International Journal of Contemporary Pediatrics
Nair VS et al. Int J Contemp Pediatr. 2018 Jul;5(4):1342-1347
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: http://dx.doi.org/10.18203/2349-3291.ijcp20182478

Original Research Article

Prevalence and risk factors of hearing impairment among neonates admitted in NICU in a tertiary care centre in South India

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Received: 26 May 2018
Accepted: 05 June 2018

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ABSTRACT

Background: Present study was conducted to assess the prevalence of hearing impairment using measurements of Otoacoustic Emission (OAE) in newborns admitted to NICU and to determine the risk factors predictive of hearing impairment in these newborns.
Methods: The study was conducted from January 2016 to June 2017 in the NICU under the Department of Pediatrics. All neonates admitted for more than 48 hours in the NICU were included. Neonates who died during the study period were excluded. All candidates underwent hearing loss in a sound treated room in the department using Distortion Product Otoacoustic Emissions (DPOAE) test at the time of discharge. Babies who failed this initial screening underwent another OAE test within 1 month after discharge, and those who failed the test again were referred to an Otologist for comprehensive audiological assessment at 3 months.
Results: Of the 200 neonates included in the study, 101cases (50.5%) failed the initial screening. 1 case (0.5%) failed the second OAE screening and moderate hearing loss was diagnosed in this child using BERA. Risk factors included mechanical ventilation ($p=0.01$), prematurity ($p=0.01$), low Apgar scores ($p<0.01$) and multiple gestation ($p<0.05$). Other conditions predominating in neonates who failed hearing screening included TTN, MAS, LBW and neonatal jaundice.
Conclusions: Newborn infants admitted to the NICU are at a higher risk for hearing impairment due to exposure to multiple risk factors. The two staged screening protocols with DPOAE is a useful protocol for detecting hearing loss in newborns and can be implemented as a national program.

Keywords: Early detection, Hearing loss, Newborn

INTRODUCTION

Hearing loss occurs in 1 to 6 cases per1000 live born infants. It may be associated with significant developmental delay in infancy and childhood, including verbal, mental, emotional and social impairments.

As per WHO estimates, in India, approximately 63 million people are suffering from significant auditory impairment. Thus, the estimated prevalence in Indian population is around 6.3%.[1]

In the last couple of decades, there has been a substantial development in the management of all types of cases in Neonatal Intensive Care Unit (NICU) with a significant drop in the mortality rate of high risk newborn infants. However, cases having severe asphyxia, severe infection, congenital anomalies, and severe respiratory distress may result in serious sequelae like hearing loss. The incidence of bilateral hearing loss is estimated at 2 to 5 cases for every 100 newborns, much higher than the low risk population with prevalence of 1 to 3 cases per1000 live births.[2] Many studies have reported that damage due to

hearing loss in infancy is often irreversible, affecting not only the development of speech and language but also the cognitive, intellectual, cultural, and social child development. Neonates with congenital hearing loss should be identified within the first 3 months of life. However, the average age at detection is usually 24-30 months.[3] Early acoustic stimulation, especially at six months of age, leads to increased nerve connections and consequently better rehabilitation of auditory pathways. Universal neonatal hearing screening (UNHS) is the first step in a neonatal hearing health program.

METHODS

This prospective cross-sectional study was conducted in the Institute over a period from January 2016 to June 2017. Approval was taken from the Institutional Human Ethics Committee before commencement.

All neonates admitted in NICU for more than 48 hours during this period were included in the study. Neonates who died or who had not completed the study were excluded. Written informed consent was obtained from the parents.

Information about each neonate was collected in the form of a questionnaire that included birth weight, gestational age, family history of congenital hearing loss, consanguinity, presence of conditions including asphyxia (Apgar score < 4), sepsis, respiratory distress syndrome, transient tachypnea of newborn (TTN), congenital pneumonia, craniofacial anomalies, congenital heart disease (CHD), or hyperbilirubinemia (≥18 mg/dL); and treatments used including phototherapy (>2 days), mechanical ventilation (>5 days), antibiotic therapy including Aminoglycosides (>5 days), use of other ototoxic drugs 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. Presence of unilateral or bilateral hearing loss was considered as deafness. Instrument used was Distortion Product OAE screener (DPOAEs), set at 2 to 5 kHz screen and 3 of 4 frequency bands was required to be present for a pass.

The intensity was calibrated at 65 dB sound pressure level for band 1 and 55 dB sound pressure level for band 2. Initial attempts were made to screen the child without sedation.

