International Journal of Otorhinolaryngology and Head and Neck Surgery
Ramanjaneyulu J et al. Int J Otorhinolaryngol Head Neck Surg. 2021 Nov;7(11):1794-1798
http://www.ijorl.com
pISSN 2454-5929 | eISSN 2454-5937

DOI: https://dx.doi.org/10.18203/issn.2454-5929.ijohns20214233

Original Research Article

Oto acoustic emissions in early detection of sensorineural hearing loss in high-risk neonates

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Received: 04 October 2021
Revised: 19 October 2021
Accepted: 20 October 2021

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ABSTRACT

Background: Early identification of congenital hearing loss and early intervention ameliorated many adverse consequences. This study was performed to observe effectiveness of otoacoustic emission in screening of hearing loss in high-risk babies.
Methods: Prospective study on 45 high-risk newborns delivered during period of 2013-2014. Selective newborn hearing performed with oto acoustic emissions (OAE) and auditory brain stem responses (ABR), in high-risk infants aged below 7 days, 15 days, after 45 days and after 90 days.
Results: Study population comprised of 45 high-risk newborns. In 1st level screening, 28 (62%) babies showed recordable OAE, 17 (38%) babies failed. In 2nd level screening 31 (81%) passed and 7 (19%) failed and death occurred in 7 infants. In 3rd level screening both OAE and brain stem evoked response audiometry (BERA), was performed in 38 cases and positivity was reported in 37 cases. 4th level screening was similar to 3rd level screening where 3 babies failed ABR test. In our study incidence of sensorineural hearing loss found to be 78.91% (3/38×1000) per 1000 high-risk babies. Auditory neuropathy was observed in 2 (4.4%) patients. Sensitivity and specificity of OAE was 100% and 33.3% respectively. In high-risk low birth weight neonates' sensitivity and specificity was 66.7% and 50.0%.
Conclusions: In high-risk babies, appropriate time for screening with OAE is around 60 days of age. OAE are useful diagnostic tool in evaluation of high-risk neonates for early detection of sensorineural hearing loss.

Keywords: OAE, ABR, BERA, Hearing loss, High risk babies, Neonate screening

INTRODUCTION

Congenital hearing loss is one of the most common congenital anomalies which can be identified early in life.[1] It is known that magnitude of hearing loss is higher in neonates with low birth weight, hyperbilirubinemia etc.[2] Early identification of hearing loss and appropriate intervention within the first 6 months of life have been demonstrated to ameliorate many of the adverse consequences and facilitate language acquisition. In developing countries like India there is no estimate of the magnitude of this problem. Studies reveal that in India incidence of permanent hearing loss is 6-7 per 1000 newborns per year. Among these an increased incidence of hearing loss of 10.2 times more is being reported in high-risk group of babies.[3]

Failure to detect congenital or acquired hearing loss in children may result in lifelong deficits in speech and language acquisition, poor academic performance, personal-social mal adjustments, and emotional difficulties. Early identification of hearing loss and appropriate intervention within the first 6 months of life have been demonstrated to ameliorate many of the adverse consequences and facilitate language acquisition.[1] The magnitude of hearing loss in high-risk

babies was not reported specifically and needs thorough research.

Diagnosis of hearing disorders in newborns and infants is generally a two-stage process by measuring OAE or performing automated ABR audiometry or both.[4] Essentiality of OAE as screening tool in diagnosis of congenital hearing loss either alone or in conjunction with ABR after OAE screening needs to be thoroughly evaluated. Also, many grim areas which need lot of exposure and answers like the best time to conduct OAE screening for babies at risk and also the number of times OAE should be performed for arrival to conclusion need to be answered.[5] We undertook this study to evaluate the prevalence of congenital hearing loss and the usefulness of otoacoustic emission in the screening of hearing loss in high-risk babies.

METHODS

This is a prospective study conducted on 45 high-risk Newborns delivered in Narayana medical college during period of 2013-2014. All the high-risk neonates born in our institution were randomly selected for the study. A thorough informed consent was obtained from the parents of these neonates selected for the study. All these neonates selected for the study have one or more high-risk factors.

