Main Article

Positive Incidence of ABR in Newborns Detected to Have "Refer" in DPOAE

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ABSTRACT

Introduction

Oto Acoustic Emissions (OAE) & Auditory Brainstem Response (ABR) are screening tests used for newborn screening. The main objective of the study is to determine the incidence of positivity of ABR in newborns detected to have "Refer" during Distortion Product Oto Acoustic Emissions (DPOAE) in Universal Newborn Hearing Screening (UNHS).

Materials and Methods

A prospective observational study was conducted at a tertiary care center over a period of one year from Jan 2020 to July 2021. All neonates will be screened by DPOAE between day 1 to day 28 (first visit). If it is reported 'Refer', DPOAE will be repeated either after 6 weeks or on the first immunization day (second visit). If it is again reported as 'Refer', the neonate will undergo ABR (third visit). The results were recorded & compiled. The data was analysed statistically using SPSS software (version 20).

Results

Out of the 409 neonates, 315 (77.0%) were reported as "Pass" and 94 (23.0%) were reported as "Refer" during DPOAE first visit. The 94 neonates with test result "Refer" in DPOAE 1 (first visit) were considered for DPOAE 2 (second visit) & 78 (83.0%) were reported as "Pass" and 16 (17.0%) were reported as "Refer". The 16 infants who underwent Diagnostic ABR, 6 (37.5%) were reported as "Normal" whereas 10 (62.5%) were reported as "Abnormal" group.

Conclusion

This study recommends universal screening with OAE & ABR to facilitate early detection of auditory neuropathy and to initiate aural rehabilitation, especially in high-risk groups such as NICU & preterm neonates.

Keywords

Otoacoustic Emissions; Auditory Brainstem Response; Universal Newborn Hearing Screening

Hearing loss & deafness are widespread & a common issue worldwide. The World Health Organisation data states that 34 million children have deafness or hearing loss globally & 60% are mostly due to preventable causes. The impact of hearing loss could be alleviated through early detection and interventions. Awareness is brought among the people through educational programs & sign language instruction for the children and their families. Assistive technologies, including cochlear implants & hearing aids could be very helpful for early rehabilitation. Children may also benefit from speech therapy & early aural rehabilitation.[1]

Early detection of hearing loss is essential to prevent further loss & to reduce the disease adjusted life years of the child. Most neonatal hearing loss is sensorineural; a known genetic cause & is found in 50% of children. Of these children, approximately 70% have nonsyndromic deafness, most often related to cochlear hair cell dysfunction.[2]

In 1963, Marion Downs, referred to as the "Mother of Paediatric Audiology", pioneered the first hospital based infant hearing screening program in Denver, Colorado using Behavioral Observation Audiometry (BOA).[3] In 1969, Marion's efforts led to the formation of the Joint Committee on Infant Hearing (JCIH) to provide multi-disciplinary approach to newborn and infant hearing issues[4].

In 1973, the Committee recommended that only infants

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with high-risk factors such as family history, congenital prenatal infections, ear, nose or throat defects & low birth weight with <1500 gm & hyperbilirubinemia will have their hearing evaluated.[5] In 1982, two additional risk factors such as bacterial meningitis and birth asphyxia including low APGAR scores were added & it also recommended BOA and physiologic screening of high-risk infants.[6]

In 1993, the National Institutes of Health Consensus statement initiated the concept of "1-3-6" as the monthly milestones for screening, diagnosis, and intervention.[7] In 1994, both the Joint committee on infant hearing (JCIH) and the Directors of Speech & Hearing Programmes in State Health & Welfare Agencies (DSHPSHWA) endorsed the Universal Newborn Hearing Screening.[8]

Generally, otoacoustic emissions (OAEs) are forms of energy, measured as sound generated by the outer hair cells of the human cochlea, in response to the received auditory input. It was first described by a geophysicist in the mid-1940s & the screening test was developed in 1978 by David Kemp.[9] Based on the natural phenomenon of 'sound echoes' a sound stimulus is sent to the inner ear through the probes positioned in the external ear canal. The probe simultaneously records emissions returning from the outer hair cells of the cochlea. OAEs can be recorded in 99% of normal hearing ears. The response is generally absent in ears with a hearing loss of 30 dB or above.[10]