However, babies who were not cooperative had to be sedated after due written expressed consent from the parents.

The first step of screening was performed with the OAE measurement on discharge from NICU. Babies who had failed the initial screening had to undergo another OAE test during the 1st vaccination visit and those failing the test again were referred to an Otologist for comprehensive audiological assessments at 3 months of age. The study was terminated on inclusion of 200 babies.

Statistical analysis was done with SPSS version 20.0. P values of 0.05 or less were considered statistically significant.

RESULTS

200 neonates were included in the study. Results of first OAE screening were analysed and it showed both ears pass in 99 (49%) neonates, while 52 (26%) neonates had both ears fail. 34 (17%) neonates showed only left ear fail and 15 (8%) neonates showed only right ear fail (Table 1).

Table 1: Results of first OAE screening.

Total number of neonates (%)	NO. neonates with passed test in both ears (%)	Number of neonates with failed test in both ears (%)	Number of neonates with failed test in left ear (%)	Number of neonates with failed test in right ear (%)
200	99 (49)	52 (26)	34 (17)	15 (8)

On examining the characteristics of the population under study, authors found that prematurity (p = 0.01) and low Apgar scores at 1 minute and 5 minutes (p< 0.01) were statistically associated with failure on initial hearing screening. Also, birth weight less than 2.5kg was associated with failed hearing screening even though it was not statistically significant (Table 2).

Maternal characteristics were studied to look for significant risk factors (Table 3). Multiple gestation, Gravida 4, Gravida 5 and breech presentation were found to be strongly associated with failure of initial screening.

Caesarean section deliveries were associated with more pass rates (65.4%) in hearing screening. It could be due to the timely intervention and lesser chances of birth asphyxia.

Pregnancy associated risk factors like Gestational Diabetes Mellitus and Gestational Hypertension were

found to be linked with temporary hearing impairment which was statistically significant. Intake of drugs by the mother was not associated with failure of screening. Drugs in this study included Eltroxin, Labetalol and Insulin.

Table 2: Correlation between birth characteristics of NICU neonates and failure of initial hearing screening.

Characteristic		Number of neonates (%)	Infants who passed screening n= 99(%)	Infants who failed screening n= 101(%)	p value
Gender	Male	120 (60)	61 (50.8)	59 (49.1)	0.64552
	Female	80 (40)	38 (47.5)	42 (52.5)	0.66
Gestational age	<37 weeks	61 (30.5)	9 (14.75)	52 (85.4)	0.01
	≥37 weeks	139 (69.5)	49 (35.2)	90 (64.7)	0.01
Birth weight	≤2500 gm	77 (38.5)	34 (44.1)	43 (55.8)	0.23014
	>2500 gm	123 (61.5)	65 (52.8)	58 (47.1)	0.23
Apgar score at 1 min	2	13 (6.5)	0	13 (100)	0.00022
	3	15 (7.5)	0	15 (100)	0.05
	4	7 (3.5)	0	7 (100)	0.00758
	8	165 (82.5)	99 (60)	66 (40)	0.01
Apgar score at 5 min	2	7 (3.5)	0	7 (100)	0.00758
	5	16 (8)	0	16 (100)	0.01
	6	12 (6)	0	12 (100)	0.0004
	9	165 (82.5)	99 (60)	66 (40)	0.01

Table 3: Correlation between maternal characteristics and initial hearing screening failure.

Characteristic		Number of neonates (%)	Infants who passed screening, n= 99(%)	Infants who failed screening, n = 101(%)	*p* value
Maternal age	16 – 25 years	125 (62.5)	60 (48)	65 (52)	0.58232
	26 – 35 years	75 (37.5)	39 (52)	36 (48)	0.58232
Gravida	Primi	92 (46)	47 (51.1)	45 (48.9)	0.6818
	2	45 (22.5)	18 (40)	27 (60)	0.14706
	3	33 (16.5)	17 (51.6)	16 (48.4)	0.80258
	4	25 (12.5)	17 (68)	8 (32)	0.0477
	5	4 (2)	0	4 (100)	0.0455
	6	1 (0.5)	0	1 (100)	0.32218
Consanguinity	Consanguineous	26 (13)	11 (42.3)	15 (57.6)	0.42952
	Non-consanguineous	174 (87)	88 (50.5)	86 (49.4)	0.42952
Mode of delivery	Normal vaginal delivery	140 (70)	62 (44.2)	78 (55.7)	0.02444
	Caesarean section	55 (27.5)	36 (65.4)	19 (34.6)	0.00544
	Forceps assisted delivery	5 (2.5)	1 (20)	4 (80)	0.18024
Indication for Caesarean section	Breech	16 (8)	12 (75)	4 (25)	0.03318
	Fetal distress	11 (5.5)	7 (63.6)	4 (36.3)	0.33706
	Oligohydramnios	11 (5.5)	6 (54.5)	5 (45.4)	0.72786
	IUGR	8 (4)	5 (62.5)	3 (37.5)	0.45326
	PROM	6 (3)	4 (66.6)	2 (33.3)	0.39532
	PPROM	3 (1.5)	2 (66.6)	1 (33.3)	0.5485
Complications during pregnancy	Hypothyroidism	1 (0.5)	0	1 (100)	0.33128
	Thick MSL and oligohydramnios	11 (5.5)	3 (3)	8 (72.7)	0.12852
	GHTN and GDM	8 (4)	1 (12.5)	7 (87.5)	0.03236
Drugs taken during pregnancy	Yes	6 (3)	1 (16.6)	5 (83.3)	0.1031
	No	194 (97)	98 (50.5)	96 (49.4)	0.1031

