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Distortion Product Otoacoustic Emissions in Infant screening.

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ABSTRACT

Objective- Hearing impairment is a major problem worldwide, significantly delaying acquisition of speech in children. Unfortunately delayed detection of hearing impairment especially in developing countries, adds a significant burden on the society and the nation. Hence early detection of hearing impairment is imperative and the need of the hour lies in developing an easy, cost effective and reliable method for testing large number of infants, Oto acoustic Emissions(OAE's) being one such test. The objective of this study was to asses the effectiveness and utility of Distortion Product Otoacoustic Emissions (DPOAE) as a screening tool for assessment of hearing impairment in infants and to assess the relationship between selected risk factors and hearing loss.

Design-This cross sectional study involving a two stage DPOAE testing, with Brainstem Evoked Response Audiometry as a confirmatory test for infants failing the two stage test .

Materials and method-One thousand infant were selected randomly and screened with DPOAE at age of 24-72 hours. Infants who gave refer result were screened with DPOAE and infants failing the second screen underwent BERA testing.

Result-Of the one thousand infants screened with DPOAE,119 infants had hearing loss on initial screen however on subsequent testing with DPOAE and later testing with BERA only 4 infants with hearing loss were detected.

Conclussion-Hence initial DPOAE screen followed by BERA in failure cases is helpful for early identification of infants with hearing loss, hence allowing for timely intervention.

Key words: infant screening, otoacoustic emission, distortion product otoscoustic emission (DPOAE).

INTRODUCTION:

Hearing loss is aptly referred to as the silent, overlooked epidemic of developing countries because of its invisible nature, which prevents detection through routine clinical procedures. Referred as epidemic because of its high prevalence, being the most frequently occurring birth defect, and even though it is not a life-threatening condition, failure to intervene in time renders it a severe threat to critical quality of life indicators.

In India, it is estimated that 18.49 million persons have disability that equivalents to 1.8 percent of the total population of the country where 10 percent of this figure are likely to have hearing disability of moderate to profound degree. Moreover, this number is likely to go up if we add lower degree of hearing disability. WHO estimates that globally the number of people with hearing loss, has more than doubled from 120 million in 1995 to at least 278 million in 2005, thus making this condition the most prevalent sensory deficit in the population.[1]

The adverse affects of hearing loss on language and cognitive development, as well as on psychosocial behavior are widely reported against the established benefits of early intervention. The income of individuals with hearing loss is reported to be 40 to 45% less than the hearing population in developed countries and will be even more pronounced in developing countries.[2]

The definition of early identification and intervention has evolved over the years. In the past, early identification was defined as intervention before the age of 18 months, however now early identification is defined as diagnosis as early as 3 months with intervention by 6 months. [3]

Though a battery of tests are available today to detect hearing loss. Screening for hearing loss in infants should be done with a screening test that is simple, cost effective, quick, sensitive, efficient, and reliable. In the absence of such objective screening test, hearing loss may not be detected until the child is 2–6 years of age, when intervention outcomes may be suboptimal.

Otoacoustic Emissions (OAE) reflects the status of the cochlea (outer hair cells).A probe microphone measures the inaudible sounds reflected by vibratory motion in cochlea. Thus OAE's are a byproduct of sensory outer hair cell transduction, reflected as echoes into the external auditory canal and preneural in origin, directly dependant on outer hair cell integrity.[4]

Brainstem Evoked Response Audiometry (BERA) is an objective test of audiological function which measures activity from the auditory nerve up to the level of brainstem on stimulating with acoustic stimulus. It assesses the neural integrity of auditory pathway up to the brainstem. However it is an indirect measure of hearing acuity.[5]

Therefore this study was undertaken to document the importance of using DPOAE as a screening tool for evaluating hearing loss and cochlear function and to screen for hearing loss in infants. Also many developing countries do not have a well defined protocol for hearing screening and very few studies have been undertaken in India.

MATERIAL AND METHODS:

The study was conducted during the period August 2009 to July 2011. A study group consisting of 1000 newborns were selected at random from the department of Pediatrics were screened in the department of ENT, Father Muller Medical College Hospital, Mangalore. Infants were evaluated by means of proper history and clinical examination including anthropometry, general examination and otoscopy.

DPOAE testing of infants was done at 24-72 hours. For pass cases no further testing was done. For refer cases repeat DPOAE testing was done at 15-30days.The infant who had failed the second DPOAE screen was subjected to BERA testing within 3 months to confirm hearing loss.

