Original Article

Effectiveness Of Transient Evoked Otoacoustic Emission (TEOAE) Test For Neonatal Auditory Screening

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ABSTARCT

Objective: The purpose of this study is to assess the efficacy of Transient Evoked Otoacoustic Emission (TEOAE) as screening test for auditory function in neonates.

Study Design: A cross-sectional study

Place and Duration of Study: This study was conducted at United Medical and Dental College, Creek General Hospital, Karachi, from July 2106 to May 2017. A total number of 120 newborn babies were screened for hearing loss before discharge from hospital but 20 were lost for follow up and 100 cases were included in this study.

Method: TEOAE was done in all neonates born during this period at 3rd day after birth. Those who were found to have hearing loss, TEOAE was repeated at the end of 1st week and again in 6th week after birth. BERA was done in those cases who showed hearing loss on TEOAE on all three occasions. All the 100 cases were followed up regularly for more than one year for appearance of any sign or symptom related with hearing loss or speech development failure.

Result: Out of 100 cases included in this study, 96 were found to have no hearing loss on TEOAE and 1 on BERA test. Remaining three cases were found to have hearing loss on both TEOAE and BERA test. True negative cases where no hearing loss was found on TEOAE and subsequent follow up were 96. True positive cases were 3 where hearing loss was found on TEOAE and BERA and also on subsequent follow-up. False positive case was 1, where hearing loss was detected on TEOAE but BERA showed normal hearing and subsequent follow-up also showed normal hearing and false negative result was not detected in any case. Sensitivity of TEOAE was found to be 100%, specificity is 98.9%, accuracy is 99%, positive predictive value is 75% and negative predictive value is 100% in this study.

Conclusion: TEOAE was found to be a cost-effective and practicable method of recognizing congenital hearing loss. It should be done in all newborns as routine screening for hearing loss.

Key words: Hearing screening, Transient evoked otoacoustic emissions; Brainstem evoked response audiometry, Congenital deafness

INTRODUCTION

The purpose of neonatal auditory screening is to recognize precisely infants with significant auditory impairment in the most quick and cost-effective way[1]. Even moderate hearing loss of less than 40db in early childhood impedes speech, language and cognitive development leading to adverse effect on social, emotional and academic performance. Regrettably, the perfect screening test for newborns has yet to be defined[2]. Recommended test according to universal newborn hearing screening programs worldwide for assessing hearing loss include Transient Evoked Otoacoustic Emissions (TEOAE) and diagnostic Brainstem Evoked Response Audiometry (BERA).

Although TEOAE is economical, fast, simple and consistent test with a sensitivity of 100% and specificity of 99%[3, 4], BERA test is the gold standard, has the additional advantage to assess function of auditory neurological pathway from periphery to the center. In contrast TEOAE is a physiological test, that measures the integrity of the outer hair cells in the cochlea. The variances in the external auditory canal and differences in the assignment and kind of earpiece can yield marked difference in the stimulus of TEOAE and therefore can lead to false negative results. The conductive pathway should be within normal limits to record TEOAE. The other advantages of BERA include measuring the average hearing threshold of frequencies at 2000-4000 Hz with high sensitivity (99%) and specificity (87%)[5, 6]. False positive results of BERA seem to be fewer[7].

The purpose of this study is to evaluate the efficacy of TEOAE as screening test for hearing in neonates in our local setup. We have used TEOAE as first screening test and BERA was done as a confirmatory diagnostic test on newborns who fail three attempts of TEOAE test. All the children were followed up for more than one year for

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appearance of any sign or symptom related with hearing loss or faulty speech development.

PATIENTS AND METHOD

This study was conducted at the department of Otorhinolaryngology, Head & Neck Surgery, Creek General Hospital, the affiliated hospital of United Medical & Dental College, Karachi, Pakistan. It was conducted from July 2016 to May 2017, over a period of 10 months, through 'hearing screening program' by an audiologist. The study was reviewed and accepted by the institutional ethical review committee (ERC) of UMDC. A total of 120 infants born at Creek General Hospital during this period were included in the study. Exclusion criteria were patients with congenital deformity of the pinna or external auditory canal and the patients lost for follow up visits.

An appropriate informational brochure for parents to assist in gratifying this responsibility was designed. A convenient sampling technique for hearing screening was adopted by collecting information through Performa filled by newborn baby's parents. Hearing screening protocol was used and Transient Evoked Otoacoustic Emissions (TEOAE) screening test was done on 3rd day after birth. Those who has abnormal TEOAE result were re-tested at the end of 1st week after birth and those who still had abnormal result were again tested on 6th week. Brainstem Evoked Response Audiometry (BERA) was done in those patients who has abnormal or failed TEOAE on all three occasions.

