

Role of Otoacoustic Emissions and Auditory Brainstem Response for Early Detection of Hearing Loss in Children 0-3 Months of Age

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Abstract

Background: Hearing impairment has a huge adverse impact on the normal developmental outcome of an individual. The various newborn period risk factors may escalate hearing loss. Early detection of hearing impairment has been made possible with the use of universal tools like OAE (Otoacoustic emission) and ABR (Auditory brainstem response) and has resulted in the general awareness and timely intervention. This study highlights the use of OAE and ABR for early detection of hearing loss in children 0-3 months along with the associated risk factors taken into consideration. **Subjects and Methods:** The present study was conducted in Maharishi Markandeshwar medical college and hospital over a period of 12 months and included 1680 newborns who were subjected to two staged OAE examination (pre discharge and at 6 weeks) followed by ABR examination done over a period of 3 months. The various risk factors were also evaluated. **Results:** A total of 1680 newborns underwent pre discharge first OAE examination, 146(8.7%) failed. A total of 141 underwent the repeat OAE examination at 6 weeks and 23(16.3%) failed. ABR examination of 20 children resulted in failure in 3(15%) culminating in overall prevalence of hearing impairment of 1.79 per 1000 population. The prevalence of various risk factors taken into consideration was 23%. **Conclusion:** The two staged sequential OAE assessment followed by ABR examination has an important role for the early detection of hearing impairment and consequent improvement in the quality of life. This should be adopted by all the newborn care providers as a part of their routine examination of the newborns.

Keywords: OAE (Otoacoustic emissions), ABR (Auditory Brainstem Response), Hearing assessment, Newborn.

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Introduction

The number of newborns with hearing loss par excels those of hypothyroidism screening at birth with an estimated prevalence of 1-3 per 1000.^[1-3] The risk factors like birth asphyxia, bacterial meningitis, hyperbilirubinemia requiring exchange transfusion etc. may increase the chances of hearing loss as high as 10 to 50 times the normal.^[3] Hearing impairment has a huge adverse impact on the normal speech, language, cognitive and psychosocial outcome.^[4-7] The early infancy is the deciding period for the normal functioning of the growing auditory areas of the brain.^[8] Lack of clinical indicators further complicates the early recognition of hearing loss during this crucial period and it becomes too late during school age to intervene and improve the outcome.

Early detection of hearing impairment has been made possible with the use of universal tools like OAE (Otoacoustic emission) and ABR (Auditory brainstem response) and has resulted in the general awareness and timely intervention, if required.^[9]

Most of the developed nations have imbibed the AAP guidelines of Universal newborn screening in 1999 and the ones who lag behind are on their path to adapt some consensus as per their resources to address this preventable issue.^[10]

This study highlights the use of OAE and ABR for early detection of hearing loss in children 0-3 months follow up along with the associated risk factors taken into consideration.

Subjects and Methods

The present study was conducted in Maharishi Markandeshwar Medical College and Hospital, Solan, Himachal Pradesh, India over a period of one year. The study included all the hospital born neonates. After the ethical committee approval, all the inborn neonates underwent pre discharge Otoacoustic emission (OAE) examination with OAE Otolite within two days of life. The second OAE examination was done at 6 weeks of life at

follow up immunization on the newborns who failed the first OAE examination. The second OAE failed newborns had to go through auditory brainstem response (ABR) examination with HIS-Smart EP ABR equipment by trained audiologist at 3 months of life.

The normal and admitted newborns were assessed for the risk factors which included prematurity and low birth weight (<2.5kg), neonates requiring phototherapy, APGAR score of less than 4 in 1st minute or less than 6 at 5 minutes, congenital infections, sepsis and meningitis, family history suggestive of hearing impairment, NICU admission for more than two days and those on ototoxic medications.

Statistical Analysis

The data was analyzed with SPSS software and was expressed as frequency and percentage. The chi square test and student’s t test were used to clarify the relationship and two tailed value of < 0.05 was considered significant.

Results

A total of 1680 neonates underwent pre discharge first OAE examination, 146(8.7%) failed and 1534(91.3%) passed the evaluation. For reassessment at 6 weeks of age, five neonates were lost to follow up. The remaining 141 underwent the repeat OAE examination, out of them, 23(16.3%) failed and 118(83.7%) passed the examination. [Table 1, 2]

