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ORIGINAL RESEARCH

Prevalence of hearing loss among neonates admitted in NICU in a tertiary care center

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ABSTRACT
Indian studies performed using different hearing screening protocols have estimated the prevalence of neonatal hearing loss to vary between 1 and 8 per 1000 babies screened. The better prognosis of individual skills like language development, academic success, social integration and successful participation in the society can be attained by early identification and intervention for hearing loss i.e. by 6 months of age. After obtaining permission from the institutional ethical committee all neonates admitted in NICU fulfilling the inclusion and exclusion criteria were taken into the study after obtaining written informed consent from parents/guardian. Information regarding the condition of each neonate was collected in the form of a predesigned questionnaire which included: gestational age; family history of congenital hearing loss and consanguinity; presence of conditions including asphyxia(APGAR score<4), sepsis, respiratory distress syndrome, transient tachypnoea of newborn(TTN),congenital pneumonia, congenial heart disease(CHD) or hyperbilirubinemia(≥18 mg/d1);and treatments used including phototherapy (>2 days),mechanical ventilation (>5 days),antibiotic therapy including aminoglycosides(>5 days),or oxygen therapy(>1 week and > 40% FIO2).
First OAE was done to all 320 neonates among whom 247 (77.8%) passed and 73 (22.8%) came as refer. Among those neonates who failed 1st OAE at first week of life repeat OAE was done around 45 days of age (6weeks).
Out of 320 neonates, 73 (22.8%) had failed in 1st OAE, among those 73 only 62 neonates came for second OAE (11 missed for follow up). Of these neonates 57 passed (91.93%) and 5 neonates failed 2nd OAE (8.064%). Out of 5 neonates who had failed in 2nd OAE, BERA was done and 4(80%) neonates failed while 1 passed BERA.
Key words: Hearing loss, neonates, BERA

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INTRODUCTION

Hearing impairment of children in the world constitutes a serious obstacle to their ideal development, education and language acquisition. The prevalence of neonatal hearing loss is known to be more than twice that of other newborn disorders such as congenital hypothyroidism and phenylketonuria[1,2].The Incidence of Bilateral congenital hearing impairment alone occurs in approximately 1 to 5 per 1000 live births, whereas when included with permanent unilateral hearing loss,incidence increases to 8 per 1000 live births[3,4,5].Indian studies performed using different hearing screening protocols have estimated the prevalence of neonatal hearing loss to vary between 1 and 8 per 1000 babies screened[6,7,8,9].The better prognosis of individual skills like language development, academic success, social integration and successful participation in the society can be attained by early identification and intervention for hearing loss i.e. by 6 months of age[5].

The critical period of brain development occurs in the 1st year of life, especially the auditory pathway. An inadequate stimulus during this time lead to suboptimal development of auditory system,whereas optimal auditory experience has a good influence on the functional development[10]. Hence, early detection is extremely important in providing suitable care, provision of hearing aid and special training for deaf and hearing-impaired babies will help them enjoy equal opportunities in society alongside all other children.

American Academy of Pediatrics (AAP) in 1999 advocated Universal New Born Hearing Screening

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Programme (UNHSP) and remedial intervention which is followed by most of the developed countries. In a developing country like India, the risk of infants to develop these difficulties is obviously more[11,12]. In India, newborn hearing screening are usually available only to newborns brought to tertiary referral hospitals[13,14].

There was an introduction of two-stage screening protocol with otoacoustic emission (OAE) as the first screen, followed by auditory brainstem response (ABR) for those who fail the first screen[15]. The AAP Task Force on newborn and infant hearing recommends UNHS by 3 months of age with intervention by 6 months of age. The Joint Committee on Infant Hearing (JCIH) position statement provides guidelines that include Newborn Hearing Screening (NHS) soon after birth, before discharge from hospital, or before 1 month of age, diagnosis of hearing loss through audiological and medical evaluation before 3 months, and intervention through interdisciplinary programme for infants with confirmed hearing loss before 6 months of age[16].

METHODOLOGY

STUDY POPULATION

All neonates admitted in NICU for more than 48 hours.

INCLUSION CRITERIA

a) All neonates admitted in NICU for more than 48 hours.

EXCLUSION CRITERIA

a) Neonates with congenital anomalies (craniofacial malformation).
b) Neonates admitted for less than 48 hours.
c) Neonates with family history of deafness.
d) Neonates who died or who have not completed OAE.

