Hearing Screening of Newborns using Distortion Product Otoacoustic Emissions

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ABSTRACT

Introduction

The present study was devised to estimate the prevalence of neonatal hearing loss and document the importance of using DPOAE as a screening tool for identifying hearing loss in newborns.

Materials and Methods

This hospital based descriptive study was conducted from August 2018 to August 2019. A total of 928 newborn babies were included in the study. These newborn babies were subjected to hearing screening by distortion product otoacoustic emissions (DPOAE) at 24-72 hrs after birth. For pass cases, no further testing was done. For refer cases, repeat testing with DPOAE was done within 15-30 days. Newborns with refer result on repeat DPOAE testing were subjected to Brainstem evoked response audiometry (BERA) within 3 months to confirm hearing loss.

Results

Nine hundred and twenty eight newborn babies were screened by DPOAE. 851 newborns passed the first DPOAE hearing screening and 77 newborns gave refer result. 21 newborns were lost to follow-up. 56 newborns underwent repeat DPOAE testing and 5 newborns were referred for BERA. Amongst the 5 newborns who underwent BERA testing, one newborn was diagnosed with bilateral profound hearing loss. Hence, the prevalence of hearing loss of 1.08 per thousand newborn babies was estimated in this study.

Conclusion

Hearing screening of newborns using DPOAE followed by BERA in refer cases to confirm hearing loss is useful for early detection followed by timely intervention and rehabilitation.

Keywords

Infant, Newborn; Hearing Loss; Neonatal Screening; Hearing Tests; Otoacoustic Emissions

Congenital hearing loss is one amongst the most common birth defects seen in newborns that can affect a child's ability to develop speech, language and social skills. According to various studies done in India, the estimated prevalence of neonatal hearing loss varies between 1 and 8 per 1000 babies screened.[1-4] The prevalence of permanent bilateral hearing loss is 1.61/1000 of at risk infants in India.[5] Hearing screening of newborns is a very important tool for the early detection and intervention for hearing impairment. Deaf and hearing impaired children often experience delayed development of speech, language and cognitive skills which may result in slow learning and difficulty progressing in school.

Joint committee on infant hearing(JCIH) recommended that all infants should undergo hearing screening prior to discharge from the birth hospital and no later than one month of age, using physiologic measures with objective determination of outcome. All infants whose initial birth screen and any subsequent rescreening warrant additional testing should have appropriate audiologic evaluation to confirm the infant's hearing status no later than 3 months of age. Early intervention services should

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be offered through an approach that reflects the family's preferences and goals for their child, and should begin as soon as possible after diagnosis but no later than six months of age.[6,7] All newborns with or without risk factors should undergo hearing screening.

Objectively determined physiologic measures must be used to screen newborns to identify those who may be deaf or hard of hearing. Currently, such measures include Otoacoustic emissions (OAE) and Brainstem evoked response audiometry (BERA). Both OAE and BERA technologies provide non-invasive recordings of physiologic activity underlying normal auditory function. OAE measures a physiologic response from the cochlear outer hair cells, while BERA measurements reflect both cochlear status as well as auditory neural function extending beyond the cochlea into the brainstem.[6,7]

Distortion product otoacoustic emissions(DPOAE) is much quicker, easier and cost effective to perform than BERA. When initial screening is done by DPOAE followed by BERA, referral rates can be minimized.[8,9] This study was undertaken to estimate the prevalence of neonatal hearing loss and document the importance of using DPOAE as a screening tool for identifying hearing loss in newborns.

Materials and Methods

This hospital based observational study was conducted in the Department of ENT and HNS, BGS Global Institute of Medical Sciences, Bengaluru from August 2018 to August 2019. Institutional Ethical Research Committee clearance was obtained. Newborn babies who were delivered in BGS GIMS hospital and whose parents gave consent were included in the study. Newborn babies whose parents did not give consent, newborns with congenital aural deformities, newborns who were lost to follow-up were excluded from the study. A total of 928 newborn babies were included in this study.

The parents were counselled regarding congenital hearing loss and informed about the need for early diagnosis and intervention prior to the screening. Written and informed consent was obtained from the parents. Newborn babies were evaluated by means of proper history and routine ENT examination. Inspection of the pre-auricular area, pinna and post-auricular area of newborns was done. Otoscopic examination of tympanic membrane was conducted using Heine 3000 series otoscope. Presence of occluding debris, if any, was gently cleaned using cotton tipped ear swab.

