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Original Research Article

Application of otoacoustic emissions and brainstem evoked response audiometry in newborn hearing screening

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ABSTRACT

Background: Newborn hearing screening was conducted in a tertiary care hospital in a step by step manner using otoacoustic emissions (OAE) and brainstem evoked response audiometry (BERA) and details were recorded.
Methods: A prospective institutional based study was conducted. All the newborns born in the hospital over a period of 18 months from December 2018 to May 2020 were considered in the study. Healthy newborns were screened bedside within 24 hours of delivery and NICU (Neonatal Intensive Care Unit) babies were screened in the NICU. Handheld OAE apparatus was used as the initial screening tool. A total of 3 OAEs were done for babies with a "refer" result in the OAEs, which were done 1 month apart. Babies with a "refer" in the third OAE were subjected for BERA.
Results: A total of 14226 babies were screened at 24-48 hours of birth. Among them, 13,069 babies passed the first OAE screening in both ears. Remaining babies were referred for further follow-up. After subsequent follow-ups and successive testing, 11 babies were found to have hearing loss, which was diagnosed within 4-5 months of the child's birth.
Conclusions: Universal newborn hearing screening is the need of the day. OAE is an effective screening tool for newborn hearing loss. When complemented by BERA, majority of congenitally deaf babies can be diagnosed at a very early age. This helps in early intervention.

Keywords: New-born hearing screening, Otoacoustic emissions, BERA

INTRODUCTION

Congenital hearing loss has a variety of causes, that may range from hereditary hearing impairment to antenatal infections in the mother, maternal diseases, complications during labor or neonatal factors.

Exposure to sound in the first two-three years of life plays a major role in the development of speech of an individual. A congenital hearing loss often goes unnoticed, until the caretakers of the child bring him/her to the doctor with complaints of delayed or absent speech.

An early screening for such a hearing loss will help in recognizing the children who need help. The younger the child, higher is the neural plasticity of the auditory system, better will be the outcomes of intervention strategies.

David Kemp described the otoacoustic emissions in 1978. Otoacoustic emissions are sounds that result from energy generated in the cochlea that are propagated through the middle ear and into the ear canal where they can be measured using a sensitive microphone.[1]

The auditory brainstem response is an evoked potential used to assess both neural response integrity and estimates

of hearing thresholds. It was first reported by Jewett and Williston.[2]

Objectives

To analyze the usefulness of OAE and BERA in newborn hearing screening. To analyze common risk factors associated with hearing impairment in the newborns.

METHODS

After approval by the institutional ethical committee, a prospective institutional based study was conducted in the tertiary care hospital over a period of 18 months- from December 2018 to May 2020. All the babies born in the study period were included in the study and the sample size at the end of study period consisted of a total of 14226 babies. Healthy newborns were screened bedside within 24 hours of delivery in the department of obstetrics and gynaecology and babies admitted to the neonatal intensive care unit immediately after delivery were screened in the NICU, department of paediatrics.

Inclusion criteria

Babies born in the tertiary hospital during the study period.

Exclusion criteria

Unstable newborns requiring urgent referral to higher centers. Babies discharged from the hospital before completion of 24 hours of birth (discharge against medical advice). Death of baby before discharge from hospital.

A detailed maternal history was taken to know if the mother had faced any complications in the antenatal period and during delivery. History of any drug intake by the mother in the antenatal period, family history of hearing impairment, condition of the baby immediately after death was noted.

The healthy babies were screened in the postnatal ward with the baby lying on the mother's lap or by the mother's side by DPOAE (Distortion product otoacoustic emissions). NICU babies were screened in the NICU.

A soft probe tip of size enough to achieve enough seal was inserted to the external auditory canal and DPOAE was recorded for both ears separately.

For babies with a "pass" result, no further testing was done. Babies with a "refer" result were recalled for a repeat DPOAE testing after one month, which was done in Department of ENT, McGann teaching hospital, Shivamogga. Babies with a "pass" result in the 2nd OAE were not tested further. In cases of "refer" result in the 2nd OAE, babies were recalled for OAE and BERA after 1 month. Babies with a "refer" result in the 3rd OAE were given appointments for BERA testing in the same or following week.

For BERA testing, electrodes were secured on the mastoid processes and vertex of the baby once the baby was asleep. Sound stimulus presented to both ears separately and the wave forms produced were recorded.

Details of each baby including- period of gestation (term or preterm), whether born to a consanguineous marriage, mode of delivery, sex of the baby, risk factors in the mother, complications at birth, low birth weight, presence of neonatal jaundice, NICU admission, etc. was entered in Microsoft Excel software and the follow-ups were updated accordingly.