Table 1: First OAE (Otoacoustic emissions) outcome of the study population

First Oae	Number	Percentage
PASS	1534	91.30 %
FAIL	146	8.70 %

Table 2: Second OAE outcome of the study population

Second Oae	Number	Percentage
PASS	118	83.7%
FAIL	23	16.3%

Table 6: Risk factors comparison of first OAE of the study population

Risk Factors		Pass Number	Fail Number	Total	Pass Percentage	Fail Percentage	χ ²	P Value
Preterm And Lbw	Normal Term	1287	105	1392	92.46 %	7.54 %	13.47	0
	Preterm And Lbw	247	41	288	85.76 %	14.24 %		
Hyperbilirubinemia Requiring Phototherapy	Absent	1431	124	1555	92.03 %	7.97 %	13.5	0
	Present	103	22	125	82.40 %	17.60 %		
Apgar Score Less Than 4 At 1 Minute Or Less Than 6 At 6 Minutes	Absent	1516	134	1650	91.88 %	8.12 %	37.73	0
	Present	18	12	30	60.00 %	40.00 %		
Congenital Infections	Absent	1522	143	1665	91.41 %	8.59 %	2.44	0
	Present	12	3	15	80.00 %	20.00 %		
Family History Of Deafness	Absent	1533	141	1674	91.58 %	8.42 %	42.27	0
	Present	1	5	6	16.67 %	83.33 %		
Nicu >2 Days	Absent	1476	108	1584	93.18 %	6.82 %	122.5	0
	Present	58	38	96	60.42 %	39.58 %		
Sepsis And Meningitis	Absent	1528	133	1661	91.99 %	8.01 %	86.4	0
	Present	6	13	19	31.58 %	68.42 %		
Ototoxic Medications	Absent	1241	84	1325	93.66 %	6.34 %	43.67	0
	Present	293	62	355	82.54 %	17.46 %		

With a further loss of three newborns to turn up, 20 underwent the ABR examination. Out of the total, 17(85%) passed and 3(15%) failed the evaluation. [Table 3]

Table 3: ABR of the study population

ABR	Number	Percentage
PASS	17	85%
FAIL	3	15%

The total of 1680 were also evaluated for the risk factors. Of the total, 388 (23.1%) had one or multiple risk factors and 1292(76.9%) were without any risk factors. [Table 4]

Table 4: One or multiple risk factors of the study population

Risk Factor	Number	Percentage
Absent	1292	76.90%
Present	388	23.10%

Of the total of 577 neonates with risk factors, 253(43.8%) were preterm and low birth weight less than 2.5kg, 136(23.6%) required phototherapy,30(5.2%) had APGAR score of less than 4 in 1st minute or less than 6 in 5 minutes,12(2.1%) had congenital infections,86(14.9%) had more than two days of NICU stay, 5(0.9%) had family history of congenital infections,18(3.1%) had sepsis or meningitis and 37(6.4%) had taken ototoxic medications.[Table 5]

Table 5: Individual risk factors of the study population

Risk Factors	Number	Percent age
Preterm And Lbw	253	43.8 %
Hyperbilirubinemia Requiring Phototherapy	136	23.6%
Apgar Score Less Than 4 In 1st Minute Or Less Than 6 At 5 Minutes	30	5.2 %
Congenital Infections	12	2.1 %
Family History Of Deafness	5	0.9 %
Nicu > 2 days	86	14.9 %
Sepsis And Meningitis	18	3.1 %
Ototoxic Medications	37	6.4 %

Table 7: Risk factors comparison of the second OAE examination of the study population

Risk Factors		Pass Number	Fail Number	Total	Pass Percentage	Fail Percentage	χ^2	P Value
Preterm And Lbw	Normal Term	92	8	100	92.00 %	8.00 %	17.4	0
	Preterm And Lbw	26	15	41	63.41 %	36.59 %		
Hyperbilirubinemia Requiring Phototherapy	Absent	106	13	119	89.08 %	10.92 %	16.21	0
	Present	12	10	22	54.55 %	45.45 %		
Apgar Score Less Than 4 At 1st Minute Or Less Than 6 At 5 Minutes	Absent	111	18	129	86.05 %	13.95 %	6.17	0.012
	Present	7	5	12	58.33 %	41.67 %		
Congenital Infections	Absent	116	23	139	83.45 %	16.55 %	0.39	0.529*
	Present	2	0	2	100.00 %	0.00		
Family History Of Deafness	Absent	116	20	136	85.29 %	14.71 %	7.24	0.007
	Present	2	3	5	40.00 %	60.00 %		
Nicu > 2 Days	Absent	99	6	105	94.29 %	5.71 %	33.83	0
	Present	19	17	36	52.78 %	47.22 %		
Sepsis And Meningitis	Absent	114	15	129	88.37 %	11.63 %	24.36	0
	Present	4	8	12	33.33 %	66.67 %		
Ototoxic Medications	Absent	107	7	114	93.86 %	6.14 %	45.12	0
	Present	11	16	27	40.74 %	59.26 %		

