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Neonatal Hearing Screening: A Retrospective Study at our Tertiary Care Center

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ABSTRACT

Hearing loss is one of the most common congenital disorders, interfering with normal development of speech and language during childhood. Hearing screening in neonates helps in early detection and intervention, which reduces the burden of deafness in community. To assess the incidence of hearing loss among neonates at our tertiary care centre. This retrospective study involved all neonates who underwent neonatal hearing screening, conducted for the period from June 2023 to May 2024. Initial screening involved aDPOAEs [automated distortion product otoacoustic emissions]. Second screening was done either before the discharge from hospital or within 3rd month of age by aDPOAEs and AABR[automated auditory brainstem response] for those neonates who failed 1st screening and with risk factors. AABR referred neonates were subjected for detailed diagnostic evaluation and for passed neonates, phone follow-up was done. Participant's demographics were recorded such as age, gender, cry after birth, birth weight, mode of delivery, term/pre-term, NICU stay etc. Total 1625 neonates underwent initial hearing screening. Out of them, 94 failed and rest passed. All 94 underwent second OAE screening, with 27 refer results. Total 249 neonates undertook AABR test, with 26 refer results. After detailed evaluation, 9 neonates had confirmed hearing loss. Among them, one case was identified by phone follow-up. There was clinically significant association between hearing impairment and high-risk factors such as consanguinity, LBW, delayed birth cry, Neonatal jaundice, NICU stay for >5days and premature delivery. Hearing screening should be mandatory for all newborn babies to recognize hearing loss in pre-linguistic period.

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Key Words
Hearing loss, neonatal hearing screening, oto-acoustic emissions, auditory brainstem response

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INTRODUCTION

Hearing loss is one of the most common congenital disorders, with an estimated incidence of 1-3/1000 live births[1,2].Hearing impairment in 1st three years of life may impair the full development and maturation of auditory system and that deafness in infancy and childhood interferes with normal development of speech and language. In the absence of normal speech, child's communication ability is hampered and this has a negative impact on child's social, emotional, cognitive and academic development[3,4].

Joint Committee on Infant Hearing (JCIH) had given risk factors to identify high-risk infants[5].Newborn hearing screening involving those newborn "with risk factors" for hearing loss is called high-risk register (HRR)[6]. But, No risk factor had been seen in 50% of the infants with hearing loss[7]. Therefore, universal hearing screening in neonates is required to dampen misdiagnosis[8].Guiding principle for newborn hearing screening is"1-3-6" principle, all infants should undergo hearing screening within their neonatal life, those with failed initial screening and subsequent re-screening should have audiological evaluation by 3 months of age and proper intervention and rehabilitation should begin within 6 months of age[9-11].

Advances in audiological testing equipment and techniques allow accurate hearing screening of the newborn, using either automated Oto-acoustic emissions (aOAEs) or automated Auditory Brainstem Response (AABR). OAE is fast, efficient, frequency-specific measurements of peripheral auditory sensitivity and highly cost-effective tool[12-14].

OAE is available as handheld portable equipment with a pass/refer criterion. Sound signals are presented by probe in both external auditory canals alternatively. Response is measure of outer hair cell and cochlear function. "PASS" results show no hearing loss. "REFER" results require further assessment. OAE can be done in awake infants whereas ABR requires the infant to sleep. However, OAE is not helpful when there is outer or middle ear dysfunction or debris/blockage in the ear canal[13,14].

ABR is more sensitive to central/neural auditory disorders, reliable and objective test but difficult to perform, otoacoustic emission is a practicable screening modality[15]. Both A-ABR and OAE technologies may miss delayed-onset hearing loss, mild hearing loss, or hearing loss that is present only at isolated frequencies[16]. Therefore, monitoring of hearing, speech and language milestones throughout childhood is essential[7].

Objectives: To assess the incidence of hearing loss among neonates in our tertiary care center.

MATERIALS AND METHODS

This is a retrospective study, done by collecting the data of neonatal hearing screening from ENT Department audiology records of Bidar institute of medical sciences (BRIMS), Bidar from June 2023 to May 2024.

Inclusion Criteria:

- All neonates born at BRIMS, Bidar.
- All neonates admitted to BRIMS, Bidar Neonatal intensive care unit (NICU) and those referred to the ENT Department BRIMS, Bidar for hearing assessment.

Exclusion Criteria:

- Neonates requiring continuous cardio-respiratory monitoring or on a ventilator or in an incubator.
- Neonates with contagious skin conditions (involving skin around ears and on scalp).

