Clinical Pediatrics: Open Access

Maung et al., Clin Pediatr 2016, 1:4

Research Article Open Access

Diagnostic Accuracy of Distortion Product Otoacoustic Emissions (DPOAE) and Transient Evoked Otoacoustic Emissions (TEOAE) in High Risk Newborn: A Comparative Study

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Received date: February 23, 2016; **Accepted date:** July 22, 2016; **Published date:** July 30, 2016

Abstract

Introduction: Hearing impairment is one of the commonest congenital disabilities in the world. Early diagnosis is essential to minimize or to prevent the disability. There are many screening methods and protocols for newborn hearing screening. TEOAE has high sensitivity and less time consuming than DPOAE. DPOAE is highly specific but more time consuming than TEOAE. This study aims to compare the accuracy of DPOAE and TEOAE by using ABR evaluation on high risk newborn.

Methods: This study was conducted on 1000 high risk newborns admitted to SCBU, CWH (Mandalay). Cases were selected with inclusion and exclusion criteria. The newborns after day 3 were screened with both DPOAE and TEOAE tests on every Monday, Wednesday and Friday. All included newborns underwent ABR confirmation at ENT Department, EENT Hospital (Mandalay).

Result: For the 1000 left ears, DPOAE yielded 787 'pass' and 213 'refer'. For the 1000 right ears, DPOAE yielded 776 'pass' and 224'refer'. For the 1000 left ears, 737 had passed TEOAE and 263 were not passed the test. For the 1000 right ears, 752 had passed TEOAE and 248 were referred. Sensitivity of DPOAE is 97.57% and specificity is 95.39%.False positive rate is 4.60% and false negative rate is 2.42%. Sensitivity of TEOAE is 96.49% and specificity is 90.60%. False positive rate is 9.39% and false negative rate is 3.50%.

Conclusion: It can be concluded that TEOAEs are useful for universal newborn hearing screening because it has short duration with acceptable accuracy and DPOAEs are useful for high-risk neonates as a hearing screening test because of good correlation between DPOAE and threshold of wave V of ABR.

Keywords: DPOAE; TEOAE; High risk newborn hearing screening

Introduction

Hearing impairment is one of the commonest congenital disabilities in the world [1]. Auditory deprivation causes serious impairment of the normal development of a child, especially in the field of normal communication and learning. Early diagnosis is essential to minimize or to prevent the disability [2].

Infants are recognized as being at risk if there is a family history of permanent childhood hearing loss, *in-utero* infections such as rubella, cytomegalovirus, syphilis, toxoplasmosis and herpes or cranio-facial anomalies. Other risk factors as recommended by the United States Joint Committee on Infant Hearing (JCIH) are: birth weight less than 1500 g (3.3 lbs), hyper bilirubinaemia at levels requiring exchange transfusion, bacterial meningitis, ototoxic medications, mechanical ventilation lasting 5 days or more, stigmata or other findings associated with a syndrome known to include sensorineural and/or conductive hearing loss; birth asphyxia with Apgar ≤ 5 at 1min or ≤ 6 at 5 min [3]. The development of otoacoustic emission (OAE) tests and auditory brainstem response (ABR) testing has enabled the detection of a hearing loss present in the newborn period and has enabled habilitation to be started in the first few months of life [4].

Both technologies are noninvasive recordings of physiologic activities that are easily recorded in newborns and are highly correlated with the degree of peripheral hearing sensitivity [5]. Kemp demonstrated existence of evoked otoacoustic emissions in 1978.There are two widely used evoked otoacoustic emissions (EOAEs) measurements that have become routine procedures in the clinical test battery - transient-evoked OAEs (TEOAEs) and distortion product OAEs (DPOAEs) [6]. Kemp reported TEOAEs were simpler than DPOAEs in terms of the technical complexity of the test and TEOAEs required less testing time [7].

There are many screening methods and protocols for newborn hearing screening. Many nations use two stage screening protocol: OAE screening followed by ABR evaluation for confirmation. The diagnosis of "hearing loss" is determined only by ABR. The neonatal hearing screening is the first part of the program of habilitation of hearing-impaired children [8].

The ideal approach is to screen all newborns and infants before 1 month of age, complete diagnostic evaluation by 3 months of age for newborns and infants who failed the screening tests and provide intervention services (audiological, medical and educational) by 6 months of age [9]. This study aimed to determine the diagnostic

accuracy of DPOAE and TEOAE in high risk newborn in terms of sensitivity, specificity, false positive rate and false negative rate.

