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Original Article

Is Hearing Loss in Infants Associated With Risk Factors? Evaluation of the Frequency of Risk Factors

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Objectives. To evaluate the frequency of risk factors and their influence on the evoked otoacoustic emission (OAE) of infants.

Methods. All newborns between November 2009 and June 2012 in Haydarpaşa Numune Education and Research Hospital were tested on distortion evoked OAE screening test. Total of 2,284 infants were examined. Sex, maternal infectious disease, birth type (vaginal birth or caesarean sectio), birth weight, familial hearing loss, intermarriage of parents, hyperbilirubinemia, intensive care were analyzed as risk factors.

Results. Total of 2,284 neonates were screened (1,220 males and 1,064 females) for the presence of OAE in both ears. Vaginal delivery, maternal infections during pregnancy, intermarriage of parents relative, low birth weight(<1,500 g) are related risk factors to failure of screening with OAE in our study. There was no statistically significant difference in sex ratios, birth weight, familial hearing loss, hyperbilirubinemia, and intensive care stay.

Conclusion. Risk factors are only as useful as their predictive power. Not enough is known about which risk factors are relevant, which babies have the risk factors, or which babies will fail to attend follow-up, the effectiveness of targeted hearing loss testing is questionable at this point in time. A system needs to be developed to clarify which risk factors are discoverable, predictive and useful.

Keywords. *Hearing loss, Newborn, Spontaneous otoacoustic emissions*

INTRODUCTION

Infant hearing loss stands out as the most common congenital sensory disorder. Its late detection compromises speech, language and cognitive skills essential for optimal early childhood development. Auditory cortex and neural connections develop with acoustic stimuli [1]. Globally, over 665,000 babies are born annually with significant hearing loss and this estimate increases with age, almost doubling by age of nine years [2].

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Universal newborn hearing screening is being promoted as an early detection strategy for hearing loss. Since optimal intervention for communication disorders is time-bound in early childhood, infants with hearing loss cannot afford to wait. The technology and expertise has developed to allow screening to detect hearing loss in newborn babies. Early intervention for permanent childhood hearing impairment has shown to reduce the deleterious effects of impaired audition on language and cognitive and social skills of affected children [3].

For effective treatment, congenital or perinatal hearing loss should be recognized within three months of birth, with formal diagnosis and initiation of early intervention beginning before the 6th month of age [4].

The first level of hearing screening takes place during the first 2–3 days of life, using the otoacoustic emission (OAE) test; all newborns are also analyzed for audiological risk factors. OAEs are believed to reflect the active biomechanical movement of

the basilar membrane of the cochlea [5]. Infants who don't pass the screening test and infants with high risk factors for hearing loss are referred to the second level where infants meet the auditory brainstem response (ABR) testing. The third level is advanced audiological centers, which are responsible for ultimate treatment and rehabilitation for children with hearing loss or deafness. This program provides a chance for early diagnosis and proper treatment of hearing impairment.

Joint Committee on Infant Hearing (JCIH) published the risk factors of hearing loss in neonates and gave resolution and standards for universal detection of hearing loss. Under ideal conditions, instruments designed specifically for newborns can test and record findings on sleeping newborns in <5 minutes [6].

One purpose of this investigation was to document the frequency of risk factors and the other purpose was, to imply their influence on the transient evoked OAE (TEOAE) of infants.

MATERIAL AND METHODS

The study was conducted at the Department of Otolaryngology-Head and Neck Surgery in Haydarpaşa Numune Education and Research Hospital.

The screening was carried out by audiologists with the neonate lying on and sleeping. Distortion product OAEs (DPOAEs) were detected with the following preset test protocols; our paradigms were DP-gram, because we tested the ears at different frequencies (frequencies tested, 4; frequency range, 2,000 to 5,000 Hz; averaging time, 4 seconds per frequency; passing frequencies for overall test pass, 3).

A probe was inserted into the external auditory canal. The loud-speaker generates the acoustic stimuli, while the microphone measures the resulting OAE that is produced within the cochlea and then transmitted back through the middle ear into the external auditory canal. The ears were screened separately. Pass means, ear tested passed the test, refer means ear tested failed the test. When a neonate has a test result as "refer," the test in this case was repeated a few minutes later and a neonate with persistent "refer" was taken as an indication for further testing. The test repeated within a week. Those failing the repeated screening with DPOAE (Natus Bio-logic AuDX Pro, Natus, San Carlos, CA, USA) and all neonates with risk factors were tested with automated ABR also.

All results, personal data, birth weight, and risk factors of newborns were recorded. The selected population included every newborn presenting one or more of defined risk factors. Analyzed risk factors for hearing loss in newborns were the following; familial hearing loss, maternal infections during pregnancy, intermarriage of parents, birth type, low birth weight(<1,500 g), hyperbilirubinemia requiring phototherapy, those hospitalised in the intensive care unit.

Data was analyzed using IBM SPSS ver. 20.0 (IBM Co., Armonk, NY, USA) and data was subjected to descriptive statistical measures. Chi-square test, exact test of Fisher test were used, following usual conditions of application. Kolmogorov Simirnov test was used to analyze the distribution of data.