All neonates who satisfied inclusion criteria, had detailed examination and by proper medical history, potential risk factors (Table-1) were identified. Neonatal hearing screening protocol followed at our centre is mentioned in flow chart-1.All neonates underwent automated distortion product otoacoustic emission (aDPOAE) as initial screening tool for hearing assessment. For OAE pass results, no further testing done in neonates with no risk factors.

For first OAE refer results and those neonates with risk factors, neonates were subjected to repeat testing with aDPOAE and AABR either before discharge from hospital or within 3months of age. For AABR refer results, detailed diagnostic evaluation was done within a month. For pass results, Phone follow-up was done at 3, 6 and 12 months, to prevent from missing delayed onset hearing loss cases. During Phone follow-up, enquiry with regards to overall development milestones of infant and counselling with regard to parent-child interaction and language stimulation was done. Infants with confirmed hearing loss were referred for proper interventions within 6 months of age.

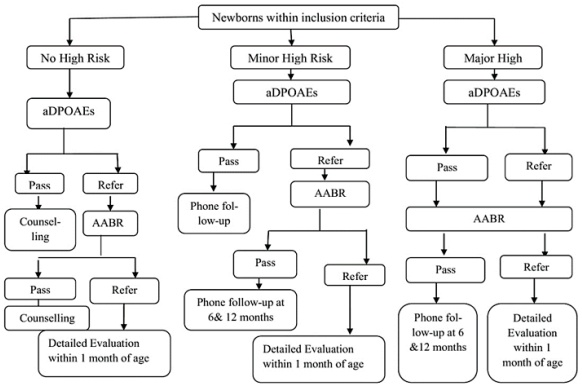

Chart 1: Newborn Hearing Screening Protocol

Table 1: Major High Risk Factors

Consanguinity	Birth asphyxia
Deaf sibling	APGAR score <4 at 1min and <6 at 5min
Family History	Fetal distress
Elderly pregnancy (>35yrs)	NICU stay (>5days)
Excessive vomiting (after 3months of pregnancy)	Cranio-facial/structural anamolies
High/low BP	Post Viral/bacterial infections
In-utero infections (TORCHS)	Convulsions
Low birth weight <1500g	Trauma to head/neck
Neonatal jaundice	Neurodegenerative diseases
Delayed birth cry	Syndromes, if any
Minor High Risk Factors	
History of (H/O) ototoxic medications	
H/O multiple abortion	
Rh factor incompatibity	
Alcohol consumption/smoking	
Maternal diabetes	

RESULTS AND DISCUSSIONS

Among 1625 neonates, there were 839 males and 786 females (chart-2). Screening was done within 7 days of age in 1136 (69.9%) neonates and for age group 7-30 days in 489 (30%) neonates. Study population had 1443 (88.8%) neonates without high risk factors and 182 (11.2%) neonates with high risk factors (170 major, 2 minor and 10 both minor and major).

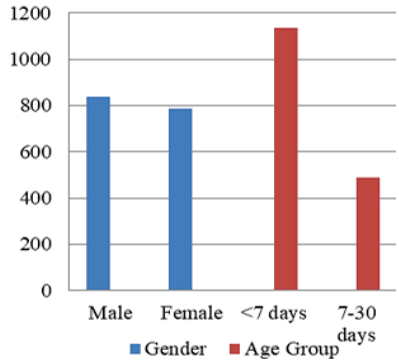

Chart 2: Gender and Age distribution of neonates

All neonates underwent screening with aDPOAEs at initial stage. 94 Neonates had Bilateral (B/L) refer results on first OAE test. These 94 Neonates along with neonates with risk factors were called for 2nd screening which involved repeat OAE and AABR. Out of 94, 24 Neonates had bilateral refer results and three neonates had unilateral refer result and rest passed for second OAE. Total 249 neonates underwent AABR, with refer results for 26 neonates. Out of them, 4 (15%) neonates had 2nd OAE pass results and for 5 (18%) AABR refer results, 2nd OAE passed (Table-2).

Table 2: 2nd OAE vs. AABR Results

		AABR			
	Results	**Pass**	**Refer**	**Not done**	**Total**
OAE	Pass	218	4	1376	1598
	Refer	5	22	0	27
	Total	223	26	1376	1625

The distribution of neonates, according to the risk factors and their association with neonatal hearing screening (aDPOAEs) is depicted in table-3. History of parental consanguinity was noted in 145 neonates, with 3 refer results in 2degreeand 8 refer results in 3degree consanguineous marriages respectively. Consanguinity had significant causal association with hearing loss in neonates, as p-value for it was <0.05.