Under the National Universal Neonatal Hearing Screening Programme, all the newborns are first screened by Distortion Product Otoacoustic Emissions (DPOAE) at birth or before discharge from hospital. Those babies who are reported 'Refer' in the first screening are re-examined & screened again by DPOAE after 4-6 weeks or on the day of first immunization. Auditory Brainstem Response (ABR) is the audiometric method to confirm hearing loss in the neonates who were reported to 'Refer' in their second screening.[11]

It is very important to confirm hearing loss by ABR in those cases who are reported 'Refer' in the 2nd DPOAE, in view of early rehabilitation & to prevent further hearing loss.

Materials and Methods

An Observational prospective study was carried out in the Department of ENT at a tertiary care center in Kolkata from Jan 2020 to July 2021. All the newborn babies delivered at our institute, at the time of discharge or during their visit to OPD or immunization clinic were included in the study. The only exclusion criteria was newborn more than 28 days old.

All neonates will be screened by DPOAE between day 1 to day 28 (first visit). If it is reported 'Refer', DPOAE will be repeated either after 6 weeks or on the first immunization day (second visit). If it is again reported as 'Refer', the neonate will undergo ABR (third visit).

The results were recorded & compiled. The data was analysed statistically using SPSS software (version 20). Categorical variables were presented as absolute numbers and percentage. Categorical variables were analyzed using Chi square test. P value <0.05 was considered statistically significant.

Distortion Product Oto Acoustic Emissions (DPOAEs): The DPOAE model used in our institution for all patients was OAE screener (Model: GSI), AUDIO screener + AUDIO trac ™ Software, Serial No. GS0075325.The results were interpreted either as pass or refer.

ABR : ABR tracing was done using LABAT device (Model EPIC PLUS). This device generates AM/FM modulated tones at continuous cycle with carrier frequencies for 250 to 10,000 Hz. This device also explores the common mode of rejection (CMR) of about >120 dB. The results were interpreted as "Normal" or "Abnormal".

Institute Ethics Committee clearance was obtained prior to the commencement of the study. A written informed consent was taken from all study participants(parents) and there was no financial burden on the study subjects.

Results

A total of 409 neonates were included in this study, after obtaining ethical committee clearance and informed consent. Out of total 409 neonates, 250(61.1%) were male neonates and 159 (38.9%) were female neonates.

DPOAE-1 (First visit):

Out of total 409 neonates, 315 (77.0%) were reported as "Pass" and 94 (23.0%) were reported as "Refer" (Figure 1).

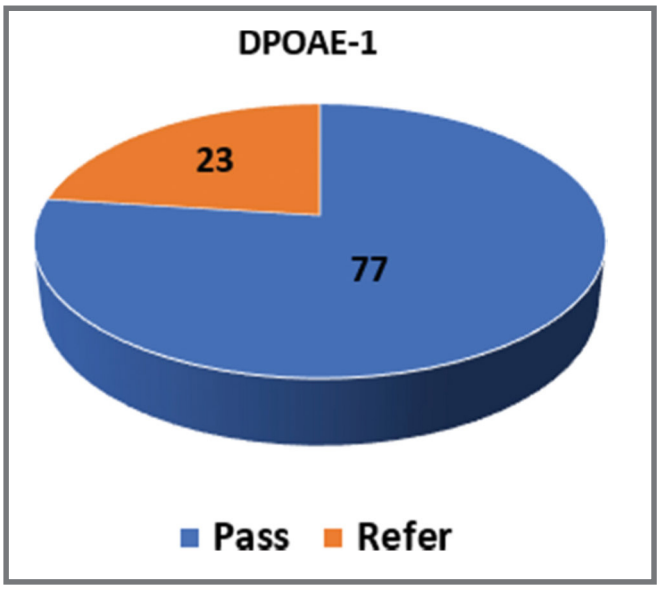

Fig. 1. Representation of results of DPOAE first visit

DPOAE-2 (Second visit):

The neonates (94) with test result "Refer" in DPOAE 1 (first visit) were considered for DPOAE 2 (second visit) & 78 (83.0%) were reported as "Pass" and 16 (17.0%) were reported as "Refer" (Figure :2).