Among the risk factors in NICU, mechanical ventilation was found to be associated with increased incidences of defective hearing (Table 4).

Risk factors such as hyperbilirubinemia, phototherapy, exchange transfusion, administration of aminoglycoside antibiotics and exposure to radiation were not found to be statistically significant, contrary to other studies.

A univariate analysis of risk factors for hearing screening outcomes was done and it showed that multiple gestation ($p < 0.01$) and low gestational age (< 33weeks) ($p = 0.05$) were linked with failed hearing during initial screening (Table 5).

However, it did not show any correlation between birth weight and maternal age and failed hearing screening.

Table 4: Correlation between NICU risk factors after birth and failure of initial hearing screening.

NICU risk factor		Number of neonates (%)	Infants who passed screening, *n* = 99(%)	Infants who failed screening, *n* = 101(%)	*p* value
Hyperbilirubinemia	Yes	99(49.5)	52 (52.5)	47 (47.4)	0.39532
	No	101(50.5)	47 (46.5)	54 (53.4)	0.39532
Phototherapy given	Yes	99 (49.5)	52 (52.5)	47 (47.4)	0.39532
	No	101 (50.5)	47 (46.5)	54 (53.4)	0.39532
Exchange transfusion	Yes	4 (2)	1 (25)	3 (75)	0.32218
	No	95 (47.5)	51 (53.6)	44 (46.3)	0.25848
No. of days of phototherapy	1	4 (2)	0	4 (100)	0.455
	2	58 (29)	27 (46.5)	31 (53.4)	0.59612
	3	23 (11.5)	14 (60.8)	9 (39.1)	0.24606
	4	6 (3)	4 (66.6)	2 (33.3)	0.39532
	5	3 (1.5)	0	3 (100)	0.08364
	6	1 (0.5)	0	1 (100)	0.32218
Mechanical ventilation	Yes	84 (42)	1 (1.1)	83 (98.8)	0.01
	No	116 (58)	98 (84.4)	18 (15.5)	0.01
No. of days of mechanical ventilation	2	17 (8.5)	0	17 (100)	0.01
	3	17 (8.5)	0	17 (100)	0.01
	4	28 (14)	1 (3.5)	27 (96.4)	0.01
	5	20 (10)	0	20 (100)	0.01
	6	1 (0.5)	0	1 (100)	0.32218
	10	1 (0.5)	0	1 (100)	0.32218
Administration of ototoxic drug (Aminoglycosides)	Yes	23 (11.5)	13 (56.5)	10 (43.4)	0.47152
	No	177 (88.5)	86 (48.5)	91 (51.4)	0.47152
Exposure to radiation	Yes	114 (57)	56 (49.1)	58 (50.8)	0.90448
	No	86 (43)	43 (50)	43 (50)	0.90448

Table 5: Analysis of risk factors for hearing screening outcomes.

Risk factors	Passed hearing (N = 99)	Failed hearing (N = 101)	*z* test	*t* test	df	*p* value
Gestational age (weeks)	38.6±3.77	32.58±3.79	-	0.03741	198	0.05
Birth weight (g)	2.68±0.71	2.68±0.70	-	0.0	198	>0.999
Maternal age (years)	24.39±3.83	24.34±3.83	-	0.09231	198	0.9265
Multiple gestation	17 (8.5%)	56 (28%)	-5.6212	-	-	0.01

DISCUSSION

Hearing plays a key role in speech development. Without speech and hearing, it is difficult for interpersonal relationships to develop and thrive. Universal newborn hearing screening is either recommended or already practiced and legally regulated in a number of developed

countries in the West but is yet to become a national reality in India.

