

Original Research Article

Hearing screening in neonates admitted in neonatal intensive care unit at tertiary care centre of Southern Rajasthan

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ABSTRACT

Background: Hearing impairment is a common congenital condition, significantly impacting speech and social development in children. Early detection and intervention are crucial for improving outcomes, yet many cases go undiagnosed. This study aims to identify hearing impairment among neonates in a tertiary care centre using otoacoustic emission (OAE) and auditory brainstem evoked response (ABER) screening methods.

Methods: A prospective observational study was conducted in the paediatric department of RNT medical college, Udaipur, over six months. Newborns admitted to the neonatal intensive care unit were screened based on risk factors as per the joint committee on infant hearing guidelines. Inclusion criteria included high-risk factors such as low birth weight, mechanical ventilation (>5 days), APGAR score etc. Descriptive analysis was performed, with statistical significance assessed using the Chi-square test.

Results: Of the 750 newborns screened, 64.67% passed bilaterally in first OAE screening, remaining were referred. Among referred babies, second OAE screening showed a referral rate of 16.9%. Significant associations were found between hearing impairment and risk factors such as low birth weight, low APGAR scores, and prolonged mechanical ventilation. ABER testing confirmed hearing impairment in 9 /140 tested infants, resulting in an incidence of 55.11 per 1,000 in high-risk infants and 3.2 per 1,000 in low-risk infants. The overall incidence was 12 per 1,000 infants.

Conclusions: In high-risk group hearing impairment primarily associated with low birth weight and prolonged mechanical ventilation (>5 days), low Apgar score, ototoxic drug. In high-risk group hearing impairment (5.5%) was more than low risk group (0.32%).

Keywords: Hearing impairment, Congenital hearing loss, OAE, ABER

INTRODUCTION

Hearing impairment can occur at any age, with the most severe cases often presenting before or immediately after birth. Congenital hearing loss is one of the most common birth defects, affecting 2 to 3 per 1,000 live births.¹ The incidence of hearing loss ranges from 1 to 6 per 1,000, and only half of affected infants are detected through high-risk screening. Early diagnosis and treatment by six months significantly improve outcomes. Hearing loss is categorized as mild (21-40 dB HL), moderate (41-70 dB HL), severe (71-95 dB HL), or profound (>95 dB HL), with the latter termed deafness. Globally, moderate to

severe bilateral hearing loss (>40 dB) affects 1 to 3 per 1,000 in well-baby nurseries and 2 to 4 per 100 in intensive care units.²

Hearing loss in children is a significant invisible disability, impacting speech development and social skills. Early use of hearing aids and rehabilitation is crucial for language development. Children with undiagnosed hearing loss, including mild or unilateral deficits, can experience delays in speech and behavioural issues.³ Universal newborn hearing screening (UNHS) has become standard practice in many countries to identify hearing impairments early for timely

intervention, improving linguistic and literacy outcomes. Studies show infants diagnosed before six months achieve better language skills. Early auditory stimulation and rehabilitation support speech, psychological, and social development.⁴

Neonatal hearing loss can be genetic or environmental. Genetic factors account for 50% of cases, with 30% syndromic and 70% non-syndromic, often due to connexion gene mutations.⁵ Non-genetic causes include congenital infections like cytomegalovirus and TORCH infections, although vaccination has reduced the risk. Perinatal factors include prematurity, low Apgar scores, hyperbilirubinemia, and exposure to ototoxic drugs or NICU noise. Hyperbilirubinemia can damage auditory pathways, and hypoxia affects cochlear function. Low Apgar scores and prolonged oxygen supplementation are linked to hearing loss in preterm infants.⁶

Some NICU graduates develop hearing loss later, between ages 2-4, likely due to delayed neural degeneration.⁷ In India, newborn hearing screening is primarily available at tertiary hospitals, using OAE and automated ABER. OAE is a simple, non-invasive screening method widely used.

This study aimed to detect hearing impairment among neonates in a tertiary care centre using the OAE and ABER.

METHODS

This prospective observational study was conducted in the paediatric department of RNT medical college, Udaipur, over a 6-month period. Institutional ethical committee approval was obtained, and written informed consent from parents was secured prior to enrolment. Data collection involved a detailed history and clinical examination using a structured proforma.

Inclusion criteria

All newborns admitted to the NICU were included, with high-risk factors as per JCIH, including family history of hearing loss, congenital infections, craniofacial anomalies, low birth weight (<1,500 g), hyperbilirubinemia requiring exchange transfusion, ototoxic medications, bacterial meningitis, low Apgar scores, mechanical ventilation for ≥ 5 days, and syndromes associated with hearing loss (e.g., Usher, Pendred, Waardenburg). Maternal risk factors such as age, gravida, mode of delivery, PIH, GDM, and thyroid abnormalities were also considered.

