

Hearing Assessment in Infants with Otoacoustic Emission and Auditory Brainstem Response: A Retrospective Study

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ABSTRACT

Aim and objective: An attempt was made to find hearing status in all high-risk infants and no risk infants with the help of otoacoustic emission (OAE) and auditory brainstem response (ABR).

Materials and methods: A retrospective study of hearing assessments of 330 infants was done with OAE and ABR from August 2019 to February 2020 at tertiary hospital. Various details of all participants such as age, sex, high-risk factors, detailed history of the current disease, maternal history during pregnancy, and complications during delivery were recorded.

Results: Among 330 infants, 156 (47.27%) had REFER on first OAE. All 30 infants who had REFER on second OAE had shown hearing impairment on ABR. Hearing loss was seen in three infants (0.90%) without any risk factor. In the present study, risk factors for the hearing impaired infants were NICU stay (39%), low birth weight (33.6%), LSCS (20.6%), preterm delivery (17%), hyperbilirubinemia (8.1%), and delayed cry (7.57%). Statistical analysis performed using the Chi-square test had shown significant association between NICU stay, low birth weight, delayed cry, and hearing loss.

Conclusion: Statistical analysis performed using the Chi-square test had shown significant association between NICU stay, low birth weight, delayed cry, and hearing loss.

Clinical significance: OAE is good screening tool for newborn and infants.

Keywords: Brainstem-evoked response audiometry, Hearing assessment, Hearing loss, High-risk infants, Newborn, Otoacoustic emission.

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INTRODUCTION

Hearing loss is the most common congenital factor seen in 0.1–0.2% infants.¹ The use of hearing aid and early rehabilitation is needed for development of speech. Auditory stimulation is needed in early months of life for preservation of neural connections in auditory pathways.² Hearing aid and rehabilitation treatment within early months of life, speech and language development, psychological support, and school and social attachments are needed for better development.³ Infants hearing screening programs are helpful to find all cases with mild-severe hearing loss (>35–40 dB HL).⁴ According to WHO, 360 million people have moderate to profound hearing loss worldwide, which makes them disable.⁵ In infants with normal hearing and good cochlear function, outer hair cells give nonlinear responses to sound stimulus.^{5,6} Populations with more chances of hearing impairment should be screened first in neonatal screening.⁷ Joint Committee on Infant Hearing (JCIH) had given risk factors to identify high-risk infants.⁸ No risk factor was seen in 50% of the infants with hearing loss.⁹ Screening of all infants is needed to avoid missed cases.¹⁰ Hearing assessment with otoacoustic emission (OAE) will not be helpful in the cases of auditory neuropathy, other neural problems, fluid in the middle ear, and vernix in the external auditory canal at birth. All infants should be screened with OAE and auditory brainstem response (ABR) to get more hearing-impaired cases.¹¹ OAE and automated ABR (AABR) are hearing screening methods. Both OAE and AABR are nonsubjective, cost-effective, safe, and noninvasive.¹² OAE is less time and money saving test as it does not require the use of the electrode. Otoacoustic emission test can be done in OPD in awake infants and ABR requires the infant sleep. No complications report from OAE testing. “PASS” results

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show no hearing loss. “REFER” results need further assessment. ABR tests require more time and are expensive. ABRs are more sensitive than OAEs. As an ABR is a reliable and objective test but difficult to perform, otoacoustic emission is a practicable screening modality.

MATERIALS AND METHODS

A retrospective study of all infants referred for hearing assessment with the help of OAE and ABR was carried out from August 2019 to February 2020 at Government Medical College, Miraj, Maharashtra. All infants referred to the ENT department for hearing assessment were included in the present study. Written informed consent of a parent was taken before the procedure. OAE was done on infants two times during the first 3 months age of infants. If OAE comes as

“REFER” twice, then we are done auditory brainstem response for infants older than 3 months.

Infants included in this study were from OAE and BERA Record Book. OAE was done by using the NEUROSOFT diagnostic OAE machine. A probe was inserted into both external auditory canals of an infant alternately to measure inner ear responses to sound signals given by a probe which was inserted into the external auditory canal. Responses of outer hair cells were recorded. OAE results were noted as either PASS or REFER. An infant with bilateral ear PASS result suggests normal outer hair cell function. These infants were not advised to follow up. Follow-up after a few weeks for repeat OAE was advised to the infants with unilateral or bilateral REFER results. After two consecutive unilateral or bilateral “REFER” OAEs, infants referred for ABR testing. The ABR was done by NEUROSOFT BERA machine. ABR results were based on the morphology of wave five. Data were collected in a case sheet from departmental AABR records. Statistical analysis was performed using the Chi-square test.

