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ORIGINAL ARTICLE

Screening of Hearing in Infants at Risk in a Tertiary Care Centre: A Descriptive Cross- sectional Study

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Abstract

Background: Screening of hearing impairment in children facilitates earlier identification, management and prevention of disability. The objective of this study was to perform a screening of hearing in infants at risk in Tribhuvan University Teaching Hospital.

Methods: A descriptive cross-sectional study was done among 228 infants who were at risk of hearing loss. All 'at risk' infants born to mothers in Tribhuvan University Teaching Hospital and 'at risk' children below one year of age admitted in the pediatric ward and intensive care unit were screened for hearing loss by automated otoacoustic emission (OAE) and automated auditory brainstem reflex (ABR). The results were categorized as pass or refer (fail). The association between hearing loss and the potential risk factors was analyzed.

Results: Out of 228 infants screened, 117 (51%) were male and 111 (49%) were female. Seventy (30.7%) failed OAE and 44 (19.3%) failed ABR. Univariate analysis (Pearson Chi-square test) showed that the failure rate for ABR was significantly associated with preterm babies ($p = 0.009$), low birth weight ($p = 0.009$), usage of ototoxic drugs ($p = 0.03$), and intensive care unit stay of more than five days ($p = 0.03$). Only preterm birth was significantly associated with failed OAE test ($p = 0.03$).

Conclusion: Premature birth (gestational age < 34 weeks) was associated with failure of the ABR and OAE tests. The infants with low birth weight, history of ototoxic drugs, ICU stay more than 5 days were only associated with ABR test failure.

Keywords: auditory brainstem reflex, hearing loss, otoacoustic emission, screening

The incidence of hearing impairment varies from 1 to 3 cases per 1000 healthy newborns.[1] Its incidence is as high as 10% in the high-risk group.[2] The causes for hearing loss can be either congenital or acquired. Auditory stimuli within the first six months of life are crucial for speech and language development resulting in better school outcomes, and improved communication skills.[3] The hearing loss is usually detected at around 20 months when parents express concern for their child's delay in language milestones.[4] However, screening can identify it within three months or younger and intervention can be done by six months of age which is critical for global development.[3,5] Hearing aids fitting age has been reduced to 5-7 months from 13-16 months because of the early screening program.[6] However, such a program is limited to the developed countries. Targeted screening, also known as "at-risk" screening, is suitable for the developing world, saving cost and resources. The Joint Committee on Infant Hearing (JCIH 2007) has identified various risk-indicators for hearing loss.[7] Universal newborn hearing screening (UNHS) is a new concept of screening every born child. The cost of hearing screening is broadly accepted as it is cost-effective in comparison to the economic burden it causes. UNHS is not feasible in a busy hospital with a huge case burden.[8] In such a scenario, screening of babies only at-risk of hearing loss (at-risk screening) is more practical. Among various tools used for screening, automated otoacoustic emission (OAE) is technically easier, faster to perform, cheaper but requires a sound-proof room and has higher false-positive rates of 15%.[9-11] Automated auditory brainstem reflex (ABR) has less false positives and can detect patients with auditory neuropathy compared to OAE.[9] The combination of OAE and ABR is associated with a reduced referral rate.[10] This study aims to perform

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the screening of hearing in infants at risk and find out which parameters are associated with failure of screening tests.

METHODS

This descriptive cross-sectional study enrolled 228 infants with a potential risk of hearing loss in Tribhuvan University Teaching Hospital, Nepal from January 2016 to June 2017. A convenient sampling technique was used. The sample size was calculated considering a 10% prevalence of sensorineural hearing loss among the high-risk babies.[2] With a 4% margin of error at a confidence interval of 95% and 5% of non-response rate (missing cases), the estimated sample size was 228. The ethical clearance was taken from the Institutional Review Committee before commencing the study. Consent from a parent was taken in written form after the parents were well explained about the risk and benefits of the tests.