There were 63 neonates with H/O delayed birth cry. Among them, 59 neonates showed pass results and 4 showed refer results. There were 44 neonates with premature delivery. Out of 44 neonates, 36 had pass and 8 had refer OAE results respectively. There is clinically significant association between hearing loss, delayed birth cry and premature delivery as p-value <0.05 for their chi-square test.

In our study, 114 Neonates had jaundice, 112 had pass and 2 had refer OAE results among them. Neonates staying in NICU for >5days were 148 in count, out of them, 131 had pass and 17 had refer OAE results respectively. As shown in table-3, Neonatal jaundice and NICU stay >5 days are significantly associated88307-44000-10000 with hearing loss in neonates.

There were 77 neonates with low birth weight i.e.<2.5Kg. Out of 77, low birth weight (LBW) neonates, 65 had pass and 12 had refer OAE results respectively. In our study, 67 neonates with normal birth weight had refer OAE results. Calculated p-value is <0.05 for association between hearing impairment and LBW, thereby proving their clinically significant association. Five neonates had history of maternal(TORCHS) infections, 4 of them passed OAE and one had refer result. There were 8 cases with elderly pregnancy (>35yrs), all of them passed OAE. There was no link between hearing loss, matrenal (TORCHS) infections and elderly pregnancy.

There were 5 neonates with family history of communication disorders. 2 had H/o hearing loss and 3 had H/o Speech-language disorder. On first screening, 2 had refer results. Among them, one had a sibling with H/o hearing loss. There were no cases of congenital cranio-facial/structural anamolies, trauma to head/neck, neurodegenerative diseases, maternal hypertension, diabetes, H/O of ototoxic medications, Rh incompatibity, alcohol consumption/smoking.

Table 3: Association Between First OAEs Results and Various Risk Factors Among Neonates

			Oto-acoustic emissions(OAE)		
			Pass	Refer	P-value*
Risk factors	Consanguinity	Negative	1397	83	0.001
		2 degree	3	3	
		3 degree	131	8	
	Low birth weight	Yes	65	12	0.001
		No	1466	82	
	Delayed birth cry	Yes	59	4	0.011
		No	1472	90	
	Neonatal jaundice	Yes	112	2	0.05
		No	1419	92	
	Premature Delivery	Yes	35	8	0.001
		No	1496	85	
	NICU>5 days	Yes	131	17	0.002
		No	1400	77	
	Mothers Viral/ bacterial infections (TORCHS)	Yes	4	1	0.173
		No	1527	93	
	Elderly pregnancy (>35yrs)	Yes	8	0	0.712
		No	1521	94	

Among 26 neonates with AABR refer results, 9(0.5%) neonates had confirmed significant hearing loss on detailed diagnostic evaluation, 5 neonates lost for follow up, 2 neonates died and 10 had normal hearing. One hearing impaired infant was identified by phone follow-up. Incidence of hearing loss in our study is 5.5 cases /1000 neonates. Out of 9 hearing impaired neonates, 4 neonates had (<40dBHL) mild hearing loss, 2 (40-70dBHL) moderate and 3 had severe (>70dBHL) hearing loss. Maximum had sensorineural hearing loss i.e. 8 neonates, only one had conductive hearing loss. Among them, one had auditory neuropathy spectrum disorder (ANSD) and 2(0.13%) neonates had no risk factor.

As per the WHO report, there are about 250 million people with hearing impairment in the world and is the second most common cause of disability. The WHO estimates that every year 38,000 children with hearing impairment are born in Southeast Asia. India has 6.3% prevalence rate of moderate to severe hearing impairment[17].The hearing loss in infants without high risk factors was seen as 0.09-2.3%[18,19] and in the high-risk infants, it was seen in 0.3-14.1%[20,21].In our study, there were 7 neonates with hearing loss had high risk factors and two neonates with hearing loss had no risk factor accounting for 3.8% and 0.13% prevalence respectively.

On analyzing the age distribution of patients, it was observed that the mean age of neonates at hearing screening was 5.8 days. In 70% neonates, screening was done within 7 days and for majority within 72 hrs of age.