RESULTS

Among 330 infants, 188 were males and 142 were females (Fig. 1). About 109 males and 87 females screened with first OAE had bilateral PASS result. About 79 male infants and 55 female infants given REFER result on first OAE were called for second OAE. Totally 174 infants had bilateral PASS results on first OAE. One hundred and thirty four infants had bilateral REFER, 15 infants had right PASS and left REFER while seven infants had left PASS and right REFER on first OAE. All 156 infants with REFER result were called for second OAE. On second OAE, 30 infants had REFER result. All REFER 30 infants were called for ABR after second OAE. No infant had lost follow-up for ABR. Distribution of hearing impaired according to risk factors is shown in Figure 2. Among 20 infants without any risk factor, three infants were having REFER, and 17 had PASS results on OAE. Statistical analysis was done with a Chi-square test to find an association between hearing loss and factors studied.

All 30 infants had provided strong behind the ear hearing aid through Rashtriya Bal Swasthya Karyakram. Infants were given speech therapy and advised to continue speech therapy sessions. Parents were convinced for cochlear implant under Rashtriya Bal Swasthya Karyakram.

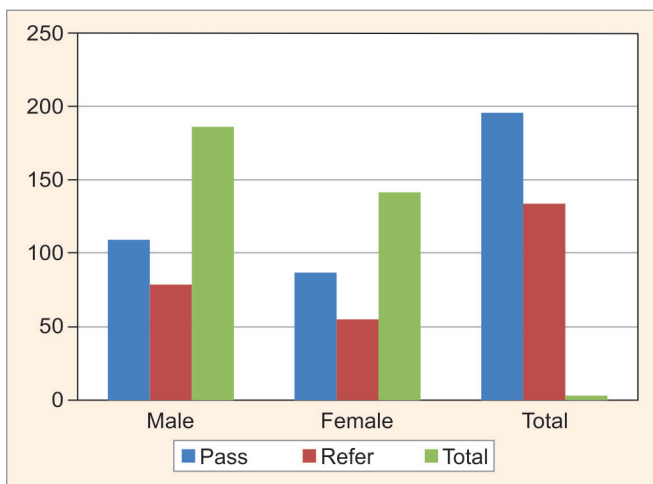


Fig. 1: Male and female distribution of OAE results (PASS and REFER)

OAE Screening According to Craniofacial Malformation and Family History

In the present study, no infant had craniofacial abnormalities. Three infants had a family history of deafness. Among three infants with family history of deafness, two had bilateral PASS and one infant had REFER result on OAE. No infant had given a history of TORCH infection.

One hundred and seventy eight infants who immediately cried after birth had PASS OAE results, and 109 infants had REFER OAE results. Eighteen infants who had delayed cry after birth had PASS OAE results, and 25 infants had REFER OAE results. After applying the Chi-square test, $p < 0.05$. There is a significant association between hearing loss and cry after birth (Table 1). Infants who had delayed birth cry had more chances of hearing loss.

One hundred and twenty-nine infants delivered after 9 months of pregnancy had PASS OAE results, and 78 had REFER OAE results. Sixty-seven infants delivered before the completion of 9 months of gestational age (prematurity) had PASS results, and 56 had REFER OAE results. After applying the Chi-square test, $p > 0.05$, so there is no significant association between hearing loss and gestational age of infants (Table 2).

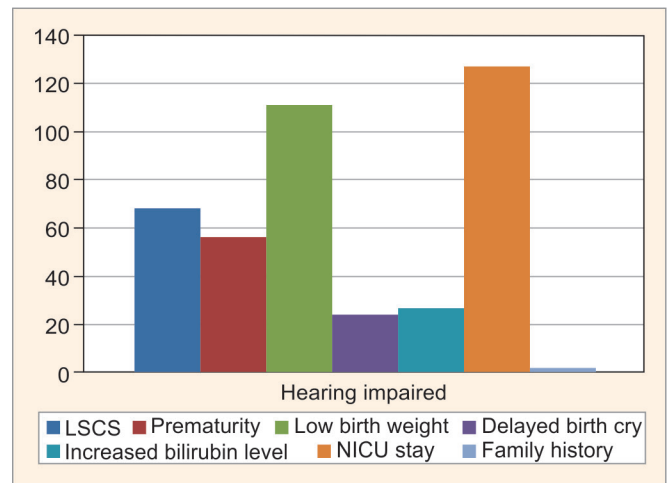


Fig. 2: Distribution of hearing impaired according to risk factors

Table 1: Distortion product otoacoustic emissions (DPOAEs) screening according to birth cry