RESULTS

Between 2009 and 2012, 2,284 infants were admitted to our clinic, of which all of them screened with distortion evoked OAE (DEOAE). There were 1,220 males and 1,064 females. Total of 4,568 ears were examined during the period of the study. Of the 4,568 ears screened for the presence of OAEs, 519 (11.3%) did not have emissions. A total of 157 neonates (6.8%) failed the screening test in both ears while 205 (8.9%) failed the screening test in only one ear. Of those failing the test, 207 of them were males while 155 were females (Table 1).

There was no statistically significant difference in sex disturbance, birth weight, familial hearing loss, hyperbilirubinemia, those hospitalised in the intensive care unit between OAEs passed neonates and did not ($P>0.05$).

The risk factors that are statistically significant were vaginal birth, maternal infections during pregnancy, intermarriage of parents and low birth weight.

Table 1. The distribution and prevalence of risk factors in the studied population

Variable	OAE pass	OAE refer	*P*-value
Sex			0.117
Female	909 (85.4)	155 (14.6)	
Male	1,013 (83.0)	207 (17.0)	
Birth type			0.027
Vaginal birth	998 (82.5)	211 (17.5)	
Cesarean section	922 (85.9)	153 (14.1)	
Birth weight	3,228±893	3,121±668	0.103
Maternal infection			0.010
+	9 (60.0)	6 (40.0)	
–	1,913 (84.3)	356 (15.7)	
Familial hearing loss			0.914
+	93 (83.8)	18 (16.2)	
–	1,829 (84.2)	344 (15.8)	
Parents being relative			
+	308 (80.2)	76 (19.8)	0.020
–	1,614 (84.9)	286 (15.1)	
Low birth weight			0.038
+	36 (73.5)	13 (26.5)	
–	1,886 (84.4)	349 (15.6)	
Hyperbilirubinemia			0.050
+	258 (88.1)	35 (11.9)	
–	1,664 (83.6)	327 (16.4)	
Intensive care			0.861
+	390 (84.4)	72 (15.6)	
–	1,532 (84.1)	290 (15.9)	

OAE, otoacoustic emission.

As the delivery type compared, the occurrence of refer in infants with vaginal birth (17.5%) are more than caesarean section (14.1%, $P=0.027<0.05$).

Also parents being relative infants (40.0%), infant having maternal infectious disease (40.0%, both $P=0.010<0.05$) and low birth weight infants (26.5%, $P=0.038<0.05$) were risk factors which were significantly related to "refer" result of DEOE.

DISCUSSION

One newborn every 500–1,000 births presents hearing impairment, which are greater incidence than the other incidence of diseases seen at birth [1]. In some populations incidence could be greater depending on different factors.

Hearing screening on infants has been performed in many developed and developing countries for early detection of hearing loss. The primary goal of this screening programme is early detection and The JCIH screening recommends that all infants with risk indicators should undergo periodic monitoring for three years. The 2007 statement expands screening protocols for newborn intensive care unit infants and provides additional guidance for the diagnostic audiology evaluation, medical evaluation, early intervention, surveillance, communication and tracking [7].

As has been observed in the literature, first-stage screening is with OAE is and requires those who pass to be exited from the program, whereas those who fail possibly after few repeat tests are scheduled for automated auditory brainstem response (AABR) screening [8].

In a study, syndromes associated with hearing loss and mechanical ventilation for more than 5 days were statistically significant risk factors in the occurrence of hearing loss. They added that most common risk factors are ototoxic medications, premature birth, low birth weight, intensive care in excess of 7 days. They concluded that as the number of risk factors an infant is exposed, the probability of hearing impairment increases [4].

They found that mechanical ventilation and intensive care was associated with hearing loss but in our study there was no statistically significant difference between infants hospitalized in intensive care unit and infants who didn't ($P>0.05$). According to literature [9], the application of mechanical ventilation could significantly damage the peripheral segment of the hearing tract. Also reported that days under mechanical ventilation and length of hospital stay were significantly increased in the group of children with sensorineural hearing loss (SNHL) [10].

In a report a risk factor hyperbilirubinemia which was found on only two occasions and was not taken into account for statistical analyses [2]. We had 293 infants requiring phototherapy for hyperbilirubinemia. But we found no correlation between hyperbilirubinemia and hearing loss.

Coenraad et al. [11] concluded a report that low APGAR scores (at 1 minute), sepsis, meningitis, cerebral bleeding and cerebral infarction are risk factors for SNHL.

Risk factor registers are used to select which babies are targeted for follow-up examinations, but such a system has fundamental problems with deciding on inclusion criteria, the under-reporting of risk factors, under-utilisation by babies enrolled, and the high cost of pediatric audiology. Risk factors are only as useful as their predictive power. Many children have ototoxic medications while in neonatal intensive care, or have a family history of hearing loss, but very few of these develop a problem [12].