SAMPLE SIZE AND SAMPLING

The sample size for the study was calculated based on the 50.5% prevalence of hearing impairment reported in the study by Nair VS *et al.*, Based on this, the required sample size with 6% absolute precision and a confidence level of 95% was calculated using the formula,

Sample size, $n = \frac{z^2pq}{d^2}$

Where, z=1.96, Z score for 95% confidence level
p=0.50, prevalence of hearing impairment [13]
q=0.495
d=0.6, absolute precision of 6%. Thus

$n = 1.962 \times \frac{50.5 \times 49.5}{6^2} = 267$

Taking into account a non-response rate of 20% i.e. 53, the total sample size will be 320.

SYSTEMATIC SAMPLING

Technique was used where all neonates meeting the criteria was included in the study during the study duration until the sample size was reached.

STUDY PROCEDURE

After obtaining permission from the institutional ethical committee all neonates admitted in NICU fulfilling the inclusion and exclusion criteria were taken into the study after obtaining written informed consent from parents/guardian. Information regarding the condition of each neonate was collected in the form of a predesigned questionnaire which included: gestational age; family history of congenital hearing loss and consanguinity; presence of conditions including asphyxia(APGAR score<4), sepsis, respiratory distress syndrome, transient tachypnoea of newborn(TTN),congenital pneumonia, congenial heart disease(CHD) or hyperbilirubinemia(≥18 mg/d1);and treatments used including phototherapy (>2 days),mechanical ventilation (>5 days),antibiotic therapy including aminoglycosides(>5 days),or oxygen therapy(>1 week and > 40% FIO2).

The screening procedure was done in a sound treated room in the department or in a quiet room adjacent to the respective wards of concerned departments. The presence of unilateral or bilateral hearing loss was considered as deafness in this study. The Instruments used is transitory evoked otoacoustic emission (TEOAE) set at a 1.5kHZ to 4 kHz screen with 3 of 4 frequency bands being required to be present for a pass. The intensity was calibrated at an 83 dB sound pressure level peak equivalent (3dB).

The firststepof thescreeningwasperformedatdischarge fromNICUwiththeOAE measurement. For babies who failed to pass the initial screening, another OAE test wasperformed within 1 month after discharge, and those failing to pass the test again were referred to a pediatric otologist for comprehensive audiological assessments at 3 months.

DATA COLLECTION METHODS

Data was collected using a standard proforma on admission. After collecting basic information based on predesigned proforma screening for hearing loss was first performed at the time of discharge from NICU with the OAE measurement. For babies who failed to pass the initial screening, another OAE test was performed on the day of first immunization visit i.e.,6weeks(45days), and those failing to pass 2nd time were referred to a pediatric otologist for comprehensive audiological assessments at 3months.

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RESULTS

Table 1: Percentage Distribution of Cases According to OAE and BERA Assessments

Assessment done	Number of neonates	Percentage (%)
1st OAE (n=320)		
Pass	247	77.8
Refer	73	22.8
2nd OAE (n=62)		
Pass	57	91.93
Refer	5	8.064
BERA (n=5)		
Pass	1	20
Refer	4	80

First OAE was done to all 320 neonates among whom 247 (77.8%) passed and 73 (22.8%) came as refer. Among those neonates who failed 1st OAE at first week of life repeat OAE was done around 45 days of age (6weeks).

Out of 320 neonates, 73 (22.8%) had failed in 1st OAE, among those 73 only 62 neonates came for second OAE (11 missed for follow up). Of these neonates 57 passed (91.93%) and 5 neonates failed 2nd OAE (8.064%). Out of 5 neonates who had failed in 2nd OAE, BERA was done and 4(80%) neonates failed while 1 passed BERA.

