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Original Research Article

A study of otoacoustic emission and brainstem evoked response audiometry as audiological assessment modalities for early detection of hearing loss in children

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ABSTRACT

Background: Aim of the research was to study the incidence of hearing loss in high risk children up to 5 years age and determine the common etiological factors associated with it.
Methods: Total 140 neonates falling under the norms of inclusion criteria and the children brought by parents with suspicion of having impaired hearing were subjected to thorough history taking and clinical examination followed by audiological examination in the form of otoacoustic emission (OAE) and brainstem evoked response audiometry (BERA). Those showing REFER or FAIL were subjected to BERA. Results were documented accordingly and analysed for identifying the common risk factors and degree of hearing loss.
Results: Maximum number of subjects with hearing loss were in the age group of 25-36 months age. Most common risk factor found was Consanguinity and most common postnatal risk factor was found to be hyperbilirubinemia. When compared to BERA, sensitivity of DPOAE was 97.59%, and the specificity was 92.98%.
Conclusions: Universal hearing screening of neonates at birth in the form of DPOAE and followed by BERA can reduce the average age of diagnosis of hearing loss and therefore, can provide an opportunity to initiate an appropriate rehabilitative program.

Keywords: Universal new-born hearing screening, OAE, BERA, Congenital hearing loss, High risk neonates

INTRODUCTION

Speech and hearing are interdependent. A child's normal speech and language development depends on the ability to hear. The most obvious impact of childhood hearing loss is on language acquisition that is delay in speech development, reading and writing. It also affects the overall literacy, development of social skills and attitudes, academic and personal development including the self-esteem of the child. However, owing to the fact that hearing is an invisible disability, it may often go undetected until the school going age, especially in children with no additional disabilities. Congenital sensorineural hearing loss is one of the most important public health problems with a frequency of about 1-6 per 1000 live births in world, thus making it one of the leading causes of childhood disability. The World Health Organisation (WHO) estimates that around 60% childhood hearing loss can be avoided through preventive measures.[1,2]

The developed countries are well aware of the burden of congenital hearing loss and have taken significant steps in the direction of early identification and subsequent rehabilitation or interventions. However, developing countries like India have no accurate estimate of the

magnitude of this problem and hence needs more data and study regarding the screening tests and their ability to identify the hearing loss as early as possible in a child. Although neonatal hearing screening tests like otoacoustic emission (OAE) and brainstem evoked response audiometry (BERA) are important for timely detection and rehabilitation for hearing loss, determining the factors that are responsible for the hearing loss are equally important as it can potentially direct interventions towards prevention of hearing loss.[1,2]

This study aims towards identifying the incidence of congenital hearing loss in paediatric age group, the potential risk factors of the congenital sensorineural hearing loss, and its early identification with the help of audiological assessment modalities in the form of OAE and BERA.

METHODS

It was an observational prospective study carried out in a tertiary care centre after obtaining clearance from institutional ethics committee.

Sample size

Final calculated sample size came to be 110. However, 140 participants fulfilling the inclusion criteria were selected by consecutive sampling technique.

Table 1: Sample size.[3]

Parameters	N
Width of 95% CI	0.1
Expected sensitivity	0.9
Expected specificity	0.85
Prevalence of hearing loss[4]	0.35
Sample size for sensitivity	99
Sample size for specificity	76
Final sample size	99
Final sample size (with 10% dropout rate)	110

The hearing assessment of total 140 children was done from August 2017-October 2019. All of these neonates/infants were referred from paediatrics OPD to the ENT OPD for hearing assessment falling under the norms of inclusion criteria and also children below 5 years of age brought by parents to ENT OPD with suspicion of impaired hearing were included. Infants and children presenting with discharging ear, children more than 5 years of age were excluded.

After written informed valid consent was obtained from the parents (both mother and father)/guardian, detailed history was obtained mostly from the mother of the child regarding the entire course of pregnancy, regarding type of marriage, family history of hearing loss. The following information was then obtained regarding the infant/child-birth weight, birth cry, admission to NICU for any reason, presence of any post- natal risk factors. The history regarding the presence of any anatomical abnormality and developmental milestones was also noted. After thorough clinical ENT examination, audiological examination was done using DPOAE. Those infants/ children passed the test were considered PASS. Those who did not, were considered as REFER, and only these children were then tested with diagnostic BERA under necessary sedation. The acoustic stimulus presented was the click stimulus at the rate of 11.1/sec to each ear individually. The analysis time was 15 milliseconds. 4000 responses were averaged. First stimulus was given at 90 dBnHL. The appearance of wave V was considered as sound stimulus heard and perceived by auditory mechanism. The threshold for each ear was noted and the hearing loss was quantified as given in Table 2.

Table 2: Classification of hearing losses by hearing thresholds using NHSP system.