The inclusion criteria were all the at-risk infants admitted in maternity and pediatric wards, and intensive care unit (ICU) during the study period. The JCIH 2007 risk factors included caregiver concerns, family history of permanent childhood hearing loss, ICU stay of more than 5 days, assisted ventilation, exposure to ototoxic drugs, hyperbilirubinemia that required exchange transfusion, in-utero infections, craniofacial anomalies, syndromic child, syndromes associated with hearing loss, neurodegenerative disorders, postnatal infections associated with hearing loss, and head trauma requiring hospitalization.[7] In addition, babies with low birth weight (< 1500 gm), preterm birth (< 34 weeks) or low Apgar score (< 3) were also considered as at-risk. The parents' refusal to give consent, normal delivery with normal outcome were excluded. Only auditory brainstem reflex (ABR) test was possible in external auditory canal abnormalities, impacted wax, or ear discharge debris. In such scenarios, infants were directly referred for diagnostic tests. Very small babies (weight < 800 gm) were excluded because of the technical problems with the fitting of the ABR headset or OAE probe and were referred for the diagnostic test. If an infant was sick, the screening was performed only after improvement in general condition. The at-risk infants who could not be evaluated during their stay in the ICU were evaluated on subsequent visits at the high-risk clinic.

The screening was done by a single person in a soundproof audiology room to increase the reliability of the test which is hampered in a busy and noisy baby nursery. The Path Medical Solution Sentiero™ device was used for measuring both automated OAE and automated ABR. Both tests were performed for all babies.

The interpretations of the screening outcomes were either pass (valid response) or refer (invalid response). Under the ideal situation of low artefact and high stability, an automated OAE test device checks the presence of transient evoked OAE at a preset level. An automated ABR testing device checks the recording against the standard template of ABR wave form. Infants with pass results in both tests needed no further testing. Those with any invalid response or failed results of either of the tests were referred for the diagnostic test (Fig. 1). Those infants with failure of both ABR and OAE test in a single set up were immediately referred to an audiology clinic for diagnostic ABR. In case the test could not be completed because of inadequate sedation, the infant was followed up and retested after six weeks in an immunization/ high-risk clinic. Missing cases, with single test results (either OAE only or ABR only), were excluded. We analyzed the failure rate of different variables for automated ABR and automated OAE using the univariate tests (Pearson Chi-square test) in SPSS version 20.

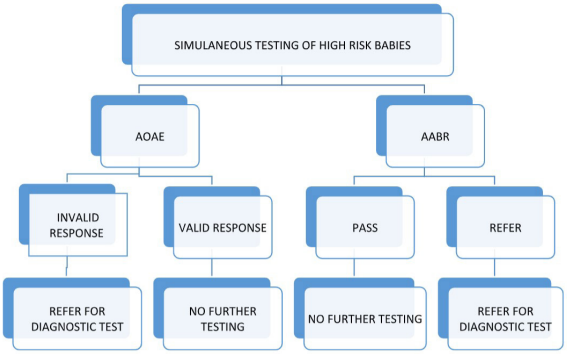

Figure 1. The flow chart showing screening process

RESULTS

Out of 228 infants enrolled in the study, 117 (51%) were males and 111 (49%) females. There was no missing data. Forty-four (19.3%) infants failed the ABR test and 70 (30.7%) infants failed the OAE test (Figure 2a and 2b).

Univariate analysis revealed that the failure rate of ABR test was significantly associated with preterm infants, low birth weight infants, those with ICU stay > 5 days and those with a history of use of ototoxic agents ($p < 0.05$). Among all the risk factors, only period of gestation was significantly associated with OAE test failure ($p < 0.05$) (Table 2).

Syndromes detected in 26 infants included meningocele/

Figure 2.
(a) Results of screening of infants with OAE (n=228)
(b) Results of screening of infants with ABR (n=228)

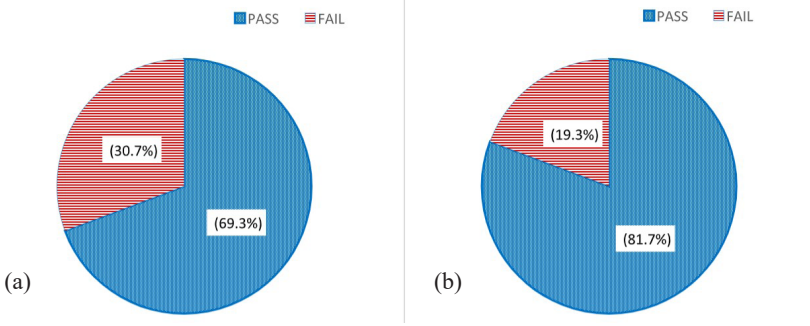

Table 1. Association of etiologic factor and ABR results (n=228)