Multiple responses were averaged. All DPOAEs were analyzed relative to the noise floor. Result was Pass if responses were obtained in at least three of the four frequencies deferring which refer result was considered.

For DPOAE testing neurosoft, neuroaudioscreen (Model TC-9442-057-137218158-2008, made in Russia). BERA was tested using Intelligent Hearing systems, Universal Smart Box Junior (Ref#M011109). Securing the various electrodes a click stimulus was presented to each ear individually and characteristic wave forms produced were noted

Babies excluded from the study were those with obvious congenital aural and head and neck deformities, infants whose parents did not consent for the procedure, infants with acute illness or infants lost in follow up. Tests were conducted in sound treated room. . For a quiet and cooperative infant, recording usually required one to two minutes per ear. For an uncooperative or noisy infant, recordings took significantly longer or had to be postponed till infant slept.

Data was processed using Excel soft ware programme. Data obtained was analyzed using Fishers Exact and Chi-square test.

RESULTS

Among the 1000 infants screened,119 failed the first screen.(TABLE1).On repeat testing only17 continued to have a negative response and were subjected to BERA testing at about 3 months of gestational age. It was observed 4 infants had hearing loss (Table 2).

RESULTS	OAE TEST 1 (frequency)	OAE TEST 1 (percent)	OAE TEST 2 (frequency)	OAE TEST 2 (percent)
B/L PASS	881	88.1	102	85.7
B/L REFER	64	6.4	13	10.9
L-PASS,R-REFER	15	1.5	2	1.7
R-PASS,L-REFER	40	4.0	2	1.7
TOTAL	1000	100	119	100

{ Altough initial DPOAE test 1030 infants were tested as 30babies with hearing loss were defaulters they were excluded from the subsequent test).

RESULT BERA

	Frequency	Percent
HEARING LOSS	4	23.5
NORMAL	13	76.5
Total	17	100.0

Of 1000 infants screened, 504 were males and 496 were females. Of 119 that had failed 60 were males and 59 were females. (P value 0.001). On repeat DPOAE screen,8 male and 9 female infants continued to have a negative response.(p value=0.765).With BERA 3 males and 1 female baby were diagnosed as having hearing loss.(p value= 0.241).Hence based on gender distribution, equal incidence of hearing loss in males and females was seen.

In our study, during the first DPOAE screen 603 infants mothers were multipara and 397 were primipara.

On applying statistical evaluation no significant difference was seen in incidence of hearing loss in infants of multipart and primipara. On repeat DPOAE screening and on conducting BERA, similar conclusion was arrived at. This is in concordance with Chu and colleagues[6] in 2003, who concluded that there were no differences between groups when compared for maternal age, parity, and race.

Of the 214 of the 1000 infants that had prenatal risk factors, 129 passed and 85 failed the initial screen (p value < 0.001) .On subsequent screening 74 passed and 11 continued to have negative results. (P value =0.508) On subsequent testing with BERA 3 infants had hearing loss. (P value of=0.555). Hence no significant difference in hearing loss in groups with and without prenatal risk factors was observed.

It was seen that of 1000 infants tested, 28 were preterm and gave refer on 1st DPOAE test. (P value <0.0001 was significant).On repeat screen 4 of these infants gave refer result. Of 17 infants tested with BERA, 4 were preterm and only 1 had hearing loss.

It was seen that of 1000 infants tested 8 infants with low Apgar score at 5 minutes at birth, were refer.992 infants had APGAR 7-10, of which 881 were pass and 111 refer. (P value < 0.001). Hence infants with an Apgar score more than 7 at 5 minutes of birth are more likely to give pass results. On subsequent screening only 2 infants with low APGAR at 5 minutes at birth were refer.(p value =0.37).It was seen that of 17 infants tested with BERA, 1 infant with low APGAR score had hearing loss whereas of 15 infants had APGAR 7-10, of which 3 had hearing loss.(p value = 0.426).

In our study 161 of 1000 infants were Low Birth Weight, of which 51 were refer on 1st DPOAE screen. A significant association could be shown on first screen, which could not be established on subsequent screen

It was seen that of 1000 infants screened 88 infants had postnatal complications, of which 86 had refer result. (P value <0.0001 –significant).On repeat testing 16 of these infants continued to have refer result (p value=0.030 significant).However no association could be demonstrated on BERA testing.