All the newborns were screened with DPOAE. Newborns were tested at 24-72 hrs in a supine position, in a sound proof room in the Audiology department with the help of a qualified Audiologist. OtoRead OAE instrument was used for hearing screening. It is a hand-held device consisting of a probe along with printer and rubber ear tips. The probe tip is gently inserted into the ear of newborn and seal is checked for any extrinsic noise levels in a systematic computerized manner preloaded in the software. DPOAEs are measured by the probe and analysed by the computer. Daily calibration of the otoacoustic emission probe was done to ensure proper functioning of the probe.

DPOAEs were analysed relative to the noise floor. The result was pass if responses were obtained in atleast three of the four frequencies deferring which refer result was considered. For newborns with pass result, no further testing was done. For refer cases, repeat DPOAE testing was done at 15-30 days. Newborns with refer result after second DPOAE testing were subjected to BERA within 3 months to confirm hearing loss. All the results were entered in Microsoft EXCEL spreadsheet and analysed using SPSS (Statistical Programme for Social Science).

Results

In this study, among 928 newborn babies, 486(52.37%) newborns were males and 442(47.62%) newborns were females. Among 928 newborn babies, 70(7.54%) newborns were identified to have high risk factors and 858 (92.46%) newborn babies were normal. Among 70 newborn babies with high risk factors, 37(52.85%) newborns were males and 33 (47.14%) newborns were females. Most of the newborns-902(97.19%) were having birth weight more than 2.5kg. 26 (2.8%) newborn babies weighed less than 2.5kg.

In this study, most of the newborns-898 (96.76%)

Table I: Distribution of associated risk factors among the newborns

SL NO	RISK FACTOR	NO (%)
1	Preterm(Gestation < 37 weeks)	11 (1.2)
2	Low birth weight(<2.5 kg)	8 (0.9)
3	Low birth weight + Preterm	15 (1.6)
4	Neonatal hyperbilirubinemia	10 (1.1)
5	Neonatal respiratory distress	13 (1.4)
6	Preterm + neonatal hyperbilirubinemia	1 (0.1)
7	Preterm + neonatal respiratory distress	1 (0.1)
8	Low birth weight + respiratory distress	1 (0.1)
9	Neonatal hyperbilirubinemia + Neonatal respiratory distress	1 (0.1)
10	Low birth weight + Preterm + Neonatal hyperbilirubinemia	1 (0.1)
11	Low birth weight + Preterm + Neonatal respiratory distress	1 (0.1)
12	Neonatal hypoglycemia	1 (0.1)
13	Neonatal tachycardia	1 (0.1)
14	Pneumonia	2 (0.2)
15	Family history of hearing loss	1 (0.1)
16	Syndromic association	2 (0.2)
	TOTAL	70 (7.54)

were having term gestation (equal to or more than 37 weeks). The period of gestation was less than 37 weeks in 30 (3.24%) newborns. The distribution of newborn babies with high risk factors is shown in Table I. The most common high risk factors identified among the newborns in this study was low birth weight along with preterm delivery. Table II shows sex distribution in newborns with high risk factors.

Figure 1 shows the screening algorithm with the number of babies at each stage of screening. Amongst the 928 newborns who underwent first stage of screening with DPOAE, 851 (91.7%) newborns passed the hearing test and 77 (8.3) newborns were referred for second stage screening. Out of the 77 newborns, 21 newborn babies were lost to follow up and 56 newborns underwent second stage screening with DPOAE. On repeat testing of 56 newborn babies, 51 newborns passed the hearing test and 5 newborns were referred for BERA. Among the 5 newborn babies, 4 newborns passed the hearing testing whereas 1 newborn was diagnosed with profound hearing loss on BERA.

In this study, 70 newborns had one or more high risk factors. Among these newborns, 54 newborns passed the first stage screening and 16 babies were referred for second stage screening. 5 newborn babies were lost to follow up. 11 newborn babies underwent 2nd stage screening and 6 newborn babies passed the hearing test. 5 newborn babies were subjected to BERA. Table III shows screening results of newborns with and without risk factors. Table IV shows the various risk factors present in the newborns who underwent second DPOAE testing.

Table II: Sex distribution in newborns with risk factors

SL NO	RISK FACTOR	MALE	FEMALE
1	Preterm(Gestation < 37 weeks)	6	5
2	Low birth weight(<2.5 kg)	3	5
3	Low birth weight + Preterm	9	6
4	Neonatal hyperbilirubinemia	5	5
5	Neonatal respiratory distress	9	4
6	Preterm + neonatal hyperbilirubinemia	1	0
7	Preterm + neonatal respiratory distress	0	1
8	Low birth weight + respiratory distress	0	1
9	Neonatal hyperbilirubinemia + Neonatal respiratory distress	0	1
10	Low birth weight + Preterm + Neonatal hyperbilirubinemia	1	0
11	Low birth weight + Preterm + Neonatal respiratory distress	0	1
12	Neonatal hypoglycemia	0	1
13	Neonatal tachycardia	1	0
14	Pneumonia	1	1
15	Family history of hearing loss	0	2
16	Syndromic association	1	0
	TOTAL	37	33

Five newborns with risk factors who were referred on second stage DPOAE screening were subjected to BERA. Among the 5 newborns, 3 were male and 2 were female. On testing with BERA, one male newborn was diagnosed with bilateral profound hearing loss. The newborn was associated with high risk factors of low birth weight (1kg) and preterm gestation (30 weeks). Hence, the prevalence of hearing loss of 1.08 per 1000 babies was detected in the newborn babies examined in this study.