Exclusion criteria

Newborns were excluded if they died, did not complete the study or follow-up, or if the parent's refused participation.

Statistical analysis

Descriptive analysis was conducted, with results for categorical data presented as numbers and percentages. Significance was assessed at a 95% confidence level, using the Chi-square test for categorical variables. Statistical analysis was performed using MS Excel and SPSS 20, with a $p < 0.05$ considered statistically significant.

Screening protocol

After ethical approval and informed parental consent, newborns were screened based on the guidelines of the Indian academy of pediatrics (IAP), American academy of pediatrics (AAP), and the joint committee on infant hearing (JCIH). Newborns were categorized as "high risk" or "low risk" based on risk factors. A two-step newborn hearing screening was followed using OAE. Low-risk infants passing the first screening were discharged, while those who failed were re-screened after two weeks. If they failed again, an ABER test was conducted. All high-risk infants underwent ABER testing. Those with abnormal results were referred for interventions like hearing aids, cochlear implants, and speech therapy. ABER was done using the intelligent hearing system (EPIC-PLUS), focusing on wave V for threshold estimation.

Screening methods

Previously, behavioural assessments like Murphy's sound localization were used, but these were subjective. Now, OAE and AABR are standard methods. OAE measures inner ear response, while AABR measures brain wave responses using electrodes. Both are objective and recommended by AAP and JCIH, offering quick, non-invasive, and reliable screening.

The hearing screening program involves three steps: screening, confirmation (for abnormal results) and early intervention (for confirmed hearing impairment)

RESULTS

In our study, 48.53% of participants were 6-10 days old, followed by 28% who were ≤ 5 days old. Males made up 60.61% of the group (M:F = 1.5:1). Most babies (53.27%) were born at > 37 weeks gestation, with 22.83% at 34-37 weeks. Birth weight > 2.5 kg was seen in 62.75% of participants, while 23.77% weighed 1.5-2.5 kg. Most mothers (65.82%) were aged 24-29 years, and 62.27% were multigravida. Inborn babies accounted for 66.4%, with 71.3% delivered vaginally and 28.7% by caesarean section.

In our study, the 1st OAE screening was conducted on 750 babies. Of these, 485 (64.67%) had a B/L pass, while 265 (35.33%) were either B/L or U/L referred. The 2nd OAE screening was performed on the 265 referred babies,

where 45 (16.9%) were still referred, and 220 (83.1%) had a B/L pass.

In our study, 1st OAE referrals occurred in 183 low-risk and 82 high-risk participants. In the 2nd OAE, 2.08% of low-risk and 25.19% of high-risk babies were referred, which was statistically significant ($p=0.00001$) (Table 1).

Among 156 males and 109 females referred in 1st OAE, 5.71% of males and 6.46% of females were referred in 2nd OAE, with no statistical significance ($p=0.7$). Referrals in the 2nd OAE were highest in the 28-32 weeks (26.92%) and <1 kg birth weight (42.86%) groups, both statistically significant ($p<0.05$). Maternal age ($p<0.05$) and delivery method showed significance, with 9.76% referrals for caesarean deliveries ($p<0.05$). However, there was no significant difference for inborn vs. out born status or gravidity. Most referrals were associated with low birth weight, low Apgar score, ototoxic drugs, and mechanical ventilation ≥ 5 days.

Low birth weight, mechanical ventilation (>5 days), congenital infections, and ototoxic drugs were the major risk factors showing a statistically significant association with hearing impairment ($p<0.05$) (Table 2).

Pregnancy induced hypertension was most common maternal risk factor present in our study. Total 82 mothers had PIH out of which 54 babies were pass and 28 were referred and babies of without PIH mothers 651 were pass and 17 were referred in 2nd OAE screening and result was statically significant ($p=0.0001$) Gestational diabetes was present in 48 mothers, among them 43 babies were OAE pass and 3 were referred, whereas 26 mothers of participant had hypothyroidism out of which 24 had pass and 2 were referred in OAE screening and result was not significant ($p>0.05$) (Table 3).

In our study, ABER examinations were conducted for all 127 high-risk participants and 13 referred low-risk participants, totalling 140 ABER tests. Of these, 131 showed normal results, while 9 participants were diagnosed with hearing impairment.

In our study, the incidence of hearing loss was 55.11 per 1000 babies in the high-risk group and 3.2 per 1000 babies in the low-risk group. The overall incidence of hearing loss was 12 per 1000 babies, with a statistically significant difference between the groups (Table 4).