OAE TEST 1

Feature	Parameter	B/L PASS	B/L REFER	TOTAL	TOS	P VALUE
1)SEX	Female	437	59	496	X2=0.001	0.999,NS
	Male	444	60	504		
	Total	881	119	1000		
2)MATERNAL HISTORY	Multipara	537	56	603	X2=1.321	P=0.2,NS
	Primipara	344	53	397		
	Total	881	119	1000		
3)PRENATAL RISK FACTOR	Absent	752	34	786	X2=200.9	P<0.0001,HS
	Present	129	85	214		
	Total	881	119	1000		
4)PRETERM	Preterm	0	28	28	Fischer's exact test	P<0.0001,HS
	Term	881	91	972		
	Total	881	119	1000		
5)APGAR	4 to 5	0	8	8	Fischer's exact test	P<0.0001,HS
	7 to 10	881	111	992		
	Total	881	119	1000		
6)Birth Weight	<2.5	110	51	161	X2=71.59	P<0.0001,HS
	>2.5	771	68	839		
	Total	881	119	1000		
7)Postnatal complications	Absent	879	33	912	X2=677.9	P<0.0001,HS
	Present	2	86	88		
	Total	881	119	1000		

TOS-Test of Significant

OAE TEST 2

Feature	Parameter	B/L PASS	B/L REFER	TOTAL	TOS	P VALUE
1)SEX	Female	50	9	59	X2=0.090	0.765,NS
	Male	52	8	60		
	TOTAL	102	17	119		
2)MATERNAL HISTORY	Multipara	53	13	66	X2=3.544	P=0.060,NS
	Primipara	49	4	53		
	Total	102	17	119		
3)PRENATAL RISK FACTOR	Absent	28	6	34	X2=0.439	P<0.508,NS
	Present	74	11	85		
	Total	102	17	119		
4)PRETERM	Preterm	24	4	28	X2=0.001	P=0.999,NS
	Term	78	13	91		
	Total	102	17	119		
5)APGAR	4 to 6	6	2	8	X2=0.804	P=0.370,NS
	7 to 10	96	15	111		
	Total	102	17	119		
6)BirthWeight	<2.5	43	8	51	X2=0.143	P=0.705,NS
	>2.5	59	9	68		
	Total	102	17	119		
7)Postnatal Complications	Absent	32	1	33	X2=4.724	P0.030,SIG
	Present	70	16	86		
	Total	102	17	119		

BERA RESULT:

Feature	Parameter	Hearing loss	Normal	TOTAL	TOS	P VALUE
1)SEX	Female	1	8	9	Fischer's exact test	p=0.241,NS
	Male	3	5	8		
	TOTAL	4	13	17		
2)MATERNAL HISTORY	Multipara	3	10	13	Fischer's exact test	P=0.700,NS
	Primipara	1	3	4		
	Total	4	13	17		
3)PRENATAL RISK FACTOR	Absent	1	5	6	Fischer's exact test	P=0.555,NS
	Present	3	8	11		
	Total	4	13	17		
4)PRETERM	Preterm	1	3	4	Fischer's exact test	P=0.700,NS
	Term	3	10	13		
	Total	4	13	17		
5)APGAR	4 to 6	1	1	2	Fischer's exact test	P=0.426,NS
	7 to 10	3	12	15		
	Total	4	13	17		
6)Birth Weight	<2.5	2	6	8	Fischer's exact test	P=0.665,NS
	>2.5	2	7	9		
	Total	4	13	17		
7)Postnatal complications	Absent	0	1	1	Fischer's exact test	P=0.765,NS
	Present	4	12	16		
	Total	4	13	17		

DISCUSSION

The study was based on DPOAE as Transient Evoked Otoacoustic Emissions (TEOAE) are used primarily in the linear protocol mode with an eliciting stimulus of 75 dB SPL whereas DPOAEs are elicited by asymmetrical protocols (75-65 dB SPL) testing the frequencies 1.5, 2.0, 3.0, 4.0 .In addition DPOAEs are found to be more immune to noise and therefore are very useful to PASS borderline cases.

Conducting the first DPOAE screening after 24 hours of birth was done to prevent a higher fail results due to occlusion of EAC with debris, amniotic fluid.