All these high-risk neonates were evaluated for their hearing using standard clinical questionnaire and protocol. The protocol for screening we followed is two stage single modality protocol and two stage, two modality protocol which included 1st level screening with OAE at 1-7 days of age, 2nd level screening with OAE at 14-21 days, 3rd level screening with OAE and ABR at 60 days of age and 4th level screening with OAE and ABR at 90-120 days of age.[6]

The test is done in a sound treated room, OAE and ABR done by a qualified audiologist. After obtaining parent consent child is made to sleep placed in supine position and ear probe snuggly fitted (3.5 mm yellow, 4.0 mm pink) into external auditory canal by gentle traction of pinna in backward and downward direction. GSI-Audera-PC software version 2.6.5.2116 was used to perform all the procedures.[7]

Two pure tones as stimulus (f1 and f2) (70-70 dB) where F2/fi=1.2 (average 1.23 to 1.24) with distortion product 2f1-f2 and distortion product OAE amplitude from noise floor level at each frequency are recorded. Extrinsic noise levels checked by computer and probe adjusted accordingly response amplitude at each frequency as sound to noise (S/N) ratio measured and plotted spontaneously as bar diagram. Frequencies in the ranges from 4 KHz, 3 KHz, 2 KHz and 1 KHz were examined.

For OAE sound/ noise ratio at least of 6 dB for at least 3 out of 4 frequencies considered as "Pass". S/N ratio less than 6 dB at many frequencies (Two or more) considered as "Fail".

ABR is test for auditory function in response to auditory stimulus like clicks, tone bursts. Surface electrodes placed over scalp to record auditory evoked potentials. Five waves noticed. Wave I and V are more prominent. Wave I is formed by distal part of auditory nerve whereas wave V is formed by auditory brainstem which is most prominent. Stimulus of 35 dB intensity 100 microseconds duration are delivered through unfiltered ear probe. Auditory evoked potentials almost instantaneously recorded. In BERA, -presence of wave V considered test as "Pass". Absence of wave V considered test as "Fail". Inter aural inter-peak latencies also observed for comparison between right and left ears.

The results of the study were calculated using percentages and simple statistics. Sensitivity and specificity of OAE in high-risk neonates and infants were calculated using independent T test. All these results of the study were calculated using SPSS version 22 software.

RESULTS

Study population comprised of 45 high-risk newborns with one or more risk factors. Out of 45 high-risk newborns 37 (82%) were reported from NICU and 10 (18%) were from non NICU. Among these 45 high-risk newborns, males were 20 (44%) and females were 25 (56%). In our study of 45 cases, we found low birth weight 26 (58%), craniofacial anomalies 7 (15.5%), hyperbilirubinemia 6 (13%), birth asphyxia 3 (6.6%), septic shock 1 (2.2%), and meningitis 2 (4.4%).

In the 1st level screening with OAE, in 45 newborns, 28 (62%) babies showed recordable OAE, 17 (38%) babies failed. Among 17 cases failed 1 (2%) was right lateral, 1 was left lateral failure and 15 (34%) were bilateral failures.

In 2nd level screening, OAE were recorded in 38 cases, as death occurred in 7 infants. The 31 (81%) passed and 7 (19%) failed the OAE test. There were 5 cases who failed during 1st level screening and passed the 2nd level screening.

In 3rd level screening both OAE and BERA was done in 38 cases and positivity was reported in 37 cases. Thus, In OAE, there was further conversion from fail to pass where 6 cases which were negative for OAE during 2nd level screening turned positive during 3rd level screening. In 3rd level ABR was performed as per the designated protocol and all these new born babies were screened. Among the study population of 38, 35 (92%) passed and 3 (8%) failed the ABR test.

In 4th level screening OAE and BERA were done in 38 cases, results for OAE were same as that of 3rd level

Screening i.e., 37 passed, and 1 failed. 3 babies failed ABR test suggesting of confirmed cases of permanent hearing loss.