Auditory Brain Stem Response (ABR):

Out of total 16 infants who underwent Diagnostic ABR, 6 (37.5%) were reported as "Normal" whereas 10(62.5%) were reported as "Abnormal" group (Figure : 3). Diagnostic ABR was done in the infants who were reported "Refer" twice during DPOAE screening. Presence of "Wave V" below 60 dB was considered as "Normal" and presence of Wave V above 60dB was considered as "Abnormal". No identifiable wave was also considered as "Abnormal".

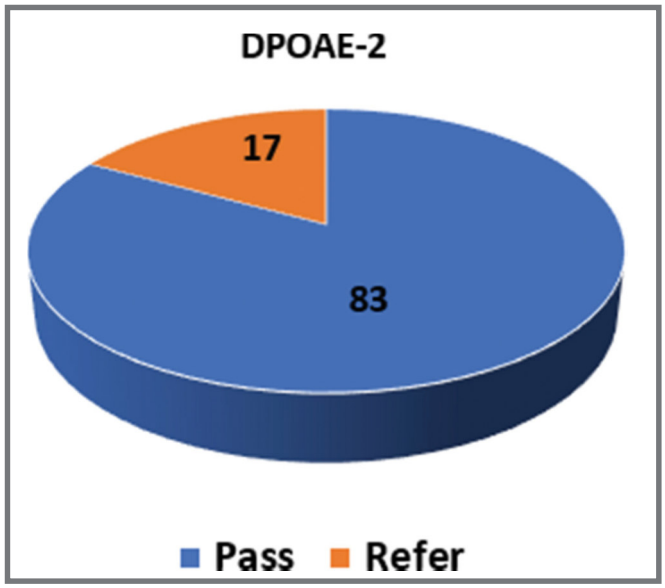

Fig. 2. Representation of results of DPOAE second visit

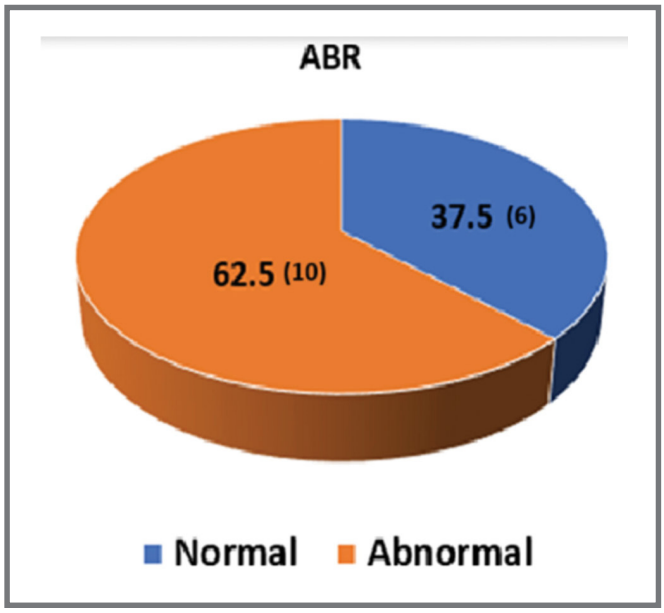

Fig. 3. Representation of results of ABR

Distribution of risk factors:

Out of 75 neonates with risk factors, 19(4.65%) were Preterm neonates, 13(3.18%) were with LBW, 2 (0.49%) were with NICU admission, 2 (0.49%) were with neonatal jaundice and 39(9.54%) were with other

risk factors. The group of other risk factors includes Cleft palate, family history of hereditary childhood SNHL, Intrauterine infections (TORCH), craniofacial anomalies, APGAR score 0 to 4 at 1 min or 0-6 at 5 min and Bacterial Meningitis.

In DPOAE-1 out of total 409 neonates, 250 were male, out of which 193 (77.2) were reported as "Pass" and 57 (22.8) were reported as "Refer" where as 159 were female out of which 122 (76.73) were reported as "Pass" and 37 (23.27) were reported as "Refer". P-value was calculated for association between gender and outcome of DPOAE-1, at 0.912, which is not significant.