According to this study an incidence of hearing loss of 4 per thousand infants was detected which is in the line with the published literature. According to WHO estimates that globally, up to 6 per 1000 live-born

infants annually, or 7, 98,000 babies worldwide, suffer permanent hearing loss at birth or within the neonatal period and at least 90% of them are in developing countries. [6]

In a study done by P Torroco and colleagues the sensitivity of 1st OAE was 100% & the specificity of 1st test 77.49% ,positive predictive value of 3.05 and quotient of probability 4.44.The specificity of second test is 99.88, positive predictive value 85.7, quotient of probability of 84.8%.This suggests that the first test if not normal the probability of having hearing loss is 3.05 % and the second test shows this the clinical suspicion rises to 85.7 %.It thus can be observed that if the first OAE screen is a refer, the probability of having hearing loss is 3.05%, while a refer on second OAE testing clinical suspicion rises to 85.7.[7]

A study done, at Christian Medical College Hospital (CMC), Vellore from February 2005 to July 2005.Of 500 infants screened with distortion product Otoacoustic emission for hearing loss, 9.2% had one or more risk factors. Although 6.4 % had hearing loss at initial assessment only 1.6% had hearing loss on retesting with DPOAE .Thus retesting with OAE before an ABR helped to exclude patients without hearing loss. The frequency of moderate to moderately severe hearing loss in this study was 0.6%.[8]

On initial DPOAE screen significant association between prenatal risk factor and hearing loss was inferred, however no such association was seen on repeat screening with DPOAE, could be explained by random selection of infants. It was seen that parity of the mother had no association on the hearing loss of the infant.

In our study no statistically significant difference between genders was inferred. This was similar to the conclusion from the research by Vanessa Sinelli et al.

On initial DPOAE testing, a statistically significant relation between absence of Otoacoustic Emissions and preterm infants was found. In 1997, Doyle et al., affirmed that there are two conditions that can be attributed to temporary hearing loss in newborns: vernix or debris in the external acoustic meatus and fluid in the middle ear. Chang et al and Del Buono et al (2005) concluded the same. However on repeat testing these infants gave pass result, which could be due to the uneven distribution of two groups. Inaddition inappropriate probe fit due to small volume of external ear canal could be responsible for the inadequate attenuation of the noise; hence a louder noise floor recording could be responsible for larger

refers in the initial screen, with improvement on subsequent screening .[9]

Newborns with low APGAR scores are more likely to have a higher risk of hearing loss than infants with normal APGAR scores was observed in the first screen which confirmed with the study of Christensen M et al.It was seen that as infants matured a pass result was more likely.[10]

In our study 161 of 1000 infants were LBW, of which 51 were refer on 1st DPOAE test. A significant association could be shown on first test, which could not be established on subsequent test. This is in agreement with the study conducted at Bobby R Alford Department of Otolaryngology-Head and Neck Surgery, Baylor College of Medicine, Houston, USA. They concluded that although VLBW alone may not have a severe impact on hearing, it is commonly associated with multiple other risk factors that can alter hearing in a synergistic fashion.[11]

Postnatal complications observed during our study included birth asphyxia, neonatal hyperbilirubinemia, meningitis and sepsis. Of the 1000 infants, 88 had one of the above postnatal complications. Of these 86, gave refer on 1st DPOAE screen. On subsequent testing with DPOAE, 16 infants with risk factors only gave refer results. On subsequent testing with BERA, four infants had hearing loss. However no significant association could be demonstrated .In the study of Azevedo et al. the following risks for hearing loss were observed-ototoxic drug use, newborn with very low weight or SGA, mechanical ventilation and congenital infection, familial antecedent of hearing loss birth asphyxia. [9]

In our study, Positive Predictive Value (PPV) of first DPOAE screen of 14.3% was documented and on subsequent DPOAE testing PPV of 23.5% was obtained. Hence the importance of repeating OAE screen cannot be overlooked, as this will not only decrease the burden of testing all infants with a screening test like BERA which is more invasive, costly, time consuming and requires cooperation of infant but also the economic burden associated with the need for audiologist required for screening for hearing loss will be decreased.[7]

As with other infant screening studies, our study also identified that screening with DPOAE is a cheap, cost effective, quick noninvasive method to be developed to screen infants. As the infants were chosen randomly, there were more chances of infants being normal. Hence association between risk factors could not be demonstrated Also this prevented bias when analyzing test values. Also all infants could not be screened during this time period. Many infants with first test as refer did not return for subsequent

testing and hence were excluded from the study.

CONCLUSSION

As it has been aptly quoted by Ralph Waldo Emmerson, “a hearing ear is close to a speaking tongue”. The importance of infant hearing screening before the ‘critical period’ of first 3-4 years cannot be over emphasized. In a country burdened with dearth of resources and manpower, where providing basic education to all children is still a challenge, providing inclusive education to hearing disabled just adds to the economic burden. OAE’s testing does hold as a good promise in hearing screening . This study was an attempt to show the importance of developing a hearing screen with DPOAE that when repeated appropriately and when required combined with BERA for cases that fail, serves as effective screening test.

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