Our study had 3 confirmed bilateral permanent hearing losses, 1 case associated with hyperbilirubinemia, 1 case with craniofacial anomaly with hypognathy (syndromic) and other case with prematurity where etiology is unknown. In our study incidence of sensory neural hearing loss found to be 78.91% (3/38×1000) per 1000 high-risk babies. In our study in the babies in intensive care unit auditory neuropathy was observed in 2 (4.4%) patients.

In our study we tried to assess the sensitivity and specificity of OAE during all the four-level screening. We observed that OAE sensitivity was high at the time of 3rd screening at the end of 60 days. Overall sensitivity and specificity of OAE in our study found to be 100% and 33.3% respectively reported at the time of 3rd screening. In our study true positives found to be 91% and false positives were found to be 5.2%. In our study we tried to assess the sensitivity and specificity of OAE in high-risk low birth weight neonates and we obtained a sensitivity of 66.7% and specificity of 50.0%. These results were tabulated in the Table 1 below.

Table 1: Sensitivity and specificity during screening with OAE.

Variables	Percentages (%)
First screening	
Sensitivity	65.8
Specificity	33.3
Second screening	
Sensitivity	82.9
Specificity	33.3
Third screening	
Sensitivity	100
Specificity	33.3
Fourth screening	
Sensitivity	100
Specificity	33.3
Sensitivity in first screening in relation to birth weight	
Low birth weight	1501-2500 gm
Sensitivity	66.7
Specificity	50

DISCUSSION

Hearing loss also can be acquired during infancy or childhood for various reasons. Infectious diseases, especially meningitis, are a leading cause of acquired hearing loss. Trauma to the nervous system, damaging noise levels, and oto-toxic drugs can all place a child at risk of developing acquired hearing loss.[8] Otitis media is a common cause of usually reversible hearing loss.

Evoked OAE are acoustic signals generated from within the cochlea that travel in a reverse direction through the middle-ear space and tympanic membrane out to the ear canal. These signals are generated in response to an auditory stimulus, either clicks or tone bursts. The signals may be detected with a very sensitive microphone/probe system placed in the external ear canal. The OAE test allows for individual ear assessment, can be performed quickly at any age, and does not depend on whether the child is asleep or awake. Mild degrees of motion artifact do not interfere with test results; however, screening results are frequently influenced by the presence of middle-ear pathologic abnormalities.

Initial screening procedures by OAE may not reflect over all outcome. At 45-60 days of age when myelinization of auditory pathway completed gives the true auditory status of auditory pathway. It is recommended to perform first OAE at later than 2 weeks and preferably before 45 days of age to avoid diagnostic errors. In our study it was observed that OAE performed in initial screening i.e.,17 (38%) cases out of 45 cases screened were negative. seven deaths occurred after 1st level screening due to various causes. False negatives of OAE reduced after 2nd level screening. This was probably due to clearance of fluid in middle ear and vernix from external auditory canal. OAE status at 3rd and 4th level screening was cross checked with the results of ABR. It is observed that false negatives of OAE came down after 15 days of age.

OAE test also does not assess the integrity of the neural transmission of sound from the eighth nerve to the brainstem and, therefore, will miss auditory neuropathy and other neuronal abnormalities.[9] Infants with such abnormalities will have normal OAE test results but abnormal ABR test results. A “failed” OAE test only implies that a hearing loss of more than 30 to 40 dB may exist or that the middle-ear status is abnormal or auditory neuropathy is another possibility.

Approximately one to two cases per 1000 newborns suffering from permanent bilateral childhood hearing impairment. A hearing impairment exceeding 40 dB HL at pure tones of 0.5, 1, 2, 3, and 4 kHz is observed in them. 60% of them are having moderate hearing loss (40 to 60 dB) and remaining having severe (61 to 80 dB) to profound (>80 dB) hearing loss. World health organization (WHO) estimated 278 million people having bilateral permanent hearing loss worldwide. Two third of them are in developing countries.[10] In India it is estimated to be having 3 million cases. Most common cause for permanent hearing loss is infection-congenital like rubella and cytomegalovirus, acquired like mumps, measles, meningitis and chronic otitis media. Next common is genetic factors.