Cry after birth	PASS	REFER
Immediate	178	109
Delayed	18	25
Chi-square test value	6.3024	
p value	0.012058 < 0.05	
Association	Significant	

Table 2: DPOAE screening according to gestational age (full term of preterm)

Birth weight	PASS	REFER
Full term	129	78
Preterm	67	56
Chi-square test value	1.97	
p value	0.160447 > 0.05	
Association	Not significant	

About 172 infants who had a history of NICU stay had PASS OAE results, and 127 infants had REFER OAE results. Twenty-four infants with no history of NICU stay had PASS OAE results, and seven infants had REFER OAE results. After applying the Chi-square test, $p < 0.05$, so there is a significant association between hearing loss and NICU stay (Table 3). NICU infants had more chances of hearing loss.

About 102 infants with low birth weight (<2.5 kg) had PASS OAE results, and 111 infants with low birth weight (<2.5 kg) had REFER OAE results. Twenty-three infants with normal birth weight had REFER OAE results. After applying the Chi-square test, $p < 0.05$, so there is a significant association between hearing loss and birth weight (Table 4). Infants with low birth weight had more chances of hearing loss.

About 175 infants who had a normal bilirubin level had PASS OAE results, and 107 infants had REFER OAE results. Twenty-one infants with increased bilirubin levels had PASS OAE results, and twenty-seven infants had REFER OAE results. After applying the Chi-square test, $p < 0.05$, so there is a significant association between hearing loss and hyperbilirubinemia (Table 5). Infants with increased bilirubin level had more chances of hearing loss.

About 113 infants delivered naturally without surgical intervention had PASS OAE results, and 66 had REFER OAE results. Eighty-three infants delivered by caesarian section had PASS result, and sixty-eight had REFER OAE results. After applying the Chi-square

test, $p > 0.05$, so there is no significant association between hearing loss and mode of delivery (Table 6).

All 30 infants had given strong power behind the ear hearing aid through rashtriya bal swasthya karyakram (RBSK). Speech therapy was started in 20 patients, and parents were convinced for cochlear implant surgery under rashtriya bal suraksha karyakram (RBSK).

DISCUSSION

In the literature, permanent hearing loss is seen in 4 (1.1–6) per 1000.¹³ Early detection of hearing loss is necessary for the rehabilitation of such infants. Risk indicators for hearing loss in infants had given by Joint Committee on Infant hearing.^{14,15} Identification of such indicators in the neonates will help us to keep following up of high-risk babies and to do the necessary investigations as early as possible. Fifty-fold increases in hearing impairment were seen in high-risk infants.¹⁷ All parents were well convinced, and awareness was created among the parents of infants during the first visit. About 90% of parents and infants were coming from remote areas. Similar findings were seen in Garg et al. study where more cases seen in rural areas than in urban areas.⁵ The hearing loss in infants without high risk factors was seen as 0.09–2.3%,^{17,18} and in the high-risk infants, was seen as 0.3–14.1%.^{19,20}

According to Maqbool et al. study, 50% infants may have a hearing impairment without risk factors and noticed when a child misses language milestones.^{9,16} In the present study, 0.9% of hearing-impaired infants are without any risk factors. It may be due to the tertiary hospital where most of the deliveries are complicated and neonates are with one or more risk factors.

Hearing loss was seen in infants with neonatal asphyxia and craniofacial anomalies.^{21,22}

In the present study, 99% of infants with hearing impairment had risk factors. Hearing loss was seen in three infants (0.90%) without any risk factor. In the present study, hearing loss was seen in infants with low birth weight, delayed birth cry, hyperbilirubinemia, and NICU stay.

According to Tanon-Anoh et al., craniofacial anomalies are associated with conductive hearing loss.²³ According to Colella-Santos, conductive hearing loss was seen in infants with cleft palate, preauricular skin appendages, and ear pits.²⁴ Antenatal care may be the reason for no infant had craniofacial malformation.

In Hille et al. study, intubated infants were presented with hearing loss.²⁵ According to Bielecki et al., use of ototoxic medication, premature birth, low birth weight, and long admittance in ICU were the risk factors for hearing loss.²⁶ According to Maqbool Study,¹⁶ hearing impairment was seen in 45% infants with a history of use of ototoxic medications, 30% infants with hyperbilirubinemia, 26% infants with perinatal asphyxia, and 10% of infants with bacterial meningitis.