Hearing threshold (hearing loss)	NHSP system (new born hearing screening programme)[5] (dB)
Normal	<20
Mild	21 to 39
Moderate	40 to 69
Severe	70 to 94
Profound	≥95

RESULTS

Out of total 140 subjects between 1 month to 5 years of age included in the study, 30.7% belonged to the age group of 1 month-12 months and 20.7% belonged to the age group of 13-24 months. Majority of the patients with hearing loss were in the age group of 25-36 months (26.5%) (Figure 1). Out of total subjects with hearing loss,48.2% were girls and 51.8% were boys. Considering the type of marriage history of parents, 44.6% subjects with hearing loss were born of consanguineous marriage (Figure 2). 6 subjects had family history of congenital hearing loss and all of them were found to have hearing loss. The p value was obtained as 0.038 (statistically significant) (Figure 3).

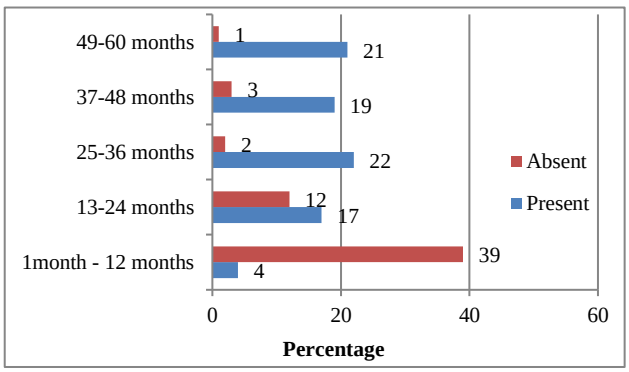

Figure 1: Distribution of subjects with and without hearing loss based on the different age groups.

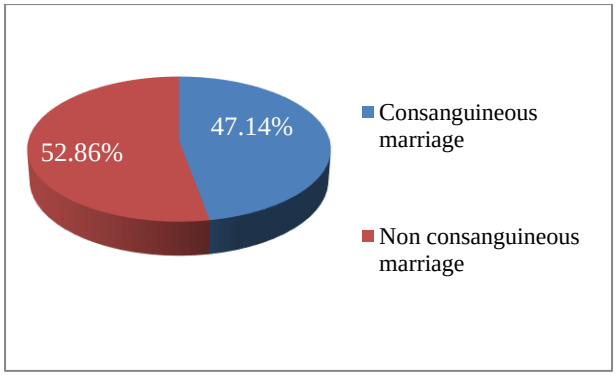

Figure 2: Distribution of the study subjects based on the marriage history of parents.

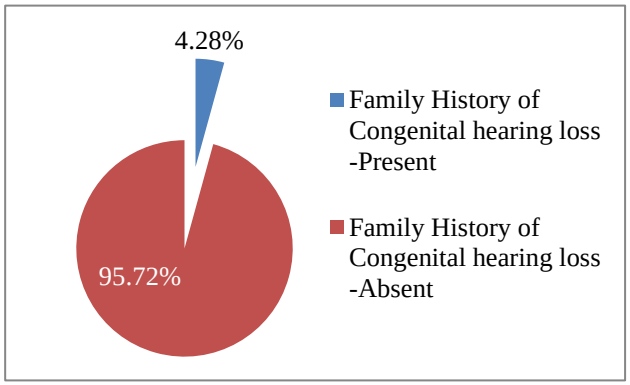

Figure 3: Distribution of the study subjects based on the family history of congenital hearing loss.

13.6% of subjects had presence of one of the prenatal risk factors for congenital hearing impairment. Pregnancy induced hypertension (PIH) and eclampsia was the most common prenatal risk factor. 17.1% subjects were preterm and 40% subjects had low birth weight. 44.3% of the subjects were having at least one of the post-natal risk factors known to cause congenital hearing loss. Out of these, 56.6% were found to have hearing loss with p value 0.0004 (statistically significant). The most common post-natal risk factor observed was neonatal hyperbilirubinemia seen in 15.7% (Figure 4).

On performing DPOAE, 39.3% were B/L pass i.e. considered to have normal hearing, 60.7% were B/L refer i.e. considered to have hearing loss. Only those subjects with B/L refer underwent BERA. However, 2 subjects were strongly suspected to have some degree of hearing loss on clinical assessment despite of recording as B/L pass on DPOAE. Hence, both of them also underwent BERA. Majority of the patients had profound hearing loss (79.3%) (Figure 5). We observed 2 subjects who were shown to have normal hearing (B/L pass) on DPOAE, but were later found to have varying degree of hearing loss on BERA. On the other hand, we observed 4 subjects who were shown to have hearing loss (B/L refer) on DPOAE, but were found to have normal hearing thresholds on BERA. The sensitivity of DPOAE on comparing with BERA, calculated was 97.59%, and the specificity of DPOAE was 92.98%.