Method and Materials

A hospital based comparative prospective study was conducted at Special Care Baby Unit (SCBU) in Mandalay Central Women Hospital (CWH) and Mandalay Eye, Ear, Nose &Throat (EENT) Hospital from January 2014 to June 2015. There were 1907 newborn babies admitted to SCBU within the study period. Cases were selected with inclusion and exclusion criteria. All high risk newborn within study period at CWH, Mandalay were included in this study. Those with congenital absence of one or both ears, those with malformed ears and seriously ill newborn at neonatal ICU were excluded. After getting informed consent, history taking was done from parents and guardians of the neonates to get history of intrauterine infection and family history of hearing loss. Then neonatal charts were reviewed. Data and the risk factors were documented in proforma. The cases of hyper bilirubinaemia, bacterial meningitis and asphyxia were taken according to decision of SCBU team. The newborns of 3 day after birth were screened with both DPOAE and TEOAE tests at SCBU, CWH (Mandalay) on every Monday, Wednesday and Friday afternoon as bedside tests. Madsen Accu Screen (Ref. 8-04-13906) from GN Otometrics was used. All the cases tested were evaluated with ABR at EENT Hospital (Mandalay). Chartr EP 200 System type 1073 (Ref. 8-04-12701) from GN Otometrics was used. The lowest intensity at which wave V identified was taken as threshold and it was noted. If wave V was present at 40 dB, baby was regarded as having normal hearing. If wave V was found above 40 dB, baby was regarded as having hearing loss. Data were collected in proforma and then entered into data master sheet. After checking data completeness, data were entered and analysed by using IBM SPSS version 19.

Results

In 1000 newborns, there were 523 male neonates and 477 female neonates, representing 53% and 48% respectively. In this study, the most common risk factor is ototoxic drug (510 cases, 51%) followed by low birth weight (482 cases, 48.2%), hyperbilirubinaemia (413 cases, 41.3%), asphyxia (88 cases, 8.8%), intrauterine infection (18 cases, 1.8%) and craniofacial anomaly (16 cases, 1.6%). There are only 5 cases (0.5%) of syndromic newborns. Bacterial meningitis is also rare risk factor (3 cases, 0.3%). There are no cases of family history of hearing loss and newborns needing mechanical ventilation (Table 1).

In 1000 newborns, DPOAE test was performed on both sides. The result were showed as 'clear response' for 'pass' and 'no clear response' for 'refer'. For the 1000 left ears, DPOAE yielded 787 'pass' and 213 'refer'. For the 1000 right ears, DPOAE yielded 776 'pass' and 224 'refer' (Figure 1).

In 1000 newborns, TEOAE test was performed on both sides. The result were showed as 'clear response' for 'pass' and 'no clear response' for 'refer'. For the 1000 left ears, 737 had passed TEOAE and 263 were not passed the test. For the 1000 right ears, 752 had passed TEOAE and 248 were referred (Figure 2).

Among 1000 high risk newborn babies, 241 have hearing loss in one or both ears. Therefore prevalence of newborn hearing loss in one or both ears is 24.1%. Other 759 have no hearing loss. In these 241 cases of hearing loss, 111 have unilateral hearing loss and 130 have bilateral hearing loss. That is 46.06% and 53.94% respectively (Table 2).

S.No	Risk factors	No	%
1	Low birth weight	482	48.2
2	Hyperbilirubinaemia	413	41.3
3	Bacterial meningitis	3	0.3
4	Family history of hearing loss	0	0
5	Intrauterine infection	18	1.8
6	Craniofacial anomaly	16	1.6
7	Syndromic babies	5	0.5
8	Asphyxia	88	8.8
9	Mechanical ventilation	0	0
10	Ototoxic drug	510	51

Table 1: Risk factors for newborn hearing loss.

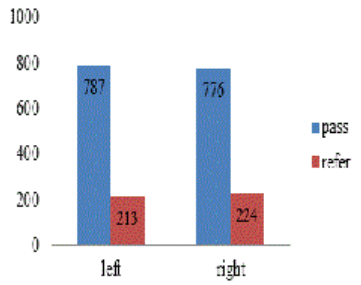

Figure 1: Frequency distribution of 'pass' and 'refer' of DPOAE.

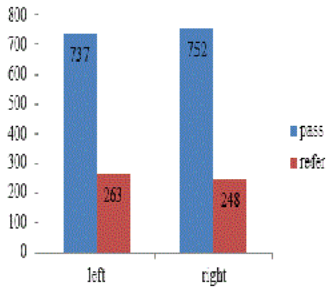

Figure 2: Frequency distribution of 'pass' and 'refer' of TEOAE.

Hearing loss	Frequency	%
Hearing loss	241	24.1
No hearing loss	759	75.9
Total	1000	100

Table 2: Frequency of hearing loss.

Sensitivity of DPOAE is 97.57% and specificity is 95.39%. False positive rate is 4.60% and false negative rate is 2.42% (Figure 3).

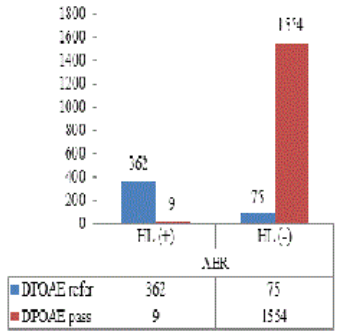

Figure 3: Accuracy of DPOAE.