Various data for the study was later collected from the details entered in the software. The incidence of hearing-impaired children was calculated by the formula:

Number of new cases occurring in the population in a given period of time×1000÷Total number of people in the same population during same period of time

Whenever a test for significance between two variables was required, chi-square test was employed.

RESULTS

A total of 14226 babies were screened within 24-48 hours of birth in the study period. In the first OAE screening, 13,069 babies passed and 1157 babies were referred for second OAE. (Figure 1)

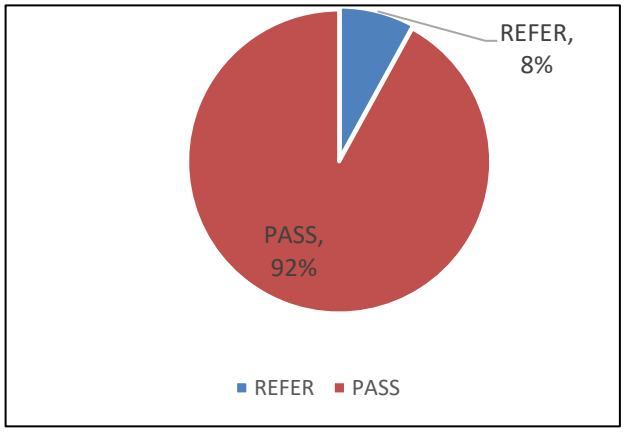

Figure 1: Results of first OAE.

In the second OAE, done after a month of first OAE, 994 of the 1157 babies passed and 163 were further referred for third OAE (Figure 2).

The third OAE was done 1 month after the second OAE testing. 5 babies were lost to follow up at this stage. Out of the 158 babies that were screened, only 20 babies failed the OAE testing (Figure 3).

Out of the 20 babies, 18 babies appeared for BERA and 2 were lost to follow up. 11 of the 18 babies subjected to BERA were found to have hearing loss (Figure 4).

In the study, a total of 11 babies were found to have hearing loss.

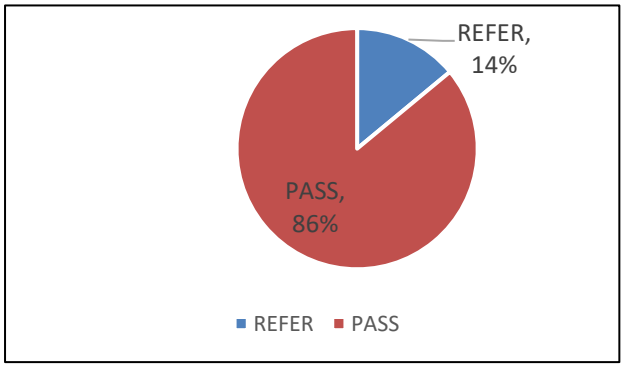

Figure 2: Results of second OAE.

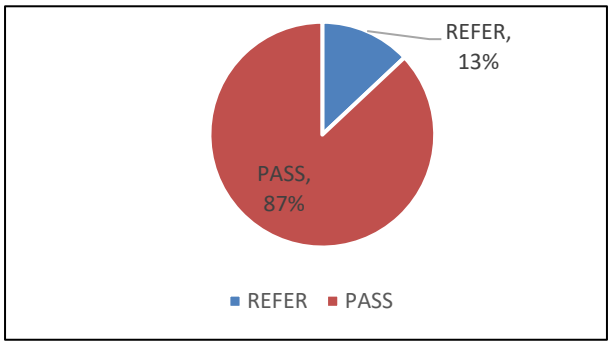

Figure 3: Results of third OAE.

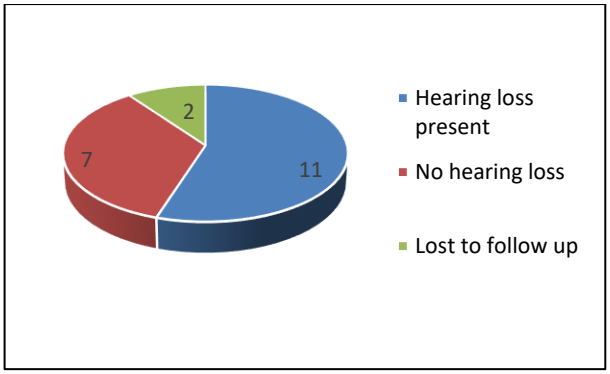

Figure 4: Results of BERA.

The babies in the otoacoustic emissions study were categorized into different groups based on the possible risk factors for referral. The results were as shown in Table 1.