Table 2: Comparison of Selected Variables Based on Risk Factors of First OAE

Risk Factor		Number of Frequency		Chi-square	P-value
		PASS	REFER		
Gestational age	Pre term	125(73.09%)	46(26.90%)	15.243	**0.002**
	Term	122(81.87%)	27(18.12%)		
Birth asphyxia	Present	19(86.36%)	3(13.63%)	1.138	0.28
	Absent	228(76.51%)	70(23.48%)		
RDS	Present	136(75.55%)	44(24.44%)	0.622	0.32
	Absent	111(79.28%)	29(20.71%)		
MAS	Present	22(70.97%)	9(29.03%)	0.753	0.38
	Absent	225(77.85%)	64(22.14%)		
TTN	Present	5(83.33%)	1(16.66%)	0.131	0.71
	Absent	242(76.82%)	73(23.17%)		
CHD	Present	27(77.14%)	8(22.85%)	0.000	0.995
	Absent	225(77.58%)	65(22.41%)		
Seizures	Present	15(51.72%)	14(48.27%)	11.74	**0.0001**
	Absent	232(79.72%)	59(20.27%)		
Sepsis	Present	71(67.61%)	34(32.38%)	8.164	**0.0004**
	Absent	176(81.86%)	39(18.13%)		
Hyperbilirubinemia	Present	152(77.15%)	45(22.84%)	0.000	0.99
	Absent	95(77.23%)	28(22.76%)		
Phototherapy	Present	152(77.15%)	45(22.84%)	0.298	0.862
	Absent	95(77.23%)	28(22.76%)		
Antibiotics	Present	89(70.78%)	38(29.92%)	6.04	**0.014**
	Absent	158(81.86%)	35(18.13%)		
NEC	Present	5(50.0%)	5(50.0%)	4.33	**0.031**
	Absent	242(78.06%)	68(21.93%)		
Oxygenrequirement	Present	155(74.16%)	54(25.83%)	3.131	0.07
	Absent	92(82.88%)	19(17.11%)		
Exchangetransfusion	Present	3(0.93%)	0(0.0)	0.895	0.344
	Absent	244(76.25%)	73(22.81%)		
CongenitalPneumonia	Present	34(10.62%)	10(3.12%)	0.000	0.99
	Absent	213(66.56%)	63(19.68%)		

Significance at the level ($p<0.05$) chi-square test

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Among risk factors, out of 171 preterm,46 failed (26.90%);among 21 neonates with birth asphyxia, 3 (13.63%) failed; out of 180 neonates with RDS,44(24.44%) failed; out of 31 neonates with MAS, 9 (29.03%) failed; among 6 neonates with TTN,1(16.66%) failed; out of 35 neonates with CHD, 8 (22.85%) failed; among 29 neonates with seizures,14(48.27%) failed, out of 105 neonates with sepsis, 34(32.38%) failed; out of 197 neonates with hyperbilirubinemia,197 received phototherapy, of which 45(22.84%) failed; out of 127 neonates who received aminoglycosides class of antibiotics, 38 (29.92%) failed; 10 neonates who had developed NEC, half of them (50%) failed; out of 44 neonates with congenital pneumonia, 10 (3.12%) failed; among 209 neonates who received oxygen 54 (25.83%) failed first OAE. Outof these factors **gestationalage (preterm),seizures, sepsis,NEC and antibiotics values were statistically significant (p<0.05).**

Table 3: Comparison of Selected Variables Based on Risk Factors of Second OAE

Risk Factor		Number of Frequency		Chi-square	P-value
		PASS	REFER		
Gestational age	Pre term	35(92.10%)	3(7.89%)	14.321	0.111
	Term	22(91.66%)	2(8.33%)		
Birth asphyxia	Present	1(100.0%)	0(0.0)	3.34	0.341
	Absent	56(91.80%)	5(8.19%)		
RDS	Present	32(94.11%)	2(5.88%)	1.32	0.751
	Absent	25(89.28%)	3(10.71%)		
MAS	Present	7(100.0%)	0(0.0)	1.018	0.79
	Absent	50(90.90%)	5(9.09%)		
TTN	Present	2(100.0%)	0(0.0)	0.106	0.991
	Absent	55(91.66%)	5(8.33%)		
CHD	Present	8(100.0%)	0(0.0)	1.24	0.745
	Absent	49(90.74%)	5(9.25%)		
Seizures	Present	12(92.30%)	1(7.69%)	13.83	**0.003**
	Absent	45(91.83%)	4(8.16%)		
Sepsis	Present	26(89.66%)	3(10.33%)	9.272	**0.026**
	Absent	31(93.99%)	2(6.06%)		
Hyperbilirubinemia	Present	41(95.34%)	2(4.65%)	3.02	0.389
	Absent	16(84.21%)	3(15.78%)		
Phototherapy	Present	41(95.34%)	2(4.65%)	3.811	0.085
	Absent	16(88.88%)	2(11.11%)		
Antibiotics	Present	29(90.65%)	3(9.375%)	6.609	0.061
	Absent	28(93.33%)	2(6.66%)		
NEC	Present	5(100.0%)	0(0.0)	7.366	0.061
	Absent	52(91.22%)	5(8.77%)		
Oxygen requirement	Present	41(93.18%)	3(6.81%)	2.25	0.521
	Absent	16(88.88%)	2(11.11%)		
Exchange transfusion	Present	0(0.0)	0(0.0)	0.78	0.86
	Absent	58(93.54%)	4(6.45%)		
Congenital Pneumonia	Present	9(14.51%)	0(0.0)	1.004	0.800
	Absent	49(79.03%)	4(6.45%)		