The screening was done at the bedside in typical postnatal ward, with the newborns in their cots or held in their mothers' arms or at NICU (Fig 1). Sedation was not required. Informed consent was taken by mothers before hearing screening. Immediate result of 'pass' or 'fail' is handedover to parents and record kept for future reference in hospital medical record. In addition, parents were instructed to return for re-screening in case of first failure at the end of first week. All patient who were declared normal after TEOAE were followed up regularly for more than one year for any deafness and language problem. All parents were also instructed to report immediately if they think their child has any problem in hearing or subsequent speech development. Data was collected and analyzed with SPSS version 23.

RESULT

During the study period of 10 months, 120 newborns were screened for hearing assessment in which 80 (66.66%) were boys and 40 (33.33%) were girls. During the first TEOAE testing, done on 3rd day after birth, out of 120 patients, 90 were found to have normal hearing (table 1). All the other 30 babies were instructed to come again after one week for retesting. Out of these 30 babies, only 10 returned for retesting after one week and other 20 were considered lost from follow up and excluded from this study. During this 2nd testing out of 10 cases, 6 were found normal and 4 were still have abnormal TEOAE result (table 1). These 4 babies

Fig. 1. Auditory screening being performed at Creek General Hospital by handheld OAE device.

with abnormal TEOAE were again tested at 6th week after birth and all of these were found to have deafness.

These 4 babies with abnormal TEOAE were then referred for BERA test and among it 3 were found to have deafness bilaterally and one has normal hearing (table 1). All the three babies with deafness bilaterally were referred for auditory rehabilitation.

Out of 100 cases included in this study, 96 were found to have no hearing loss on TEOAE and 1 on BERA test. These 97 children were followed up regularly in OPD and on phone for development of any hearing or speech problem, but all have normal hearing and normal speech development. Remaining three cases were found to have hearing loss on both TEOAE and BERA test and also found to be deaf on subsequent follow-up. So, the true negative cases where no hearing loss was found on TEOAE and subsequent follow up were 96 (fig. 2). True positive cases were 3 where hearing loss was found on TEOAE, BERA and subsequent follow-up as well. False positive case was 1, where hearing loss was detected on TEOAE but found normal on BERA and subsequent follow up. False negative result was not detected in any case where TEOAE has given result of no hearing loss and subsequently found to have hearing loss (fig. 2). Table 2 is showing details of calculation of sensitivity, specificity, accuracy, positive predictive value and negative predictive value for TEOAE. Sensitivity was found to be 100%, specificity is 98.9%, accuracy is 99%, positive predictive value is 75% and negative predictive value is 100% in this study.

DISCUSSION

Hearing during the first six months of life is essential for speech and language development. Detection of hearing loss before three months of age and appropriate therapeutic measures not later than six months is vital to improve the quality of life in children with hearing loss. Most of Pakistan's population is poor and lives in the rural areas where congenital hearing loss is very prevalent. Steps should be taken to provide facilities for evaluating hearing loss in newborn

	Total no. of patients	No Hearing Loss	Hearing Loss
1st TEOAE (at 3rd day)	120	90	30
Lost for Follow up	20	--	--
2nd TEOAE (at end of 1st week)	10	6	4
3rd TEOAE (at end of 6th week)	4	0	4
BERA (after 3 failed TEOAE)	4	1	3

Table 1. Results of TEOAE and BERA

	Formula		Result
Sensitivity	TP/TP+FN	3/3+0	100%
Specificity	TN/TN+FP	96/96+1	9 8.9%
Accuracy	TP+TN/TP+TN+FP+FN	3+96/3+96+1+0	99%
Positive predictive value	TP/TP+FP	3/3+1	75%
Negative predictive value	TN/TN+FN	96/96+0	100%

Table 2. Sensitivity, Specificity, Accuracy, Positive predictive value and Negative predictive value of TEOAE
TP = True Positive TN = True Negative FP = False Positive FN = False Negative

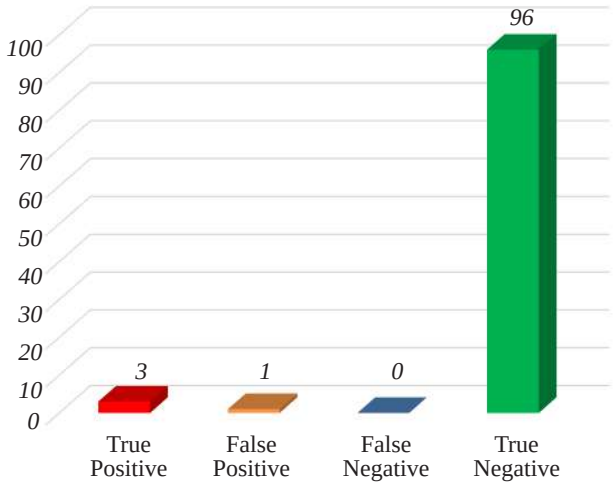

Fig. 2. No. of True Positive, False Positive, False Negative and True Negative Result on TEOAE

nurseries as part of the immediate post-delivery examination screening program[8].