Hearing losses may be caused by adverse environmental conditions surrounding the pregnancy or birth, or by certain hereditary conditions, both of which may have delayed audiological symptom expression. Not enough is known about which risk factors are relevant, which babies have the risk factors, or which babies will fail to attend follow-up, the effectiveness of targeted hearing loss testing is questionable at this point in time. A system needs tobe developed to clarify which risk factors are discoverable, predictive and useful.

Maris et al. [13] performed a retrospective analysis on the prevalence of auditory neuropathy/dyssynchrony in a population of infants referred after failed a neonatal hearing screening. This is a neuropathy of the cochlear nerve in combination with a general peripheral neuropathy. Normal TEOAE in combination with an absent or severely abnormal ABR are crucial for diagnosis [13]. Because of this they concluded that ABR must be the method of choice for neonatal hearing screening.

The effect of intermarriage of parents on neonatal hearing screening didn't study before. When this risk factor analyzed, there was a statistically significant difference between neonatas' parents being relative (40.0%) and those weren't (15.7%, $P=0.010<0.05$).

The risk factors mentioned in this study are for the congenital hearing loss babies and in these babies the patients with auditory neuropathy could be included. While evaluating these babies this must be kept in the mind.

Postnatal hearing loss is a looming challenge faced by early intervention programmes. Universal neonatal hearing screening programmes use registers to enrol at-risk infants into follow-up tests. This wealth of knowledge would help evaluate the current practice and determine the need for improved or additional screening and diagnostic procedures.

Limitation of this study was the absence of the automated ABR, necessary for confirmation and identification of hearing loss after the OAE screening.

In conclusions, the risk factors that are statistically significant in our study were vaginal birth, maternal infections during pregnancy, intermarriage of parents and low birth weight. There was no statistically significant difference in sex disturbance, birth weight, familial hearing loss, hyperbilirubinemia, those hospitalised in the intensive care unit between OAEs passed neonates and did not.

Little is understood about the numbers and characteristics of

babies who go on to have significant hearing losses and couldn't pass a newborn hearing screen. The data from universal neonatal hearing screening programmes would be useful for developing evidence-based practice and policy regarding children with significant post-natal hearing losses. The goal of early hearing detection and intervention is to maximize linguistic competence and literacy development for children who are hard of hearing.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Ohl C, Dornier L, Czajka C, Chobaut JC, Tavernier L. Newborn hearing screening on infants at risk. Int J Pediatr Otorhinolaryngol. 2009 Dec;73(12):1691-5.
2. Olusanya BO. Can the world's infants with hearing loss wait? Int J Pediatr Otorhinolaryngol. 2005 Jun;69(6):735-8.
3. Kumar S, Mohapatra B. Status of newborn hearing screening program in India. Int J Pediatr Otorhinolaryngol. 2011 Jan;75(1):20-6.
4. Bielecki I, Horbulewicz A, Wolan T. Risk factors associated with hearing loss in infants: an analysis of 5282 referred neonates. Int J Pediatr Otorhinolaryngol. 2011 Jul;75(7):925-30.
5. Okhakhu AL, Ibekwe TS, Sadoh AS, Ogisi FO. Neonatal hearing screening in Benin City. Int J Pediatr Otorhinolaryngol. 2010 Nov; 74(11):1323-6.
6. Nelson HD, Bougatsos C, Nygren P; 2001 US Preventive Services Task Force. Universal newborn hearing screening: systematic review to update the 2001 US Preventive Services Task Force Recommendation. Pediatrics. 2008 Jul;122(1):e266-76.
7. American Academy of Pediatrics; Joint Committee on Infant Hearing. Year 2007 position statement: principles and guidelines for early hearing detection and intervention programs. Pediatrics. 2007 Oct; 120(4):898-921.
8. Olusanya BO, Somefun AO, Swanepoel DW. The need for standardization of methods for worldwide infant hearing screening: a systematic review. Laryngoscope. 2008 Oct;118(10):1830-6.
9. Galambos R, Despland PA. The auditory brainstem response (ABR) evaluates risk factors for hearing loss in the newborn. Pediatr Res. 1980 Feb;14(2):159-63.
10. Martinez-Cruz CF, Poblano A, Fernandez-Carrocera LA. Risk factors associated with sensorineural hearing loss in infants at the neonatal intensive care unit: 15-year experience at the National Institute of Perinatology (Mexico City). Arch Med Res. 2008 Oct;39(7):686-94.
11. Coenraad S, Goedegebure A, van Goudoever JB, Hoeve LJ. Risk factors for sensorineural hearing loss in NICU infants compared to normal hearing NICU controls. Int J Pediatr Otorhinolaryngol. 2010 Sep; 74(9):999-1002.
12. Hutt N, Rhodes C. Post-natal hearing loss in universal neonatal hearing screening communities: current limitations and future directions. J Paediatr Child Health. 2008 Mar;44(3):87-91.
13. Maris M, Venstermans C, Boudewyns AN. Auditory neuropathy/dyssynchrony as a cause of failed neonatal hearing screening. Int J Pediatr Otorhinolaryngol. 2011 Jul;75(7):973-5.