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Risk factors of hearing defects and their relationship to the outcome of hearing screening among neonates

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Abstract:

Background: Increased exposure to risk factors of hearing loss leads to a high susceptibility to deafness among neonates admitted to neonatal care units in developing countries.

Objective: This article aims to study the prevalence of risk factors for neonatal hearing defect and determine their effect on the result of transient evoked otoacoustic emissions hearing test (TEOAE).

Methods: A longitudinal study was carried out for a period of one year from 1st October, 2016 to 30th September, 2017 in the CWTH, Medical city, Baghdad, Iraq. Demographic characteristics and certain risk factors were recorded for screened neonates. TEOAE test was done and if they failed to pass two steps, they were referred to automated auditory brainstem-response (AABR).

Results: Out of 400 neonates, 342 (85.5%) passed from step 1 TEOAE, while 58 (14.5%) were referred to step 2. From 58, 26 (44.8%) have passed step 2 and 32 (55.2%) not pass step 2 and were referred to AABR. From those 32 neonates with suspected hearing defect, NICU stay >7 days, ototoxic drugs >7 days, use of ventilator >7 days, birth weight <1500gm, and craniofacial malformations were the main risk factors for hearing defects occurring in (90.6%), (90.6%), (59.4%), (40.6%), and (21.9%) respectively.

Conclusions: Low birth weight, long intensive care stay, mechanical ventilation, drugs ototoxicity and craniofacial malformation of neonates are the main risk factors for failed TEOAE test.

Keywords: Hearing defect, Hearing Screening, Neonates, Risk Factors.

Introduction:

Hearing loss (HL) is one of the common congenital problems among neonates [1]. The prevalence of significant HL ranges from 1.2 per 1,000 healthy newborn infants and 2 to 5% in high-risk newborns [2, 3]. Nearly 50% of congenital HL is due to genetic defects [1]. About 50% of hearing defects can be detected in a selective screening based exclusively on hearing risk criteria [1]. Early detection and intervention at a younger age are critical for future speech, language and cognitive development. Neonates with congenital HL should be identified within the first 3 months of life. However, the average age at detection is currently 24-30 months [4]. Hearing assessment can be done either by Transient evoked Otoacoustic emission (TEOAE) or by Automated Auditory Brainstem Response (AABR). OAEs provide a simple, efficient and non-invasive objective indicator of healthy cochlear function. OAEs may be either spontaneous or induced by acoustic stimulation. TEOAE is an effective method for neonatal audiological screening both in the general population and in high-risk infants [5].

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Risk factors associated with HL were identified by the Joint Committee on Infant Hearing (JCIH) in 2007 [6]. The use of risk factors is no longer recommended to select children who should undergo hearing screening. Studies have shown that only 50% of the pediatric population with congenital HL would be identified by this procedure. However, it is essential to identify risk factors for HL, because an infant with any of these factors in neonatal history has a greater chance of experiencing HL. Additionally, it can guide the approach to be adopted after the results of the hearing screening [7]. Newborn hearing screening was initially targeted toward those newborn ‘‘at risk’’ for HL called High-Risk Register (HRR) [6].This group included infants who had asphyxia, meningitis, congenital or perinatal infections, anatomic defects or stigmata, hyper-bilirubinemia, family history of HL, low birth weight, ototoxic medications, and neonatal illnesses requiring mechanical ventilation. HRR screening resulted in around 50% of congenital HL being undetected [8]. It was soon realized that a more logical approach is to implement universal newborn hearing screening aiming at the early identification of most, if not all children with congenital HL[9]. This study Aimed to find out the prevalence of risk factors for neonatal HL and determine their relationship the result of TEOAE hearing test in neonates referred and admitted to NICU of Children Welfare Teaching Hospital, Medical City, Baghdad.

Patients and Methods:

A longitudinal study was carried out for the period from 1st October, 2016 to 30th September, 2017 in the CWTH, Medical city, Baghdad, Iraq. This 250 beds tertiary hospital had 34 incubators and a level 3Neonatal Intensive Care Unit (NICU) which receives infants referred from other hospitals, primary health centers and private clinics for further management of neonates. Inclusion criteria include all neonates less than 28 days old who were referred to hospital for screening from other NICUs and discharged well. Exclusion criteria included neonates who failed in the step 1 of screening and have not attended the second one, and those whose parents refused participation due to deteriorated health status. Data was collected from the parents and the neonates` discharge cards in the outpatient neonatology clinic and case sheets of neonates admitted to NICU/CWTH through direct interview and filling the prepared data collection sheet. The data collection sheet was designed by the researchers depending on the experience of previous international literatures. The questionnaire included the followings: Demographic characteristics, age and gender of neonates, gestational age of neonates, gestational history, type of delivery, birth weight, consanguinity and craniofacial malformations, family history of HL, clinical history, NICU stay duration, sepsis, meningitis, use of ventilator, ototoxic drugs, hyperbilirubinemia and exchange transfusion, Results of step 1-TEOAE, and results of step 2-TEOAE. After identifying eligible neonates, their data was collected and a TEOAE hearing test was performed by a well-trained healthcare provider. Neonates who have passed the 1st step were considered normal. The 2nd TEOAE test was performed after two weeks for a neonate who had failed the 1st test. They were referred to AABR to complete the assessment of their hearing if they failed the 2nd TEOAE hearing test. TEOAE test was carried out for both ears using the ILO Echo-check system, a portable device which uses click stimuli involving frequency bands between 1,500 Hz and 3,800 Hz. The click is presented at an intensity of 75 to 83 dBpeSPS. The response was considered positive (pass) when the otoacoustic emissions captured were 6 dB higher than the noise. Approval to conducts the study was obtained from the Ethical committee of CWTH. Oral informed consent was taken from neonates` parents by the health care provider. The neonates were screened as part of the hospital policy to screen all neonates who came to CWTH neonatology outpatient clinic and admitted neonates to NICU before discharge. The data of screening were collected from registry of hearing screen room.