Table 8: Risk factors comparison of ABR examination of the study population

Risk Factors		Pass Number	Fail Number	Total	Pass Percentage	Fail Percentage	χ^2	P Value
Preterm And Lbw	Normal Term	6	1	7	85.71 %	14.29 %		
	Preterm And Lbw	11	2	13	84.62 %	15.38 %		
Hyperbilirubinemia Requiring Phototherapy	Absent	11	1	12	91.67 %	8.33 %	1.04	0.306
	Present	6	2	8	75.00 %	25.00 %		
Apgar Score Less Than 4 At 1 Minute Or Less Than 6 At 5 Minutes	Absent	13	2	15	86.67 %	13.33 %	0.13	0.717
	Present	4	1	5	80.00 %	20.00 %		
Congenital Infections	Absent	17	3	20	85.00 %	15.00 %		
	Present	0	0	0	0.00	0.00		
Family History Of Deafness	Absent	15	3	18	83.33 %	16.67 %	0.39	0.593
	Present	2	0	2	100.00 %	0.00		
Nicu > 2 Days	Absent	5	0	5	100.00 %	0.00	1.17	0.278
	Present	12	3	15	80.00 %	20.00 %		
Sepsis And Meningitis	Absent	13	1	14	92.86 %	7.14 %	2.26	0.132
	Present	4	2	6	66.67 %	33.33 %		
Ototoxic Medications	Absent	5	1	6	83.33 %	16.67 %	0.018	0.891
	Present	12	2	14	85.71 %	14.29 %		

On the first OAE evaluation, out of 288 pre-terms and low birth weight neonates, 41(14.24%) failed and 247 (85.76%) passed the assessment;125 neonates required phototherapy and 22(17.60%) failed;12(40%) out of 30 had APGAR score of less than 4 in 1st minute or less than 6 in 5 minutes ;96 neonates had NICU stay more than two days with 38(39.58%) failing and 58 (60.42%)passing the OAE examination;13 (68.42%) out of 19 failed who had sepsis or meningitis and 62(17.46%) of 355 who were given ototoxic medications failed. All the values of comparison were statistically significant [Table 6]

On the second OAE evaluation, 15(36.59%) out of 41 preterm and low birth weight neonates failed and 26 (63.41%) passed the test;10(45.45%) of 22 who required phototherapy failed and 12(54.55%) passed;5(41.67%) of 12 who had APGAR score of less than 4 in 1st minute or less than 6 in 5 minutes failed;17(47.22%) more than two days stay of NICU failed;8(66.67%) who had sepsis and meningitis and 16(59.26%) with ototoxic medications failed

the second OAE examination. All the values except congenital infections were statistically significant ($p < .05$). [Table 7]

Discussion

The developed nations are now well aware of the burden of congenital hearing loss and have taken necessary steps for its early detection whereas the developing nations like India are far behind.^[1] Downs and Yoshingata-Itano have reported that the diagnosis of hearing loss before 6 months of age is of critical importance for the normal development of speech in neonates.^[12] Hunter MF et al has advocated for a two staged screening protocol with OAE as first screen followed by BERA for those who fail OAE screen.^[13] Indian Academy of Pediatrics has elucidated for the universal screening in early infancy as 50% of infants with hearing loss have no risk factors and are usually discharged from well baby nursery.^[14]

The prevalence of the failure of BERA examination of this study is 1.79 per 1000 population and is comparable to the range of 1 to as high as 8 per 1000 if the unilateral permanent hearing loss is also incorporated.^[15,16] This study showed the prevalence of neonate at high risk of 0.52 per 100. The studies done by Finitzo et al (0.5-1.0 per 100), Abraham K Paul (0.7 per 100) and James M et al revealed 0.63 per 100 high risk neonates.^[10,17,18]

The prevalence of the risk factors grouped together is 23% and comparable to Paul AK et al and James M et al with 16.63% and 21.7% respectively.^[10,18]

The prevalence of separate risk factors comprises of pre-terms and low birth weight babies (15%), neonates requiring phototherapy for hyperbilirubinemia (8%), APGAR score of less than 4 in 1st minute or less than 6 in 5 minutes (15%), congenital infections(0.71%), family history of deafness(0.3%), ototoxic medications (2.2%), NICU admission for more than two days(5.1%) and the newborn babies who had sepsis and meningitis (1.07%).

The first OAE failure rate was 8.7% amongst the neonates. The failure rate of first OAE tested varied from 6.3% in the study done by James et al to 7.2% by De Oliveira JS et al and 12% depicted by Paul AK et al.^[18,19] The high value of our study is mainly attributed to the early pre discharge and the sample size in comparison to the other studies.

A total of 20(1.19%) neonates failed the 2 staged sequential OAE assessment amongst the whole group as in concordance with the other studies with the approximate value of 1%.^[10]

Conclusion

The two staged sequential OAE assessment followed by ABR examination has an important role for the early detection of hearing impairment irrespective of any risk factors. This should be adopted by all the newborn care providers as a part of their routine examination of the newborns. Newborn hearing assessment in a timely manner can impede the impairment of the quality of life of an individual.

This study had the limitation of deciding the criteria for the first assessment for OAE examination within two days which could have affected the inferences. Moreover the study group did not represent the community as a whole. Moreover prolonged duration of follow up lead to loss of some neonates albeit subtle.

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