Table I: Cross-tabulation analysis between various riskfactors and DPOAE 1

		NO	YES	TOTAL	P VALUE	SIGNIFICANCE
ANY RISK FACTOR	PASS	302(81.62)	13(33.33)	315(77.02)	<0.001	Significant
	REFER	68(18.38)	26(66.67)	94(22.98)		
	TOTAL	370(100)	39(100)	409(100)		
LBW	PASS	310(78.28)	5(38.46)	315(77.02)	0.003	Significant
	REFER	86(21.72)	8(61.54)	94(22.98)		
	TOTAL	396(100)	13(100)	409(100)		
PRETERM	PASS	307(78.72)	8(42.11)	315(77.02)	0.001	Significant
	REFER	83(21.28)	11(57.89)	94(22.98)		
	TOTAL	390(100)	19(100)	409(100)		
NICU	PASS	315(77.4)	0(0)	315(77.02)	0.009	Significant
	REFER	92(22.6)	2(100)	94(22.98)		
	TOTAL	407(100)	2(100)	409(100)		
NEONATAL JAUNDICE	PASS	314(77.15)	1(50)	315(77.02)	0.407	Not Significant
	REFER	93(22.85)	1(50)	94(22.98)		
	TOTAL	407(100)	2(100)	409(100)		

The cross-tabulation analysis between various risk factors & DPOAE-1 revealed that any risk factors, LBW, preterm, NICU admission were found to be statistically significant (Table I). The cross- tabulation analysis between neonatal jaundice & DPOAE-1 was found to be statistically insignificant (Table I).

Table II: Chi-square test applied to cross-tabulation analysis of DPOAE-1

RISK FACTOR	PEARSON CHI SQUARE VALUE	DEGREE OF FREEDOM	ASYMPTOMATIC SIGNIFICANCE (2-SIDED)	EXACT SIGNIFICANCE (2-SIDED)	EXACT SIGNIFICANCE (1-SIDED)
ANY RISK FACTOR	46.477[a]	1	.000	.000	.000
LBW	11.276[a]	1	.001	.003	.003
PRETERM	13.720[a]	1	.000	.001	.001
NICU	6.735[a]	1	.009	.052	.052
NEONATAL JAUNDICE	.829[a]	1	.363	.407	.407

Table III: Cross-tabulation analysis between various risk factors and DPOAE 2

		NO	YES	TOTAL	P VALUE	SIGNIFICANCE
ANY RISK FACTOR	PASS	64(94.12)	14(53.85)	78(82.98)	<0.001	Significant
	REFER	4(5.88)	12(46.15)	16(17.02)		
	TOTAL	68(100)	26(100)	94(100)		
LBW	PASS	74(86.05)	4(50)	78(82.98)	0.027	Significant
	REFER	12(13.95)	4(50)	16(17.02)		
	TOTAL	86(100)	8(100)	94(100)		
PRETERM	PASS	70(84.34)	8(72.73)	78(82.98)	0.391	Not Significant
	REFER	13(15.66)	3(27.27)	16(17.02)		
	TOTAL	83(100)	11(100)	94(100)		
NICU	PASS	78(84.78)	0(0)	78(82.98)	0.017	Significant
	REFER	14(15.22)	2(100)	16(17.02)		
	TOTAL	92(100)	2(100)	94(100)		
NEONATAL JAUNDICE	PASS	77(82.8)	1(100)	78(82.98)	0.649	Not Significant
	REFER	16(17.2)	0(0)	16(17.02)		
	TOTAL	93(100)	1(100)	94(100)		

Chi-Square test was applied to support of the findings of DPOAE-1 by using Pearson Chi-Square. The Pearson Chi-Square value was 0.012 and the p value was 0.912 (>0.05). Hence failed to reject the Null hypothesis and concluded that there is no significant association between Gender and the Outcome of DPOAE -1. The other variables tested like any risk factor, LBW, Preterm & NICU admissions were found to be statistically significant when chi square was applied. The variable neonatal jaundice was not statistically significant when chi square was applied (Table II).

In DPOAE-2 out of 94 neonates, 57 were male in which 45(78.95%) were reported as "Pass" and 12(21.05%) were reported as "Refer" where as 37 were female in which 33(89.19%) were reported as "Pass" and 4 (10.81) were reported as "Refer". P-value was calculated for association between Gender and Outcome of DPOAE-2, at 0.197, which is not significant (<0.005 was considered as highly significant).