In our study the relationship between ABER and risk factor in high-risk group. Low birth weight (<1.5 kg), mechanical ventilation (>5 days), low APGAR and ototoxic drugs are the major risk factor that shows statistically significant association with hearing impairment ($p<0.05$) (Table 5).

In our study 39 babies had 3 risk factors for hearing impairment, 18 babies had 2 risk factor, 32 babies had 1 risk factor, 16 babies had 4 risk factors and only 2 babies had >4 risk factor (Table 6).

In our study sensitivity of OAE was 100%, specificity of OAE was 72.52% and positive predictive value (PPV) 20%.

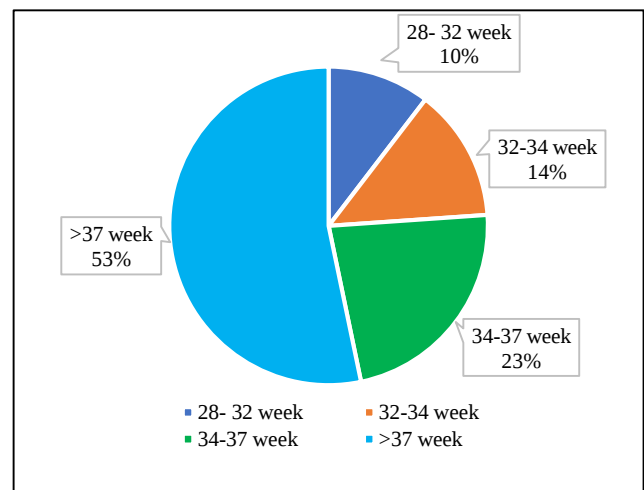


Figure 1: Gestational age Distribution of study participants.

Table 1: Distribution of 1st and 2nd OAE refer participants as per risk factor.

Risk category	Frequency	1 st OAE refer	2 nd OAE refer	2 nd OAE refer	P value
Low risk	623	183	13	2.08%	0.00001
High risk	127	82	32	25.19%	
Total	750	265	45	—	

Table 2: Relationship between OAE screening and risk factor in high-risk group, (n=127).

Fatal risk factor	N	Pass (N)	Refer (N)	χ^2	P value
Low birth weight <1.5 kg	Absent (39)	34	5	4.57	0.032
	Present (88)	61	27		
Apgar ≤ 4 at 1 min or ≤ 6 at 5 min	Absent (99)	76	23	0.919	0.337
	Present (28)	19	9		
Mechanical ventilation ≥ 5 days	Absent (76)	64	12	8.886	0.002
	Present (51)	31	20		

Continued.

Fatal risk factor	N	Pass (N)	Refer (N)	χ^2	P value
Hyper-bilirubinaemia required exchange transfusion	Absent (114)	83	31	2.354	0.124
	Present (13)	12	1		
Bacterial meningitis	Absent (118)	87	31	1.02	0.312
	Present (9)	8	1		
Congenital infection	Absent (118)	91	27	4.737	0.029
	Present (9)	4	5		
Ototoxic drugs	Absent (38)	33	5	4.17	0.02
	Present (89)	62	27		
Congenital anomaly	Absent (120)	89	31	0.468	0.247
	Present (7)	6	1		
Familial H/O hearing loss	Absent (124)	92	32	1.035	0.154
	Present (3)	3	0		

Table 3: Relationship between OAE screening and maternal risk factor (n=750).

Risk factor	N	OAE screening (2 nd)		X^2	P value
		Pass	Refer		
Pregnancy induced hypertension	Absent (668)	651	17	129.31	0.00001
	Present (82)	54	28		
Gestational diabetes	Absent (702)	660	42	0.0057	0.939
	Present (48)	45	3		
Hypothyroidism	Absent (724)	681	43	0.136	0.711

Table 4: Result of screening protocol.

Risk category	No. of neonates	No. of neonates with hearing loss	P value	Incidence of hearing loss/1000 babies
High risk group	127	7	0.0001	55.11
Low risk group	623	2		3.2
Total	750	9		12

Table 5: Relationship between ABER screening and risk factor in high-risk group, (n=127).