Sensitivity of TEOAE is 96.49% and specificity is 90.60%. False positive rate is 9.39% and false negative rate is 3.50% (Figure 4). Minimum duration for DPOAE was 60 seconds on both sides and maximum duration was 240 seconds for left and 200 seconds for right with mean duration of 115.09 on left and 115.95 on right. TEOAE took minimum duration of 30 seconds on both sides and maximum duration was 120 seconds on both sides with mean duration of 73.91 on left and 72.97 on right.

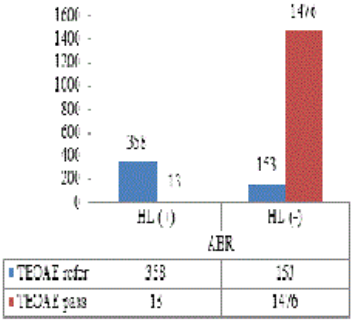

Figure 4: Accuracy of TEOAE.

Discussion

In this study, male newborns (523) were more than female newborns (477). Hearing loss was identified in 122 male newborns as 62 unilateral and 60 bilateral cases. In female newborns, hearing loss was identified in119 babies with 49 unilateral and 70 bilateral cases.

According to the results, DPOAE has sensitivity of 97.57% and specificity of 95.39%. This result is different from other study. The study of Ochi, Yasuhara and Kobayashi [10] in 1998, sensitivity of DPOAE is 90.5% and specificity is 95%. Although there is not much difference in specificity (95.39% vs 95%), sensitivity of DPOAE is higher in this study (97.57% vs 90.5%). In 2004, Hall, Smith and Popelka [11] conducted newborn hearing screening with DPOAE and ABR on 300 neonates in well baby nursery. They found that DPOAE had 100% sensitivity and 99.7% specificity.

For TEOAE, sensitivity is 96.49% and specificity is 90.60% in this study. There is not much difference with other studies. The study of Dhawan and Mathur [12] in 2006 evaluated TEOAE as screening modality for hearing impairment and used Brainstem Evoked Response Audiometry (BERA) was as gold standard diagnostic tool on 200 randomly selected neonates. The sensitivity of TEOAE was found to be 80%, which means that TEOAE will miss out 20% hearing impaired neonates when used as an independent screening tool. The specificity of TEOAE in this study was calculated to be 92.85% that means that 7.14% of the neonates when screened by TEOAE will give false positive result. The two-staged hearing screening study of Bhatt and Chhangte [13] in 2015 showed that TEOAE had sensitivity & specificity of 70% and 61% at 0 month and 70% and 99% at 3 month.

There are several factors that affect the accuracy of the test. The factors includes: the level of noise present during the OAE recording, the age of patients, probe fitting, state of the infant, presence of debris/vermix in the EAC or middle ear effusion [14].

False positive rate of DPOAE is 4.60% and TEOAE has higher false positive rate 9.39% in this study. The harmful consequences of false-positive results of any screening test may not be minimal. Disease labeling and emotional distress have been reported; there is a risk of Iatrogenesis from additional, unnecessary diagnostic testing; and false-positive results squander time and expenses [15].

In this study, DPOAE has lower false negative rate (2.42%) compare to that of TEOAE (3.50%). False negative refers to those with disease missed by screening. This is also important finding because in high risk group where hearing loss is more common and missing may causes adverse consequences.

In this study, after ABR confirmation, of the 1000 newborn babies, 111 have unilateral hearing loss and 130 have bilateral hearing loss. The remaining 759 have no disabling hearing loss. The prevalence of hearing loss in one or both ears is high (24.1%) because of the study population (high risk newborns). Other 759 have no hearing loss. In that sense, hearing loss referred to disabling hearing loss which is threshold of more than 40 dB on ABR test.

Conclusion

Both DPOAE and TEOAE can be used as screening tool for newborn babies. DPOAE has better accuracy in screening of high risk newborns but TEOAE needs less time to perform. It can be concluded that TEOAEs are useful for universal newborn hearing screening because it has short duration with acceptable accuracy and DPOAEs are useful for high-risk neonates as a hearing screening test because of good correlation between DPOAE and threshold of wave 'V' of ABR.

Recommendation

Most of the screening programs use two staged protocol for at-risk and non-risk newborns: OAE screening (usually TEOAE) followed by ABR confirmation. As a developing country, it is better to start newborn hearing screening on high risk babies as two staged method; OAE screening followed by ABR confirmation for 'refer' cases. As DPOAE uses high frequencies (2 kHz to 8 kHz) for screening, it is more suitable as a screening tool in SCBU where there is some environmental noise. To avoid extra burden to the families and health care personals as well as the adverse consequences of missed neonatal hearing loss, DPOAE should be used as screening method, since it has significantly better diagnostic accuracy.

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