It was observed that incidence of auditory neuropathy in low-risk newborns in terms of false positive rates of OAE range between 4% and 17%. In high-risk newborns auditory neuropathy was observed to be 10 times more ranging from 40%-170% per 1000 high risk newborns.[11] In our study auditory neuropathy was observed in 54% of

children. If OAE screening is alone is used in the neonatal hearing screening program, children with auditory neuropathy are missed. The combined ABR/OAE screening was the only means to avoid missing infants with the auditory neuropathy profile or on those infants with neurologic risk factors. Higher incidence of auditory neuropathy seems to be due to increased aminoglycoside usage, prolonged intubation, and prolonged stay in admission. However, the mutation gene for auditory neuropathy was not studied in our work. Karyotyping of gene, genetic predisposition should be considered in all high-risk babies. Similarly, ABRs when conducted in initial periods are often not satisfactory. Thus, initial screening with OAE at 15 days and ABR at 45 days suitable for high-risk babies as per the results of our study.

In our study of 45 cases, we found low birth weight 26 (58%), craniofacial anomalies 7 (15.5%), hyperbilirubinemia 6 (13%), birth asphyxia 3 (6.6%), septic shock 1 (2.2%), and meningitis 2 (4.4%). Nearly 60% of children presented with low birth weight alone. Reasons could be nutritional, anemia, short stature, teenage marriages, consanguinity marriages, genetic factors, early pregnancy, lack of birth spacing, lack of immunization, lack antenatal checkups, intrauterine infections, multiple pregnancy, pregnancy induced complications and others.

Incidence of sensorineural hearing loss in high-risk babies in our study found to be 78.91% (per 1000 high-risk newborns). This is probably due to aminoglycoside usage and consanguinity marriages. Latest studies revealing that in India incidence of permanent hearing loss is 6-7 per 1000 newborns per year. In high-risk babies' incidence of permanent hearing loss 10.2 times more that is 60-70% per 1000 high-risk babies per year.[3] Our study had 3 confirmed bilateral permanent hearing loss, 1 case associated with hyperbilirubinemia, 1 case with craniofacial anomaly with hypognathy (syndromic) and other case with prematurity where etiology is unknown. In our study incidence of sensorineural hearing loss found to be 78.91% (3/38×1000) per 1000 high-risk babies which is slightly higher, probably due to increased usage of aminoglycosides and consanguineous marriages.

Candidacy for cochlear implantation should be considered when there is limited residual hearing or when progress with amplification.[12] Recommendations to the family regarding cochlear implantation should be based on a team evaluation that includes audiology, otology, psychology, speech-language pathology, and other intervention personnel where OAE and ABR form the initial screening procedures for evaluation in all neonates.

CONCLUSION

In high-risk babies, the appropriate time for initial screening is after 15 days and <45 days of age. Newborn hearing screening programme should be taken up by the government as health policy. Researches to be taken up to establish population based, cost effective hearing screening modalities and guidelines. All high-risk babies though they pass screening tests at birth should be followed up at least for 3 years at least with one confirmatory test at 24 to 30 months of age.

ACKNOWLEDGEMENTS

Author would like to thanks to Dr. Suryaprakash Rao, dean, Narayana medical college, Dr. Seshamma, medical superintendent, Narayana medical college for their support. Also, to the head of the institution, Dr. P. Narayana, Chairman, Narayana medical college and hospital, Nellore for broad institutional support.

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

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Cite this article as: Ramanjaneyulu J, Kumar SR, Chaitanya VK, Kusumanjali A. Oto acoustic emissions in early detection of sensorineural hearing loss in high-risk neonates. Int J Otorhinolaryngol Head Neck Surg 2021;7:1794-8.