Fatal risk factor	N	ABER		X^2	P value
		Normal	Hearing loss		
Low birth weight <1.5 kg	Absent (39)	39	0	3.032	0.040
	Present (88)	81	7		
Apgar ≤ 4 at 1 min or ≤ 6 at 5 min	Absent (99)	96	3	5.304	0.010
	Present (28)	24	4		
Mechanical ventilation ≥ 5 days	Absent (76)	75	1	6.398	0.011
	Present (51)	45	6		
Hyper-bilirubinaemia required exchange transfusion	Absent (114)	107	7	0.794	0.373
	Present (13)	13	0		
Bacterial meningitis	Absent (118)	111	7	0.565	0.452
	Present (9)	9	0		
Congenital infection	Absent (118)	112	6	0.583	0.445
	Present (9)	8	1		
Ototoxic drug	Absent (38)	38	0	3.163	0.037
	Present (89)	82	7		
Congenital anomaly	Absent (120)	113	7	0.432	0.51
	Present (7)	7	0		
Familial H/O hearing loss	Absent (124)	117	7	0.179	0.672
	Present (3)	3	0		

Table 6: Distribution of case according to the number of risk factor and hearing loss in high-risk group.

No. of risk factors of hearing impairment	Hearing impairment		Total
	Present	Absent	
1	0	32	32
2	1	37	38
3	2	37	39
4	3	13	16
>4	1	1	2
Total	7	120	127

DISCUSSION

The aim of our study was to estimate the incidence of hearing impairment in infants admitted to the NICU of RNT medical college, Udaipur. This observational study included 750 neonates categorized into high-risk (n=127) and low-risk (n=623) groups based on risk factors. Screening was conducted in two stages: a detailed history, general and ENT examinations, followed by newborn hearing screenings using OAE and ABER protocols established by the Indian Academy of Paediatrics and other relevant organizations. Neonates in the low-risk group who passed the OAE were discharged, while those who failed and all high-risk neonates were rescreened after two weeks. Those who failed the ABER screening were referred to the ENT department for interventions like hearing aids, cochlear implants, and therapy. Ultimately, nine newborns were identified with hearing impairment and referred for early intervention.

In our study, 750 babies underwent 1st OAE screening, with 64.67% (n=485) passing bilaterally, while 33.33% (n=265) were either bilaterally/unilaterally referred. In 2nd OAE screening, conducted on 265 referred babies, 83.1% passed bilaterally, and 16.9% were referred again. These findings align with Gouri et al where 95% passed and 5% were referred, and with Chavan et al who reported 90% passing and 10% being referred in OAE screenings.^{8,9}

In our study, 1st OAE referrals included 183 low-risk and 82 high-risk participants. In 2nd OAE screening, 2.08% of low-risk (n=13) and 25.19% of high-risk (n=32) babies were referred, with statistically significant difference (p=0.00001). Other risks, such as low Apgar scores, hyperbilirubinemia requiring exchange transfusion, bacterial meningitis, congenital anomalies, and familial history of hearing loss, showed no significant association with OAE referrals. Our findings align with Shukla et al who similarly reported no significant link between these risk factors and OAE referrals.¹⁰

In our study, the incidence of hearing impairment among newborns with no risk factors was 3.2 per 1,000 (0.3%), compared to 55.11 per 1,000 (5.5%) in those with risk factors. The overall incidence of hearing loss (HL) was 12 per 1,000 (1.2%). This aligns with findings from Anand et al who reported a hearing impairment incidence of 7.8% in high-risk and 1.12% in low-risk newborns.

Similarly, Anil et al found an overall incidence of 6.25 per 1,000, with rates of 3.96 per 1,000 in low-risk and 46.5 per 1,000 in high-risk babies.^{11,12}

In our study of 127 high-risk participants, 32 had only one risk factor with no cases of hearing loss. Among 38 participants with two risk factors, 1 (2.63%) had hearing loss; in the group of 39 participants with three risk factors, 2 (5.13%) had hearing loss; 3 (18.75%) out of 16 participants with four risk factors had hearing loss; and of the 2 participants with more than four risk factors, 1 (50%) had hearing loss. This aligns with findings from Bhat et al and Anand et al which indicated that the probability of hearing impairment increases with the number of risk factors.^{11,13}

Although OAE screening is faster and easier than ABER, it can be influenced by fluid or debris in the external or middle ear. Our study found the sensitivity of OAE to be 100% and specificity to be 72.52%, consistent with Sreedharan et al who reported 100% sensitivity and 93.87% specificity. The PPV of OAE in our study was 20% (95% CI: 15.92% to 24.82%), similar to Gupta et al who found a PPV of 17.5%.^{14,15}

CONCLUSION

Our study identified hearing impairment in 9 out of 750 newborns (1.2%), primarily associated with low birth weight, low APGAR scores, prolonged mechanical ventilation, and ototoxic drugs. Pregnancy-induced hypertension was significantly linked to hearing impairment, while gestational diabetes and hypothyroidism were not. Effective antenatal care is essential to prevent hearing loss. The low incidence emphasizes the need for early detection through efficient screening, advocating for a national universal newborn hearing screening program to enhance outcomes.

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Conflict of interest: None declared

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