Significance at the level (p<0.05) Chi-square test

Out of 73 neonates who failed in 1st OAE, 2nd OAE was done at the time of first vaccination i.e., 6weeks (45days). Out of 73, 2nd OAE was done only on 62 neonates as others could not be followed up due to increasing COVID cases and Lockdown. Among the risk factors, out of 38 preterm, 3 (7.89%) failed; out of 34 neonates with RDS, 2 (5.88%) failed; out of 13 patients with seizures,1(7.69%) failed; among 29 neonates with sepsis, 3(10.33%) failed; among 43 neonates who received phototherapy, 2(4.65%) failed; among 32 neonates who received antibiotics, 3 (9.37%) failed; out of 44 neonates who received oxygen, 3(6.81%) failed. Out of all these risk factors values of neonates with seizures (p=0.003) and sepsis (p=0.026) were statistically significant.

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Table 4: Comparison of Selected Variables Based on Risk Factors of BERA

Risk Factor		Number of Frequency		Chi-square	P-value
		PASS	FAIL		
Gestational age	Preterm	1(25.0%)	3(75.0%)	3.348	0.764
	Term	0(0.0%)	1(100.0%)		
Birth asphyxia	Present	0(0.0%)	0(0.0%)	0.375	0.829
	Absent	1(20.0%)	4(80.0%)		
RDS	Present	1(33.33%)	2(66.66)	0.842	0.656
	Absent	0(0.0%)	2(100.0%)		
MAS	Present	0(0.0%)	0(0.0%)	0.545	0.762
	Absent	1(20.0%)	4(80.0%)		
TTN	Present	0(0.0)	0(0.0)	0.097	0.953
	Absent	1(20.0%)	4(80.0%)		
CHD	Present	0(100.0)	0(0.0)	5	0.2
	Absent	1(0.0%)	4(100.0%)		
Seizures	Present	0(0.0)	1(100.0%)	0.313	1
	Absent	1(0.0%)	3(100.0%)		
Sepsis	Present	0(62.5%)	3(100.0%)	3.744	0.152
	Absent	1(50.0%)	1(50.0%)		
Hyperbilirubinemia	Present	1(33.33%)	2(66.66%)	0.850	0.654
	Absent	0(80.0%)	2(100.0%)		
Phototherapy	Present	1(33.33%)	2(66.66%)	0.856	0.931
	Absent	0(80.0%)	2(100.0%)		
Antibiotics	Present	0(0.0%)	3(100.0%)	2.756	0.252
	Absent	1(50.0%)	1(50.0%)		
NEC	Present	0(0.0)	0(0.0)	0.164	0.921
	Absent	1(20.0%)	4(80.0%)		
Oxygen Requirement	Present	0 (0.0%)	2(100.0%)	0.942	0.623
	Absent	1(33.33%)	2(66.66%)		
Exchange transfusion	Present	0(0.0)	0(0.0)	0.048	0.946
	Absent	1(20.0%)	4(80.0%)		
Congenital Pneumonia	Present	0(0.0)	0(0.0)	0.810	0.667
	Absent	1(20.0%)	4(80.0%)		

DISCUSSION

Hearing loss can be considered as the most common birth defect. Early detection of hearing impairment by screening at or shortly after birth helps in appropriate intervention that are critical for speech, language and cognitive development. Universal Neonatal Hearing Screening (UNHS) is done in all child irrespective of presence or absence of risk factor to identify hearing impairment as early as possible to provide interventions.

This study was conducted for a period of 10 months, included a total of 320 neonates after excluding newborns who died (10), early discharge before OAE screening (8) and having family history of hearing loss (3). First OAE was done on 320 neonates of which 73 (22.8%) failed. This high number of false positives (22.8%) may be due to premature outer hair cells or due to incomplete clearance of normal fetal middle ear fluid as first OAE is done before discharge, which are the reasons to verify these results later with 2nd OAE after 6 weeks or with more specific methods such as BERA. Out of 73 who failed first OAE, 11 neonates were missed due to COVID and various other reasons so 2nd OAE was done only on 62 neonates, of which 5 (1.56%) failed and all these 5 neonates were followed up and among them 4 (1.25%) failed in BERA.