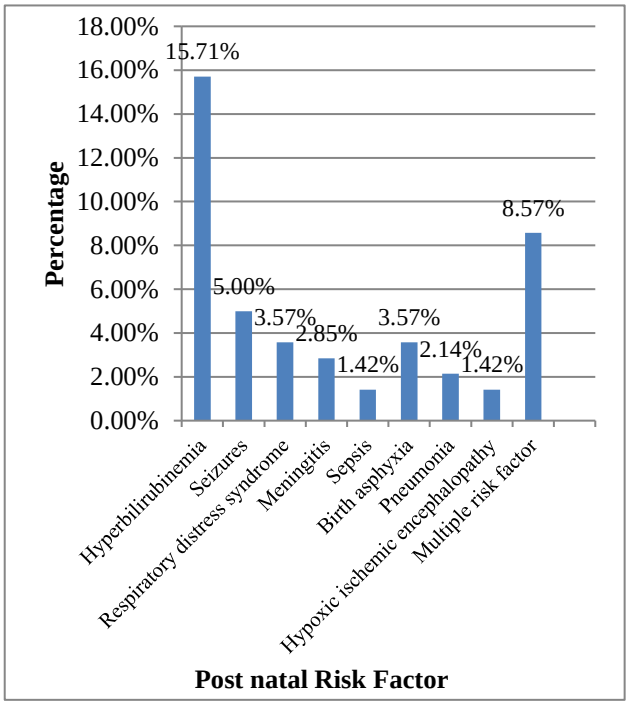

Figure 4: Distribution of the study subjects based on the postnatal risk factors (n=140).

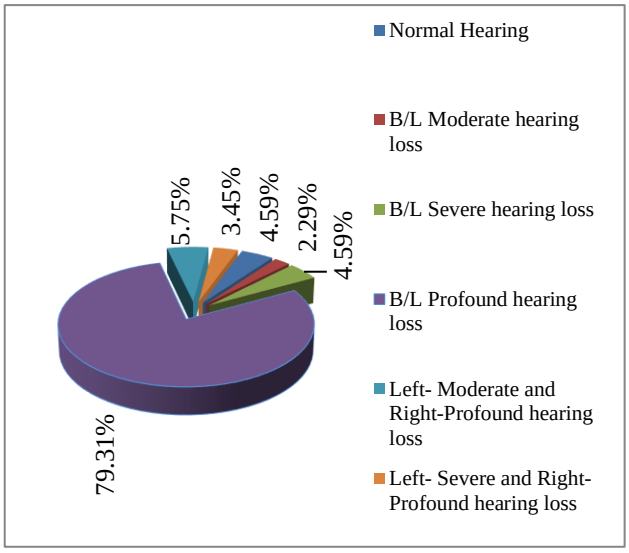

Figure 5: Distribution of the study subjects based on BERA findings.

DISCUSSION

The high percentage of diagnosis of hearing loss in the age group of 1-4 years can be attributed to the fact that most of the speech and language development occurs during this period and the hearing loss is identified only when the child presents with delayed speech. According to Jakubikova et al and Marttila et al, lack of universal

hearing screening leads to delay in diagnosis and more than 30% of hearing losses remain undiscovered before the age of 3 years.[6,7] Hence a 2-staged screening protocol of hearing assessment in neonates, first by OAE and then by BERA for early identification of hearing loss should be introduced and made obligatory at the time of birth. The screening programme could reduce the average age of diagnosis of significant hearing loss, thus providing an opportunity for early intervention services and preventing further disabilities.

Literature states that the cause for hearing loss in 20-50% of the children is idiopathic. The idiopathic nature of hearing loss in our study was slightly on the lower side as compared with the other studies which might be due to the fact that we included infants and children with high risk factors and the reported children with idiopathic hearing loss were referred only for complaints with delayed speech and language. Thus, we recommend that universal screening for hearing in neonates should be practiced for avoiding miss-outs of such infants and children who show idiopathic nature of hearing loss.

There was statistically significant association between subjects with congenital hearing loss and family history of the same. Hence, we recommend compulsory hearing screening of the infants/neonates who have a positive family history of congenital hearing loss. We reported family history of congenital hearing loss as a risk factor in 7.2% of the subjects and findings were similar to Aiyer et al.[10]

Thirunavukarasu et al and Zakzouk et al reported consanguinity (50%) as the most common risk factor in their subjects.[4,11] We also found consanguineous marriage as a risk factor in similar percentage (44.57%) of infants and children with hearing loss. Consanguineous marriages being commonly practiced in India and other developing countries can lead to autosomal recessive SNHL. Hence, discouraging the practice of consanguinity and creating awareness about the association of hearing loss and consanguinity is strongly recommended as it may result in decline in the number of permanent childhood hearing impairment.