The cross-tabulation analysis between various risk factors & DPOAE-2 revealed that any risk factors , LBW & NICU admissions were found to be statistically significant (Table :3). The cross- tabulation analysis between neonatal jaundice, Preterm & DPOAE-2 were found to be statistically insignificant (Table III).

Table IV: Chi-square test applied to cross-tabulation analysis of DPOAE-2

RISK FACTOR	PEARSON CHI SQUARE VALUE	DEGREE OF FREEDOM	ASYMPTOMATIC SIGNIFICANCE (2-SIDED)	EXACT SIGNIFICANCE (2-SIDED)	EXACT SIGNIFICANCE (1-SIDED)
ANY RISK FACTOR	21.597[a]	1	.000	.000	.000
LBW	6.733[a]	1	.009	.027	.027
PRETERM	.927[a]	1	.336	.391	.279
NICU	9.962[a]	1	.002	.027	.027
NEONATAL JAUNDICE	.207[a]	1	.649	1.000	.830

Chi-Square test was applied to support the findings of Table:3 by using Pearson Chi-Square. The Pearson Chi-Square value was 1.666 and the P value was 0.197 (>0.05). Hence we failed to reject the Null hypothesis and concluded that there is no significant association between Gender and the Outcome of DPOAE-2. The other variables tested like any risk factor, LBW & NICU admissions were found to be statistically significant, when chi square was applied. The variable neonatal jaundice was not statistically significant when chi square was applied (Table IV).

Among the 16 neonates who underwent ABR, 12 were male neonates & 04 were female neonates. Out of the 12 male neonates , 4(33.33%) were reported as "Normal" and 8 (21.05%) were reported as "Abnormal". Among the 4 female neonates, 2(50%) were reported as "Normal" and 2(50%) were reported as "Abnormal". P-value was calculated for association between ABR and outcome of gender & was found to be statistically insignificant.

The cross-tabulation analysis between various risk factors & ABR was revealed that only preterm neonates were found to be statistically significant (Table V).

Table V: Cross-tabulation analysis between various risk factors and ABR

		NO	YES	TOTAL	P VALUE	SIGNIFICANCE
ANY RISK FACTOR	NORMAL	0(0)	6(50)	6(37.5)	0.234	Not Significant
	ABNORMAL	4(100)	6(50)	10(62.5)		
	TOTAL	4(100)	12(100)	16(100)		
LBW	NORMAL	4(33.33)	2(50)	6(37.5)	0.604	Not Significant
	ABNORMAL	8(66.67)	2(50)	10(62.5)		
	TOTAL	12(100)	4(100)	16(100)		
PRETERM	NORMAL	3(23.08)	3(100)	6(37.5)	0.036	Significant
	ABNORMAL	10(76.92)	0(0)	10(62.5)		
	TOTAL	13(100)	3(100)	16(100)		
NICU	NORMAL	5(35.71)	1(50)	6(37.5)	0.696	Not Significant
	ABNORMAL	9(64.29)	1(50)	10(62.5)		
	TOTAL	14(100)	2(100)	16(100)		

Table VI: Chi-square test applied to cross-tabulation analysis of ABR

RISK FACTOR	PEARSON CHI SQUARE VALUE	DEGREE OF FREEDOM	ASYMPTOMATIC SIGNIFICANCE (2-SIDED)	EXACT SIGNIFICANCE (2-SIDED)	EXACT SIGNIFICANCE (1-SIDED)
ANY RISK FACTOR	3.200[a]	1	.074	.234	.115
LBW	.356[a]	1	.551	.604	.489
PRETERM	6.154[a]	1	.013	.036	.036
NICU	.152[a]	1	.696	1.000	.625

Chi-Square test was applied to support the findings of Table 5 by using Pearson Chi-Square. The Pearson Chi-Square value between ABR & gender was .356, which is statistically insignificant. Hence there was no association between ABR and gender. When Chi-square test was applied between different riskfactors and ABR, only "preterm neonatal group" was found to be statistically significant (Table VI).