In present study, 1 out of 200 neonates failed BERA. Thus, the prevalence of hearing loss was 0.5%. A study from Kerala done by Jose DJ et al found the prevalence rate among high risk neonates to be 0.9% which is similar to present observation. Two other studies had also found the prevalence to be 0.7% and 0.13%.[4,5]

In present study, unilateral hearing loss was found in 49 (24.5%) and bilateral hearing loss was found in 52 (26 %) neonates in the first hearing test. Vasistha et al found prevalence of unilateral and bilateral hearing loss to be 7% and 8% respectively.[6] Riper et al reported a predominance of bilateral hearing loss.[7] However, Meyer et al reported almost equal incidence of unilateral (3.2 %) and bilateral (2.05 %) hearing loss.[8]

Prevalence of individual risk factor as in JCIH includes preterm birth (30.5%), perinatal asphyxia (17.5%), and hyperbilirubinemia requiring phototherapy (49.5%), assisted ventilation (42%) and exposure to ototoxic drugs (11.5%).

Present study found prematurity ($p = 0.01$) to be significantly related to failure of initial screening. Similar observation was seen in study by Pourarian S et al where prematurity (gestational age of less than 36weeks) was significantly ($p=0.013$) associated with hearing loss.[9] Due to their underdeveloped respiratory system, preterm neonates require prolonged oxygen. Additionally, they are also vulnerable to various infections on account of their weak immune mechanism, thus exposing them to medications, few of which are ototoxic.

Authors also observed that low Apgar scores at 1 min and 5 mins of birth was significantly associated with hearing loss ($p<0.01$). However, a study by Amini E found no statistical association between hearing impairment and low Apgar cores.[10] Some studies have also pointed out that asphyxia and low Apgar score are the reasons for temporary hearing loss but not permanent loss. Jiang et al reported that after 3 days of hypoxic-ischemic damage to central auditory system, it tends toward recovery and after 1 week the system recovers significantly.[11]

This study also found that multi gravid mother ($p<0.05$) is a significant risk factor. There is lack of research on the correlation between multiple gestations and hearing loss. Complications such as breech delivery ($p<0.05$) and gestational hypertension with gestational diabetes mellitus ($p<0.05$) were also found to be statistically significant risk factors. Iiknur et al also found that the type of delivery was a significant risk factor in newborns with hearing impairment.[12]

Kumar P et al observed increased incidence of hearing loss in newborns mechanically ventilated for more than 5 days.[13] Present study also found that mechanical ventilation ($p= 0.01$) was strongly associated with temporary hearing loss. But no correlation was seen with the duration of ventilation. This could be due to the small sample size.

Present study did not show statistically significant correlation between aminoglycoside administration, phototherapy or hyperbilirubinemia with hearing loss, which is in contrast to some of the other studies and this again may be explained by the smaller sample size.[14]

Authors had found that various risk factors contribute to transient hearing loss among neonates. But authors could not conclude if these factors actually contributed to actual hearing impairment as except 1 neonate, other newborns who had failed initial screening passed the 2nd stage test. This could be attributed to premature outer hair cells in newborns or other physiological changes in newborn ear. The high number of false-positive cases in the present study (50.5%) may be due to incomplete clearance of normal fetal middle ear fluid and is another good reason as to why the results of hearing screening performed before discharge from the hospital should always be verified by the second OAE test after several weeks or more specific methods such as BERA.

CONCLUSION

In a developing country like India, there is a dilemma on proper implementation of new born hearing screening due to poor compliance by parents for follow up and a lack of general awareness on early identification and immediate intervention. If screening is performed before the discharge, percentage of false positive results is very high because of the incomplete clearance of normal fetal middle ear fluid. Hearing screening can be performed at the time of follow up visit or at least during visit for infant's vaccinations (after 4-6 weeks of life). However, it is likely that in such situations the population of screened infants would be smaller.

Systematic and sustained advocacy by Pediatrics and Otorhinolaryngological Associations and widespread public health education, combined with strong health care guidelines may be the catalyst for change at the national level and may one day lead to the implementation of a National Universal New born Hearing Screening programme.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Human Ethics Committee of the Institute

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Cite this article as: Nair VS, Das P, Soundararajan P. Prevalence and risk factors of hearing impairment among neonates admitted in NICU in a tertiary care centre in South India. Int J Contemp Pediatr 2018;5: 1342-7.