In the present study, no significant difference in hearing loss was observed with birth weight and prematurity. Results of our study were comparable with studies by Khairy et al and Jakubikova et al for prematurity whereas Aiyer et al and Ohl et al also demonstrated no statistically significant difference in hearing loss with regards to birth weight.[10,12-14] 3 children with very low birth weight (VLBW) i.e. less than 1500 gms had hearing loss. The other risk factors in these 3 subjects were meningitis, hypoxia and preterm birth respectively, which are independent risk factors known to cause hearing loss. Presence of these risk factors may act in combination with VLBW to cause hearing impairment. Cristobal et al similarly reported that VLBW alone does not have a severe impact on hearing and is commonly associated with other multiple risk factors that can alter hearing in a synergistic fashion.[15]

Table 3: Majority of degree of hearing loss in various studies.

Parameters	Present study	Thirunavukarasu et al.[4]	Desarda et al.[8]	Beigh et al.[9]
Majority of children with hearing loss (age-group)	1-4 (69.89%)	1-4 (68%)	1-4 (50%)	>4 (50%)
Majority of degree of hearing loss	Profound HL (79.3%)	Profound HL (77.27%)	Profound HL (28%)	Profound HL (85.79%)

Table 4: Various risk factors identified in children with hearing loss in different studies.

Parameters	Present study	Thirunavukarasu et al.[4]	Jakubikova et al. [6]	Watson et al.[17]	Aiyer et al. [10]
Hearing loss with no etiological factors	17.5%	32%	25.4%	33.6%	--
Children with family history of hearing loss	7.2%	-	-	16.4%	7.0%
Most common risk factor	Consanguinity	Consanguinity	Prematurity and low birth weight	Severe asphyxia and hypoxia	Hyperbilirubinemia
Most common post-natal risk factor	Hyperbilirubinemia	-	-	Severe asphyxia	Hyperbilirubinemia

In our study, most common post-neonatal risk factor encountered was neonatal hyperbilirubinemia. Aiyer et al also reported hyperbilirubinemia as the most commonly observed post-natal risk factor.[10] Sharma et al recorded similar abnormal BERA responses in 22 of the 30 neonates with hyperbilirubinemia.[16] He further postulated that on follow up, 7 of these patients showed persistent abnormality which was due to permanent damage caused by axonal degeneration while in other patients, responses reverted back to normal due to phototherapy/blood

transfusion. In our study, we did not follow up with cases for observing any changes in morphology of waves in BERA. Hence, data regarding this could not be obtained in our study.

In our study, 4.9% of the subjects with hearing loss had meningitis as the risk factor. However, these findings were less compared with those in studies by Aiyer et al as 22% and Ohl et al as 13%.[10,14] 19 subjects required mechanical ventilation due to birth asphyxia, respiratory distress syndrome, and hypoxic ischemic encephalopathy, of which 7 developed hearing loss. These results were comparable with Khairy et al who reported most important risk factor leading to hearing impairment were sepsis, and prolonged mechanical ventilation.[12] Watson et al also observed majority of hearing loss in infants with severe asphyxia and history of neonatal intensive care unit (NICU) admission.[17]

In the present study, the sensitivity and specificity of OAE with respect to BERA was 97.59% and 92.98% respectively. These findings were in accordance with those reported by Khairy et al, Bhatt et al and Suppiej et al.[12,18,19] Hence, DPOAE is an effective tool for screening of hearing loss in neonates at birth. However, confirmation of hearing loss and the degree of hearing loss is more accurately done with BERA and hence, BERA must be done before initiating the rehabilitation program of any child with hearing loss. In our study, 79.3% had bilateral profound hearing loss on BERA. Similar findings were reported by Thirunavukarasu et al, Beigh et al, Desarda et al, and Watson et al, where majority of the subjects with hearing loss had severe to profound degree of hearing loss.[4,8,9,17]

The present study has limitations as being bias more towards the high-risk infants/children, smaller sample size and did not follow-up with children for any changes in waveforms of repeat BERA.

CONCLUSION

From the above discussion it can be concluded that no child is young for hearing evaluation and any degree of hearing loss can be measured. This can be efficiently achieved by means of screening with DPOAE and its confirmation by BERA. Though infants with high risk factors are more vulnerable to hearing loss, screening of infants with no known risk factors should also be considered on clinical grounds. Introduction of universal hearing screening of neonates at birth can reduce the average age of diagnosis of hearing loss and therefore, can provide an opportunity to initiate an appropriate rehabilitative program at the earliest for the child in the form of hearing aids or cochlear implantation.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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