Discussion

One of the most common congenital anomalies that are detected early in life is hearing loss. Its early detection and intervention is of utmost importance for a child's overall development. The National Programme for Prevention and Control of Deafness (NPPCD) & Rashtriya Bal Swasthya Karyakram (RBSK) are

significant government level initiatives in the implementation of systematic nationwide hearing screening programs. There are number of studies on various screening programmes and protocols adapted for neonatal hearing screening. Based on these studies, the Universal Hearing Screening programme recommends a three phase screening protocol with DPOAE & ABR.

In our study 409 neonates were screened at the time of discharge or during their OPD visit in Paediatric & immunisation clinics. The primary goal of our study was to determine the incidence of ABR positivity in newborns who were found to have twice 'refer' in DPOAE in neonatal hearing screening.

Out of total 409 neonates, 315 (77.0%) were reported as "Pass" and 94 (23.0%) were reported as "Refer" in 1st OAE screening. Out of the 94 neonates who were reported "Refer" 78 (83.0%) were reported as "Pass" and 16 (17.0%) were reported as "Refer" in the 2nd OAE screening. Out of the 16 infants who were reported "Refer" underwent diagnostic ABR & 6 (37.5%) were reported as "Normal" whereas 10 (62.5%) were reported as "Abnormal" group.

In our study, referral rate at 1st screening with DPOAE was 23.0%. These results were comparable to the study done at a tertiary care hospital in Karnataka by Reddy et al, in which 950 neonates were screened with DPOAE & 204 (21.4%) were reported as refer in the 1st screening.[12] The results of DPOAE 1st screening is also comparable to the study done at Chennai by Vignesh et al.[13] In our study the referral rate in DPOAE 2nd screening is 3.9%, which is comparable to the study done by Reddy et al which is (3.43%).[12] The results of DPOAE 2nd screening were also comparable with the study done at Chennai by Vignesh et al.[13]

Out of the 75 neonates with risk factors, 19 (4.65%) were preterm neonates, 13 (3.18%) were LBW neonates, 2 (0.49%) were with NICU admission, 2 (0.49%) were with neonatal jaundice & 39 (9.54%) were with other risk factors. The group of other risk factors includes Cleft palate, family history of hereditary childhood SNHL, Intrauterine infections (TORCH), Craniofacial anomalies, APGAR score 0 to 4 at 1 min or 0-6 at 5 min, Bacterial Meningitis and Maternal risk factors.

The distribution of risk factors in our study is comparable to the study done by Reddy et al, in which out of 950 babies who were screened, 56 (5.89%) babies were premature &103 (10.8%) were low birth weight (LBW) babies. In our study out of 75 neonates with risk factors, 19 (4.65%) were Preterm neonates, 13 (3.18%) were with LBW, 2 (0.49%) were with NICU admission, 2 (0.49%) were with neonatal jaundice and 39 (9.54%) were with other risk factors. Our study results were also comparable to the study done by Gouri et al & Nagapoornima et al.[14, 15] It was also observed that neonates with risk factors had higher referral rates as compared to the neonates without risk factors.

Out of the total 16 infants who underwent diagnostic ABR, 6 (37.5%) were reported as "Normal" whereas 10 (62.5%) were reported as "Abnormal" group. Diagnostic ABR was done in the infants who were reported "Refer" twice in the DPOAE screening. In our study the incidence of hearing loss observed in neonates with risk factors is 2.45% which is comparable to the study done by Jaideep Bhatt et al.[16]

In the study done by Jaideep Bhatt et al, 500 newborns were assessed. Initial OAE was done within 24hrs after birth. If the responses of OAE were 'Refer', they were retested in 3 months after birth by OAE. Also, all neonates were assessed by ABR at the age of 3 months and 6 months. The incidence of permanent congenital hearing loss according to diagnostic testing was five out of hundred newborn with risk factors (5%) and it was 0.5% in well nursed baby, which is 10 times less than high risk population. It is also comparable with the study done by Paul A et al, in which the incidence of hearing loss in high-risk neonates ranged between 2.5% -10%.[17]

Conclusion

The present study followed the three phase screening programme and found it to be very efficient and accurate, which helped in initiating treatment at an early stage. The combination of ABR and OAE testing, was found to be effective in the diagnosis of hearing loss & should be considered in the future as a standard protocol in newborn hearing screening.

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