DISCUSSION

A hearing screening study by Nagapoornima et al was conducted at St. John's medical college hospital, Bangalore on 1769 infants (1490: not at risk, 279: at risk). It showed the incidence of hearing impairment to be 5.65 per 1000 screened. 3 "at risk" infants and 7 "not at risk" infants were found to have hearing impairment. It was thus concluded that basic hearing screening of all neonates was necessary.[3]

Table 1: Evaluation of possible risk factors for hearing loss in the newborn.

	1st OAE		2nd OAE		3rd OAE		BERA	
	No. of babies screened	**No. of babies referred**	**No. of babies screened**	**No. of babies referred**	**No. of babies screened**	**No. of babies referred**	**No. of babies screened**	**No. of babies with hearing loss**
Total	14226	1157	1157	163	158	20	18	11
Male babies	7291	603	603	83	81	11	10	7
Female babies	6933	554	554	80	77	9	8	4
Babies born to mothers with PIH (Pregnancy Induced Hypertension)	344	74	74	17	16	2	2	1
Babies born to mothers with GDM (Gestational Diabetes Mellitus)	44	6	6	1	0	0	0	0
Babies born out of consanguineous marriage	1435	140	140	31	30	4	4	3
LSCS (Lower segment Cesarean	5576	376	376	56	55	8	7	3

Continued.

	1st OAE		2nd OAE		3rd OAE		BERA	
section) delivery								
Low birth weight babies	170	110	110	20	20	3	3	2
NICU babies	755	451	451	72	70	5	4	1
Preterm babies	259	167	167	31	30	3	3	1
Babies with neonatal jaundice within 24-48 hours of birth	21	18	18	8	8	1	1	1

A study was conducted by Kumar et al on routine hearing screening of babies born above 35 weeks not requiring NICU care between January 2007 and March 2016. Of the 30,600 neonates screened, 75 failed. 58 of the 75 passed the test after a week. 17 of the babies were investigated with auditory steady state response audiometry, 8 of these babies were diagnosed to have hearing difficulties.[4]

Similarly, in our study, a step-by-step methodology followed showed 11 babies to have hearing impairment out of the 14226 children screened (Figure 4). The incidence thus being 0.77 per 1000 live births. The screening with OAE multiple times helped in reducing the number of children to be subjected for BERA. Since all children were included in the study, irrespective of risk factors, universal screening was achieved.

In a study by Bakhshee et al, it was seen that failure rates after the first OAE screening was statistically significant between offspring of pre-eclamptic and healthy women, but difference in results of second OAE and ABR between the two groups was not statistically significant.[5]

PIH was found to have a transient effect on hearing of the neonate in our study as well (Table 1).

In a review article by Cristobal et al it has been mentioned that a large number of low birth weight infants who fail the initial hearing screening are found to have only a mild conductive hearing loss due to middle ear effusions.[6] Rosenfeld RM et al said that most of these effusions resolve spontaneously within few weeks of birth.[7] This may attribute to the improvement in hearing outcomes in subsequent OAE screenings.

Several risk factors for development of hearing loss in neonates in the NICU has been mentioned in a study by Cristobal et al. These factors may improve in a child as it is discharged from the NICU, thus improving hearing results as well. (Table 1)

Studies have shown that early OAE screening (within 24 hours of life) can yield higher false positives due to debris in the external auditory canal or middle ear fluid. This is thought to be resolved in first few hours or days of life.[8] But, screening in that time period ensures not missing any babies from screening.

Limitations

Since the study required multiple visits to the hospital, there were 5 babies who were lost to follow up for third OAE and 2 babies that were lost to follow up for BERA.

CONCLUSION

Hearing impairment is an invisible anomaly at birth, becoming apparent only when a child fails to develop normal speech. Identifying such an impairment at the earliest will help in early rehabilitation by making use of the child's neural plasticity. Otoacoustic emission testing offers to be a quick, cost effective, acceptable, non-invasive bed side screening tool for the purpose. Although BERA is a better diagnostic tool, it needs more resources and is time consuming. Thus, it is not an ideal screening tool and needs to be reserved for confirmation of the diagnosis. Also, the otoacoustic emission testing can be done by anyone with the help of a hand held device, hence its routine usage in maternity hospitals will help in recognizing hearing loss at the earliest. Since BERA requires an expert to carry out the procedure and interpret the results, babies referred in OAE testing can be subjected to BERA. The present study showed significant association between pregnancy induced hypertension, preterm delivery, low birth weight, NICU admission and neonatal jaundice with failure results in first OAE screening. But such an association was not seen in subsequent OAE screening and BERA. No particular risk factors for hearing loss in the newborn can be established from the present study. Thus, the study establishes the importance of universal hearing screening.

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