Discussion

Congenital hearing loss is one of the most common congenital anomalies which can be identified early in life. Early recognition of a child who is deaf or hard of hearing in infancy and early intervention can prevent delays in speech and language development, academic achievement, social and emotional outcomes. Congenital hearing loss may affect the auditory neuropathway of children at a later developmental stage if appropriate and optimal interventions are not provided within the critical period of central auditory pathway development. Therefore, early detection is a vitally important element in providing appropriate support for deaf and hearing impaired newborns.[4]

Currently, the acceptable tests for screening of neonatal hearing loss include OAE and BERA. OAE measures sound waves generated in the inner ear in response to clicks or tone bursts emitted and recorded through miniature microphones placed in the external ear canal of the infant.[9] DPOAEs are elicited by asymmetrical

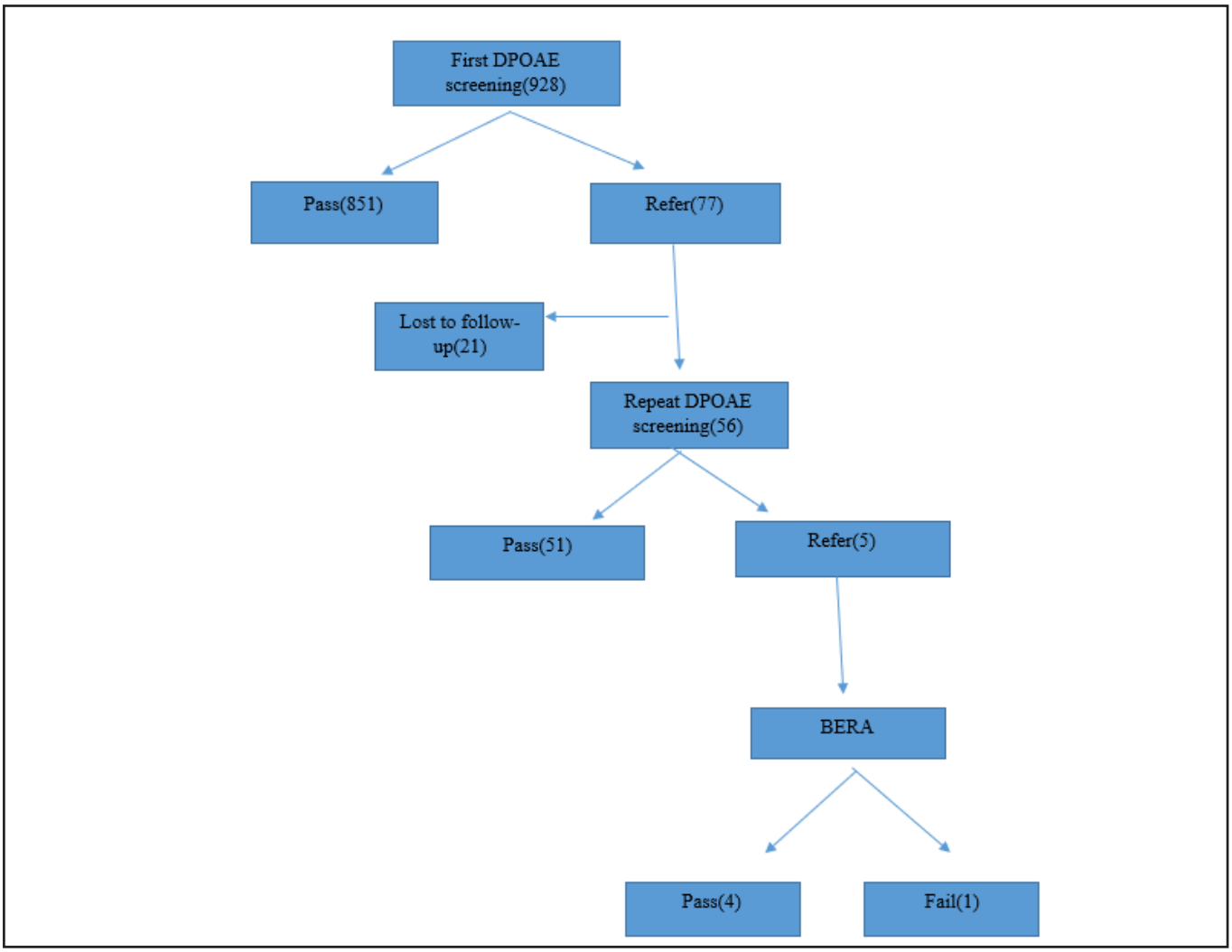

Fig. 1: Screening Algorithm[9]