In our study 320 neonates were included and it showed that 4 out of 320 neonates failed BERA. Thus, the prevalence of hearing loss was 1.25%. A study by James M *et al*., 48 found the prevalence rate among high-risk newborns as 0.63% which is almost similar to our study. Following table shows prevalence of hearing loss among high-risk newborns in various studies.

Table 5: Comparison with other studies

Study on hearing loss in high risk newborns	Prevalence per 100 with first OAE	Prevalenceper100 with Second OAE	Prevalenceper 100BERA
Our study (n=320)	73 (22.8%)	5(1.56%)	4 (1.25%)
James M*etal*.[17](n=4628)	275 (6.4%)	44 (0.95%)	6 (0.63%)
Nair VS *et al*.,[18] (n=200)	101 (50.5%)	-	1 (0.5%)
Paul AK*et al.*[19](n=2031)	234 (11.52%)	78 (3.84%)	21 (1.03%)
Jose *et al*., [20] (n=231)	38 (6.1%)	4 (1.73%)	2 (0.86%)

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Prevalence of individual risk factor as in JCIH (Joint committee on infant hearing) includes 171 neonates are preterm (53.4%), 22 neonates had perinatal asphyxia (6.7%),hyperbilirubinemia requiring phototherapy were 197 neonates (61.6%), 209 (65.3%) required oxygen and ototoxic medicine were given to 127 neonates (39.7%).

Present study found prematurity (p=0.002) to be significantly related to failure of initial screening. Similar observation was seen in study by Nair VS *et al*.,(p=0.01), James M *et al*., (p=0.000) and Pourarian S *et al*., (p=0.013) where prematurity was significantly associated with hearing loss. Prematurity should be considered as one of the risk factors for hearing loss in NICU population, as their respiratory system is not fully developed which necessitates the oxygen requirement and infections occurring due to their weekend immune system which requires antibiotic coverage. Among these variables' we found that antibiotics (aminoglycosides) given (p=0.014) was significantly associated with hearing loss which was similar to the finding in a study by James M *et al*. (p=0.000), oxygen requirement was also seen to be associated with hearing loss (p=0.07) but it was not statistically significant. This was similar to the finding in the study by Pourarian S *et al.*

Present study also showed that 10 (3.12%) neonates out of 320 had developed NEC, among which 5 (1.56%) of them failed the initial screening (1st OAE) which was statistically significant (p=0.031) but all these 5 neonates passed in 2nd OAE.

We also found 29 (9.1%) neonates out of 320 had developed seizures of which 14 (4.37%) failed the initial screening and out of 14 neonate's 2nd OAE was done on 13 neonates as 1 missed follow up, among these 13 neonates 1 (7.69%) failed the 2nd OAE screening, both of which are statistically significant (p=0.0001 and p=0.003 respectively). A study by Bergman I *et al*., showed that 16.7% of neonates surviving seizures had developed hearing loss. However, there is lack of research on the correlation between seizures and NEC with hearing loss which needs further studies to find the association.

Sepsis is found to be associated with the failure of both 1st and 2nd OAE screening and is statistically significant (p=0.0004 & p=0.026) which is similar to the study by James M *et al*., but is in contrast the study by Pourarian *et al*., which may be explained by the smaller sample size.

Present study didn't show any statistically significant correlation between RDS,TTN, Congenital Pneumonia, CHD and Birth asphyxia with hearing loss, which is similar to the finding from the study by Pourarian *et al*.,

As described above many risk factors have been found to be associated with transient hearing loss among neonates (failure of initial screening). But the same association was not established for actual hearing impairment found in BERA. This could be attributed to premature outer hair cells in newborns or other physiological changes in newborn ear.

CONCLUSION

Even though high risk newborns are at greater risk, hearing evaluation is important in all newborn irrespective of presence of risk factor for hearing impairment. Two step evaluation with OAE followed by BERA are tend to be useful. And also, while dealing with these newborns unnecessary oxygen therapy and antibiotics should be avoided. Hearing aids are to be advised to those babies with hearing impairment as early as possible to avoid significant morbidity and disabilities associated with hearing loss.

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