Sociodemographic Variables		Result of ABR n (%)		$\chi 2$ value (df =1)	*p* value
		Pass	Refer (fail)		
Period of gestation	Preterm	51 (63.0)	30 (37.0)	6.78	0.009*
	Term	116 (78.9)	31 (21.1)		
Antenatal risk factor	Present	16 (88.9)	2 (11.1)	2.44	0.11
	Absent	151 (71.9)	59 (28.1)		
ICU stay > 5 days	Present	46 (63.9)	26 (36.1)	4.70	0.03*
	Absent	121 (77.6)	35 (22.4)		
Ototoxic drug	Present	36 (62.1)	22 (37.9)	4.96	0.03*
	Absent	131 (77.1)	39 (22.9)		
Family history of hearing loss	Present	11 (73.3)	4 (26.7)	0.00	0.99
	Absent	156 (73.2)	57 (26.8)		
Birth weight	Normal birth weight	116 (78.9)	31 (21.1)	6.78	0.009*
	Low birth weight	51 (62.9)	30 (37.1)		
Syndromic association	Present	20 (76.9)	6 (23.1)	0.20	0.65
	Absent	147 (72.8)	55 (27.2)		

$\chi 2$ value: chi squared test (df = degree of freedom); *Statistically significant ($p < 0.05$) at 95% Confidence Interval

Table 2. Association of etiologic factor and OAE results (n=228)

Sociodemographic variables		Result of OAE n (%)		$\chi 2$ value (df=1)	*p* value
		Pass	Refer (fail)		
Period of gestation	Preterm	65 (80.2)	16 (19.8)	4.78	0.03*
	Term	133 (90.5)	14 (9.5)		
Antenatal risk factor	Present	15 (83.3)	3 (16.7)	0.21	0.65
	Absent	183 (87.1)	27 (12.9)		
ICU stay > 5 days	Present	58 (80.6)	14 (19.4)	3.64	0.06
	Absent	140 (89.7)	16 (10.3)		
Ototoxic drug	Present	48 (82.8)	10 (17.2)	1.13	0.29
	Absent	150 (88.2)	20 (11.8)		
Family history of hearing loss	Present	14 (93.3)	1 (6.7)	0.59	0.44
	Absent	184 (86.4)	29 (13.6)		
Birth weight	Normal birth weight	132 (89.8)	15 (10.2)	3.16	0.07
	Low birth weight	66 (81.5)	15 (18.5)		
Syndromic association	Present	22 (84.6)	4 (15.4)	0.13	0.72
	Absent	176 (87.1)	26 (12.9)		

$\chi 2$ value: chi squared test (df = degree of freedom); *Statistically significant ($p < 0.05$) at 95% Confidence Interval

meningomyelocele/ encephalocele (n = 12), Downs syndrome (n = 6), craniofacial anomaly (n = 4), anal atresia (n = 2), and Sturge-Weber Syndrome (n = 2). There was no association with the OAE and ABR failure rate in these syndromic infants.

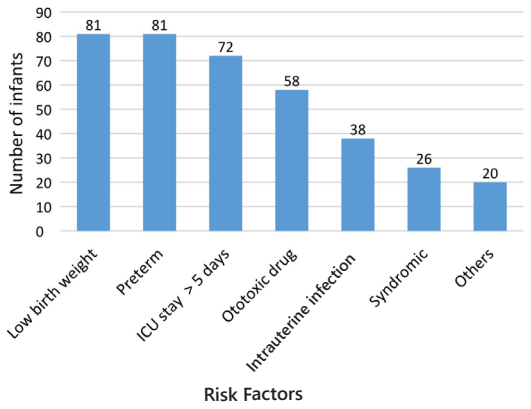

Figure 3. Distribution of high-risk factors among infants at-risk (n=228)

