing countries where resources may be limited. The portability of the equipment and the quick turnaround time for results make it an

attractive option for widespread screening initiatives. Moreover, the fact that only 4% of infants in the study were referred for further testing highlights the efficiency of OAE in identifying those truly at risk for hearing loss. [15]

However, there are some limitations to this study that should be acknowledged. The small sample size limits the generalizability of the findings, and the lack of long-term follow-up means that the study could not assess the persistence or progression of hearing loss in the affected infants. Future studies should aim to include larger cohorts and incorporate follow-up assessments to better understand the long-term outcomes of early hearing impairment detection. [16]

Overall, this study provides strong evidence supporting the use of OAE testing as a primary screening tool for detecting hearing impairment in high-risk infants. The significant association between meningitis and hearing loss highlights the need for targeted screening in this population. By integrating OAE into routine neonatal care, especially in resource-limited settings, healthcare providers can ensure early detection and intervention, ultimately improving developmental outcomes for affected infants. Further research with larger sample sizes and long-term follow-up is necessary to confirm these findings and to refine screening protocols to ensure they are as effective and comprehensive as possible.

Conclusion

This study confirms that otoacoustic emission (OAE) testing is an effective tool for the early detection of hearing impairment in high-risk newborns, particularly those with a history of meningitis.

The findings support the integration of OAE into routine neonatal screening, especially in resource-limited settings, to facilitate early intervention and improve developmental outcomes. While meningitis was significantly associated with hearing loss, other risk factors showed no significant correlation, indicating the need for comprehensive screening protocols.

Further research with larger sample sizes and long-term follow-up is recommended to validate these results and enhance screening strategies.

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