For auditory screening in newborns, two approaches are used generally. One is Otoacoustic Emissions, which is based on recording of physiological sound produced by the outer hair cells of the cochlea while the other is Brainstem Evoked Response Audiometry (BERA) which is a recording of the electrical event from the brainstem in response to a sound stimulus. Both methods are generally used for auditory screening. A study by Norton et al.[9, 10] compared the efficacy of Transient Evoked Otoacoustic Emission (TEOAE), Distortion Product Otoacoustic Emissions (DPOAE) and Brainstem Evoked Response Audiometry (BERA). They observed that, all the three methods are equally good for auditory screening in newborns. None of these procedures detects hearing loss rather its goal is to objectively assess auditory function[11,12]. Numerous researchers have studied the overall cost of auditory screening in the early childhood period as well as the advantages and disadvantages of the different available methods [13,14]. Assessing which among all these is more cheap and cost-effective in our region is of great interest. The results shown in the present study concludes that it is possible to incorporate a two-stage TEOAE hearing screening and diagnostic BERA in Pakistan to assess newborn hearing at early age.

The normal outer hair cells of the cochlea not only perceive sounds, but it also generates sounds of low intensity called Otoacoustic Emission (OAE). The sound is generated by

the expansion and contraction of the outer hair cells in response to sound stimuli. These OAEs are present in healthy normal persons where hearing loss does not exceed 30db. The chief purpose of TEOAE test is to estimate status of the cochlear, precisely function of the outer hair cell in response to sounds stimulus. The sound stimulus is given in the form of a series of clicks at 80-85 db SPL using a probe which encompass a transducer. It also contains a microphone to receive OAEs generated by the outer hair cells of the cochlea. The test has certain limitation as it is affected by high environmental sounds in the surroundings and it is absent if the hearing loss is more than 40 db. On the other hand, the brainstem evoked response audiometry (BERA) is an electrophysiological measurement of the function of the auditory pathway from the cochlear nerve through the brainstem. It is mostly recorded when the babies are sleeping or sedated. Through BERA degree of hearing loss can be assessed accurately at all decibels. Hence it is valuable as a confirmatory test for hearing loss in infants and newborns. Main limitation of BERA is the cost and time involved in performing the test.

Very few studies are carried out in Pakistan about the auditory screening program in neonates[15,16]. As the neonatal hearing loss cannot be detected without a suitable test because newborns with mild to moderate hearing loss may still react to some environmental sounds, making parents imagine that their babies hearing falls within standard parameters[17]. Although comprehensive neonatal screening program have been introduced since mid-eighties but major factor contributing to late detection is the absence of proper neonatal screening program at maternity hospitals[18].

In our study out of initial 120 newborns, 20 (16.6%) were lost in follow up and patient compliance after first screening was very low. Only 10 returned for re-screening out of 30 mainly due to lack of awareness regarding screening and anxiety caused by the process. Detection of unilateral hearing loss on TEOAE is very vital in diagnosing uncommon causes of unilateral deafness such as tumor in the eighth cranial nerve[19]. Hearing device should be fitted before 6 months of age as it will improve subsequent hearing development and is considered as an initial standard goal in the management of children with hearing loss[20].

A study by Tzanakakis[21] compared TEOAE and DPOAE and concluded that TEOAEs testing is easier to perform and it is more reliable as compared to the DPOAEs test. The specificity for TEOAE was found to be 92% which is much similar to our study where we found it as 98.9%. The study by Sachdeva[22] concluded that Distortion Product Otoacoustic Emission and then confirmation by BERA is very beneficial tool in early identification of congenital hearing loss in neonates. The sensitivity for TEOAE found in our study is 100% which is much similar to another study by Iwasaki et al[5].

There are certain factors that might contribute to the delay between diagnosis and intervention in children with hearing loss in our society. It includes, low literacy rate among parents, cultural considerations, doubts about the degree of hearing loss, the benefits of hearing amplification, acceptance in wearing hearing aids, cost and technical considerations[23]. Congenital hearing loss is typically predominant in low-income population. Annually, about 740,000 children (roughly six per 1,000 live births) are detected to have sensorineural hearing impairment in low and middle-income class countries as compared with 28,000 (around two per 1,000 live births) in high income class countries[24]. Available data from the World Health Organization (WHO) suggest that approximately 7.5 million children below the age of 5 years have disabling hearing impairment worldwide, the clear majority (at least 80%) of whom reside in low and middle income countries[25.26,27].

Conclusion:

TEOAE was found to be a cost-effective, rapid and practicable method of identifying congenital hearing loss. It should be done in all newborns as routine screening for hearing loss. Our study strengthens the fact that like other developing countries where they have introduced neonatal hearing screening, the same can be implemented in Pakistan in a cost-effective way, which will help to decrease the impact on child's social, emotional, intellectual and linguistic development.

Limitations:

20 patients were lost for follow-up after first initial TEOAE test after birth who were declared failed. There might be more positive cases who had hearing loss among these 20 patients, causing a change in overall results.

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Conflict of Interest:

None

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