According to Driscoll study, 1.43% of infants with a positive family history of congenital hearing loss[22]. Family history of hearing loss is seen usually along with consanguinity and the hearing loss in infants depends on the degree of parental consanguinity[23,25].In the present study, eleven infants with parental consanguinity had refer result on OAE. Out of them, 4 (44%) neonates had significant hearing loss. Hence, Public awareness must be created with regards to discouraging consanguineous marriage.

In our study, two infants with a family history of deafness had refer result on OAE. One confirmed significant hearing loss. Nagapoornima[26] recorded that out of total eight cases screened with a family history of childhood sensorineural hearing loss, two (25%) cases were set up to cause hearing impairment. In the study done by John they reported that 5.2% of cases of failed hearing screening by OAE had birth weight less than 1500 g[27].Low birth weight is also included as a risk factor for hearing impairment in JCIH 2000 criteria[28]. In our study, out of 77 low birth weight (LBW) neonates, 12 had refer OAE results on first screening, one among them had significant hearing loss. Such a lower rate of hearing impairment in our study could be due to higher mortality in low birth weight (LBW) neonates and lost for follow up.

In our study, 5 neonates with significant hearing loss had H/o NICU stay for >5 days accounting for 55% cases with hearing loss. It was the most common risk factor in our study. Hearing loss in hospitalized infants may be due to delayed maturation of the auditory system[29].The risk factors which have been identified for the development of ANSD in different literatures are intracranial hemorrhage, asphyxia, hyperbilirubinemia, prematurity, low birth weight, neonatal ventilation, ototoxic drug exposure, dysmorphic features, low Apgar scores, respiratory distress, cytomegalovirus infection, sepsis, meningitis, asphyxia, and family history of hearing loss. In our case of ANSD, risk factors were prematurity, low Apgar scores and NICU stay >5 days[30-32].

Our study showed significant association between hearing loss and premature delivery. Prematurity and low birth weight were present in combination in most cases of hearing loss among NICU admitted neonates. This finding is in accordance with other studies in literature[33]. Hearing loss is a severe consequence of prematurity., its prevalence is inversely related to the maturity of the baby. Premature infants have many concomitant risk factors which influence the occurrence of hearing deficit[34].

In our study, out of 94 neonates who failed 1st screening, on 2nd screening with OAE, 67(71.2%) had pass and 27 (28.8%) had refer results. Those

underwent 2nd screening with AABR, 26 had refer results. For 4 (15%) neonates with 2nd OAE refer, AABR passed and for 5 (18%) AABR refer results, 2nd OAE passed. Out of 26 neonates who failed 2nd screening, 9 neonates had confirmed hearing loss after detailed evaluation. So, only 9 (9.5%) neonates among those who failed 1st screening had confirmed hearing loss, resulting in high false-positive rate.

OAE and ABR both tests have advantages and disadvantages. The false positive rate for OAE testing is 5%-21% and for ABR testing is 4% during the first three days of life. This large variation between ABR and OAE testing is commonly felt to reflect the OAE testing device's increased sensitivity to residual amniotic fluid and vernix in neonate's ear canal. High false positive rate is the most worrying issue for newborn hearing screening which may cause persistent anxiety and adversely affect parent-child relationships[34-37]. Lower referral rates is achieved when OAE combined with automated ABR in a two step screening strategy.

In our study, only 9(0.5%) neonates had confirmed significant hearing loss on detailed diagnostic evaluation. This rate is much lesser than initial screening and re-screening referral rates. This is in concordance with literature which has given a range varying from 0.18%-0.5%[38,39].

In our survey, few ante-natal risk factors for hearing loss were not significant such as mothers (TORCHS) infections and elderly pregnancy. Similar findings were observed by Gouri[40]. In our study, significant number of neonates had lost for follow up. It could be because 70% of our study population belonged to rural areas, with lack of parental education and low socio-economic status. Appropriate rehabilitative measures such as hearing aids, speech/language therapy and cochlear implants were proposed to those with significant hearing loss.

- **Analysis:** Data has been analyzed by using IBM SPSS 27.0 statistical software and Statistical significance checked by performing the Chi-square test.

CONCLUSION

The prevalence of hearing loss in high risk neonates and normal neonates was 3.8% and 0.13% respectively among the study group. All neonates should undergo hearing screening as early as possible after birth with OAE as screening tool. OAE combined with ABR reduces false-positive results, thereby decreasing unnecessary parental anxiety. Early diagnostic evaluation by 3 months and appropriate intervention by 6 months age has positive impact on overall child development.

Declarations:

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Conflict of Interest: None.

Ethical Approval: The study was approved by the Institutional Ethics Committee.

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