In the present study, risk factors for the hearing impaired infants were NICU stay (39%), low birth weight (33.6%), LSCS (20.6%), preterm delivery (17%), hyperbilirubinemia (8.1%), and delayed cry (7.57%).

According to Maqbool study,¹⁶ none of the study infants had a family history of hearing loss. According to Driscoll et al. study, 1.43% of infants with a positive family history have hearing loss.²⁷ A family history of hearing loss is seen along with consanguinity,^{28–30} and the hearing loss in infants depends on the degree of parental consanguinity.^{28,31} In the present study, two infants with a family history of deafness had bilateral PASS, and one infant with a family history of hearing loss had REFER result on OAE.

Table 3: DPOAE screening according to NICU stay

DPOAE	PASS	REFER
NICU stay	172	127
No NICU stay	24	07
Chi-square test value	6.3024	
<i>p</i> value	0.012058 < 0.05	
Association	Significant	

Table 4: DPOAE screening according to birth weight

Birth weight	PASS	REFER
Birth weight <2.5 kg	102	111
Birth weight >2.5 kg	94	23
Chi-square test value	32.9815	
<i>p</i> value	<0.00001	
Association	Significant	

Table 5: DPOAE screening according to hyperbilirubinemia

Bilirubin level	PASS	REFER
Normal	175	107
Hyperbilirubinemia	21	27
Chi-square test value	6.3024	
<i>p</i> value	0.012058 < 0.05	
Association	Significant	

Table 6: DPOAE screening according to mode of delivery

OAE	PASS	REFER
Normal	113	66
Caesarian section	83	68
Chi-square test value	2.2622	
<i>p</i> value	0.136425	
Association	Not significant	

The present study had shown similar findings as Hille et al.²⁵ and Maqbool study.¹⁶ According to Vos study, hearing loss was associated with gestational age and birth weight. Intraventricular hemorrhage and congenital white matter lesions in preterm infants are associated with hearing loss.³¹ In the present study, 56 preterm infants had REFER OAE results, and no significant association was seen between gestational age and hearing loss.

Hearing loss was seen in an infant with NICU stay of more than 5 days.³² According to Vos study, hearing impairment was seen in 3–14.1% of babies in NICU³¹, and 20.68% of infants with NICU stay of 5 days.³¹ Hearing loss in hospitalized infants may be due to delayed maturation of the auditory system.³³ According to van Dommelen et al., hearing losses in NICU babies depend on premature birth and birth weight.³⁴ Low birth weight was associated with hearing loss.^{16,34} Therefore, whether hearing loss associated with premature birth and low birth weight or NICU stay is controversial.^{31,35} In the present study, 127 infants with NICU stay had REFER OAE results. Hearing loss was seen in 1.2–7.5% premature babies born in 24–31 weeks.¹⁵ According to van Dommelen et al., hearing loss was increased in low birth weight babies. About 1.4–4.8% of babies weighing 750–1500 g had hearing loss.³⁴ In the present study, 111 infants with low birth weight (<2.5 kg) had REFER OAE results.

Increased bilirubin levels lead to bilirubin-induced neurologic dysfunction (BIND) syndrome.^{36,37} Several studies show that severity of hyperbilirubinemia and duration of hyperbilirubinemia both are associated with hearing loss.^{36,37} Prematurity, sepsis, and hypoxia lead to hyperbilirubinemia.^{36,37} Agrawal et al. had reported hyperbilirubinemia induced BAER abnormalities in infants.³⁸ According to Vos, transient hearing disabilities in infants with hyperbilirubinemia can improve after normal bilirubin level.³¹ Auditory damage in infants with hyperbilirubinemia can be prevented by exchange transfusion.^{39,40} In the present study, 27 infants with hyperbilirubinemia had REFER OAE results.

Similar to Güven study, in the present study, hearing loss was not significantly associated with mode of delivery, that is, LSCS and normal delivery.

Through rashtriya bal swasthya karyakram (RBSK), early intervention is provided from birth to 18 years of age. Till the time parents notice the delay in the speech and language, the child had wasted time of 2–3 years of age, which was very important for auditory stimulation. Failure to timely intervene may cause permanent disabilities.

CONCLUSION

Statistical analysis performed using the Chi-square test had shown significant association between NICU stay, low birth weight, delayed cry, and hearing loss.

Clinical Significance

OAE is a good screening tool for newborn and infants.

COMPLIANCE WITH ETHICAL STANDARDS

Ethical Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional ethical committee as per ICMR guidelines and University Protocol by letter No. GMCM/IEC-C/78/2020.

Informed Consent

Informed consent was obtained from parents.

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