DISCUSSION

In this study, we used both automated ABR and automated OAE for screening infants for hearing loss. Around 19% of infants failed the ABR test and 30% failed the OAE test. Our figures are higher than those reported as 0.6 to 16.7% in the literature.[10,12,13] The lower failure rate in the developed countries could be because of better perinatal management, avoidance of ototoxic drugs and reduced incidence of perinatal asphyxia. Only one study reports the failure rate comparable to ours.[14] The wide variation in the failure rate could be due to a lack of uniformity in the distribution of risk factors, selection criteria, study designs and sample size. The higher failure rate doesn't indicate hearing loss but signifies that the child needs to be followed-up till hearing loss is ruled out through diagnostic tests. These infants have an increased likelihood of hearing impairment. As the number of risk factors grows, the chance of hearing loss and failure rate increases.[12,15] The results also depend on the type of the devices and techniques used. Automated test has higher failure rate (high false positive) than a diagnostic test.[16]

ICU stay of more than five days is an important risk factor.[7,12,15] Our study showed similar findings in the ABR test. Babies requiring ICU stay have multiple comorbidities associated with hearing loss (hypoxia, prematurity, hyperbilirubinemia, bacterial meningitis), with a history of ototoxic medication.[12] Adequate oxygenation and perfusion are crucial for cochlear function while severe hypoxia may cause irreversible injury to the outer hair cells and stria vascularis. Moreover, birth asphyxia causes hypoxic brain injury with damage to the auditory pathway.[11] It explains that they are susceptible to more failure rates in ABR which was also confirmed in our study.

In our study, preterm babies had a higher failure rate in both OAE and ABR. Preterm babies have poor neurological development and maturation and are more prone to hearing loss.[17] These patients are commonly exposed to multiple risk factors (low Apgar score, ICU care with mechanical ventilation, hypoxia, ototoxic drugs, and hyperbilirubinemia) which make them more vulnerable to hearing loss.[11]

Low birth weight (< 1500 gm) is not emphasized in the JCIH criteria. However, many other studies have included this as a risk factor.[15] Our study demonstrated a significant association of low birth weight and failure at ABR but not with OAE. Low birth weight may not be the sole risk factor but associated prematurity could have influenced the findings. However, very low birth weight babies have a higher incidence of poor development of the central nervous system.[11]

Early identification of risk factors helps in prevention, early detection and management. Hence, the screening in the antenatal period itself is suggested to avoid missing any cases. Our study failed to show any association between maternal risk factors and failure of both OAE and ABR tests. However, a few studies have identified maternal risk factors.[7,18]

The family history of permanent childhood hearing loss is a strong predictor for hearing loss.[7,19] Martines et al. showed a significantly higher failure rate of 31.6% in children with a positive family history of hearing loss.[12] However, a family history was not a predictor of failure in our study. This could be because only a few babies had a positive family history in our study.

The limitations of this study include fallacy in the identification of comprehensive and accurate risk factors. Our infants, especially those admitted in the ICU, had multiple interrelated risk factors, hence we cannot rule out the confounding effect of any risk factor. A similar study with a larger sample size would increase the validity of the findings. We also could not provide adequate sedation to all the infants. We did not follow up the infants with failed results for confirmation of the hearing loss. This is a limiting factor for screening studies even in the developed countries because of the time, resources, and funding constraints.[20]

CONCLUSION

Premature birth (gestational age < 34 weeks) was associated with failure of the ABR and OAE tests. The infants with low birth weight, history of ototoxic drugs, ICU stay more than 5 days were only associated with ABR test failure.

DECLARATIONS

Ethics approval and consent to participate: Ethical approval obtained from the Institutional Review Committee, Tribhuvan University Teaching Hospital. Written informed consent taken from a parent of each participant before enrollment.

Consent for publication: Not applicable

Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request. All relevant data are within the manuscript and its supporting information files.

Competing interest: None

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Authors' contributions: BK: concept, literature search, data acquisition, data analysis, manuscript preparation. PT: design, data analysis, manuscript revision. YN: design, data analysis, manuscript revision. PR: design, data analysis, manuscript revision. SLK: design, data acquisition. RPSG: concept, design, literature search. All the authors have read and approved the final manuscript.

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