Table III: Screening results of newborns with and without risk factors

	NEWBORNS WHO UNDERWENT FIRST SCREENING	NEWBORNS REFERRED ON FIRST SCREENING	NEWBORNS WHO UNDERWENT SECOND SCREENING	NEWBORNS REFERRED ON SECOND SCREENING
Newborns without risk factors	**858**	**61**	**45**	**00**
Newborns with risk factors	**70**	**16**	**11**	**05**
Total	**928**	**77**	**56**	**05**

Table IV: Newborns with risk factors who underwent second DPOAE testing

SL NO	RISK FACTOR	PASS	REFER
1	Preterm	01	00
2	Low birth weight + preterm	01	02
3	Neonatal respiratory distress	03	00
4	Neonatal hyperbilirubinemia	01	03
	TOTAL	06	05

protocols (75-65 dB SPL) testing the frequencies 1.5, 2.0, 3.0, 4.0 and are found to be more immune to noise. BERA measures the electroencephalographic waves generated in response to clicks by three electrodes placed on the infant's scalp.[9]

All the newborns in this study were screened with DPOAE and the test was repeated for those who were referred on initial screening. The newborns who did not respond on re-screening with DPOAE were tested with BERA. In this study, we found that most of the newborns (52.37%) were males. The findings were similar to that of Ohl et al.,[10] Mishra et al.,[11] Kulkarni et al.,[12] Rozario et al.,[13] Boo et al.[14] and Chaudhari et al.[15] where male predominance was observed.

In this study, most of the newborns (97.19%) were having birth weight of more than 2.5kg. These findings were similar to study by Kulkarni et al.[12] and Chaudhari et al.[15] In this study, most of the newborns(96.76%) were having term gestation. Study by Kulkarni et al.,[12] Boo et al.[14] and Chaudhari et al.[15] also favoured this study. In this study, the most common high risk factors were preterm gestation and low birth weight. Study by Kulkarni et al.,[12] Rozario et al.,[13] Chaudhari et al.[15] and Johnson et al.[16] also favoured this study.

In this study, a two stage protocol was used, wherein newborns were subjected to two stages of otoacoustic emission screening. Those newborns who had failed the second stage were subjected to BERA. This protocol was put forward by the Joint committee of Infant Hearing and was also followed by Finitzo et al.,[17] Kulkarni et al.,[12] Rozario et al.[13] and Chaudhari et al.[15] In this study, most of the newborns (91.7%) passed the first stage of OAE screening. Study by Shreeya Kulkarni et al.,[15] Glen et al.,[18] Rozario et al.[13] and Chaudhari et al.[15] also favoured this study.

In this study, the prevalence of neonatal hearing loss was 1.08/1000 newborns. Study by Nikita Chaudhari et al.15 found the prevalence rate of 1.41, Fortum et al.[19] found it 1.1, Cynthia C Morton et al.[20] found it 1.33, Renitha et al.[21] found it 1 and Kumar et al.[22] found it 1.61.

In 2006, India launched the National Programme for Prevention and Control of Deafness. This programme is currently running in over 60 districts of the country and its aim is to identify newborns with bilateral severe-profound hearing losses by 6 months of age and initiate rehabilitation by 9 months of age.[5] Under this programme, both Institution-based and Community-based infant hearing screening are being implemented. The protocol of Institution-based screening is to screen every newborn born in a hospital or admitted there soon after birth using OAE. Those who fail the test are re-tested after 1 month. Those who fail the second screening are referred for BERA testing. The same protocol was implemented in this study.

Providing children and families the earliest possible start in intervention is considered best practice. Early interventions are widely recognized as a means to provide infants access to linguistic input, whether through spoken and/or sign language. Hearing aids may be fitted for infants as early as 2 months of age. This should be followed with auditory training and speech therapy. Children with bilateral profound hearing loss should be considered for cochlear implantation.

Conclusion

In short, it is necessary to secure holistic development of the child by detecting hearing loss at birth and providing remedial measures at the earliest. Hearing screening of newborns using DPOAE followed by BERA in refer cases to confirm hearing loss is useful for early detection followed by timely intervention and rehabilitation.

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