Statistical analysis:

All patients' data were analyzed using Statistical Package for Social Sciences (SPSS) version 22. Descriptive statistics were presented as (mean ± standard deviation) and frequencies / percentages. Kolmogorov Smirnov analysis verified the normality of the data set. Chi square test was used test the association between categorical data (Fishers exact probability test was used when expected variables were less than 20% of total). Independent sample t-test was used to compare between two means. The level of significance (p value) was set at ≤ 0.05.

Results:

A total of 400 neonates screened for HL were included with mean age of 19±8 days. Two-hundred and thirty (57.5%) screened neonates were males and 170 (42.5%) were females with male to female ratio of 1.3:1. The mean gestational age (GA) was 35.3±3.3 weeks; 4 neonates (1%) were born before 28 weeks of gestation, 34 (8.5%) were 28- <32 weeks of GA, 208 (52%) were 32- <37 weeks of GA and 154 (38.5%) were ≥37 weeks of G.A. of 400 screened neonates, 161 (40.2%) were delivered vaginally (VD), while 239 (59.8%) were delivered by cesarean section (CS). Birth weight less than 1500g was found in 95 neonates (23.7%). Consanguinity was found in 204 (51%). Craniofacial malformations were found in 30 neonates (7.5%). A positive family history of HL was found in 22 neonates (5.5%). The mean NICU stay duration was 11±6 days, 128 (32%) neonates stayed ≤7 days and 272 (68%) had stayed more than 7 days. History of sepsis was present in 171 (42.8%), meningitis in 34 (8.5%), on ventilation >7 days in 70 (17.5%), on ototoxic drugs >7 days in 271 (67.8%), significant hyperbilirubinemia in 216 (54%) and requiring exchange transfusion in40 (10%) of neonates (Table 1).

Table 1: Clinical history of 400 neonates

Variable	No.	%
NICU stay duration mean ±SD (11±6 days)		
≤7 days	128	32.0
>7 days	272	68.0
Sepsis	171	42.8
Meningitis	34	8.5
Ventilator >7 days	70	17.5
Ototoxic drugs >7 days	271	67.8
Significant hyperbilirubinemia	216	54.0
Exchange transfusion required	40	10.0
Total	400	100.0

Of 400 screened neonates, 342 (85.5%) passed step 1 TEOAE while 58(14.5%) were referred to step 2 TEOAE. Of those 58 neonates referred to step 2 TEOAE, 26 (44.8%) have passed step 2 while 32 (55.2%) have failed it and were referred to AABR. Neonates referred to AABR represented 32 (8%) of total screened neonates. There was no significant association between gender and being referred to AABR. A significant association was found between referral to AABR and lower GA (p=0.02) (Table 2).

Table 2: Distribution of neonates' gender and gestational age according to TEOAE passing (No AABR) and referral to AABR

Variable	AABR		No AABR		Total	χ^2	P
	No.	%	No.	%			
Gender						0.2	0.6
Male	17	7.4	213	92.6	230		
Female	15	8.8	155	91.2	170		
Gestational age						9.8*	0.02 *Signi-ficant*
≥37	10	6.5	144	93.5	154		
32 - <37	14	6.7	194	93.3	208		
28 - <32	7	20.6	27	79.4	34		
<28	1	25.0	3	75.0	4		

Fishers exact probability test

No significant associations were detected between neonates being referred to AABR and the type of delivery, consanguinity and family history of HL. A significant association between low birth weight and referral to AABR (p=0.01) was detected as well as a highly significant association between craniofacial malformation and referral to AABR (p<0.001), (Table 3).

Table 3: Distribution of obstetrical and family history according to TEOAE passing (No AABR) and referral to AABR

Variable	AABR		No AABR		Total	χ^2	P
	No	%	No.	%			
Type of delivery						0.6	0.4
Vaginal	15	9.3	14	90.7	161		
CS	17	7.1	22	92.9	239		
Birth weight <1500gm						5.4	0.01 *Sig*
Yes	13	13.	82	86.3	95		
No	19	6.2	28	93.8	305		
Consanguinity						0.3	0.5
Positive	18	8.8	18	91.2	204		
Negativ	14	7.1	18	92.9	196		
Craniofacial malformation						10.3 *	0.00 1 *High*
Yes	7	23.	23	76.7	30		
No	25	6.8	34	93.2	370		
Family history of hearing loss						2.1*	0.1
Positive	0	0	22	100.	22		
Negativ	32	8.5	34	91.5	378		

Fishers exact propability test

There was no significant association between neonates being referred to AABR and having sepsis, meningitis, hyperbilirubinemia and exchange transfusion. There was a significant association between referral to AABR and increased NICU stay duration (p=0.004), neonates on ventilator for >7 days (p<0.001) and ototoxic drugs use for >7 days (p=0.004), (Table 4).

Table 4: Distribution of neonates' clinical history according to TEOAE passing (No AABR) and referral to AABR

Variable	AABR		No AABR		Total	χ^2	P
	No.	%	No.	%			
NICU stay duration						8.1	0.004 *Sig*
≤7 days	3	2.3	125	97.7	128		
>7 days	29	10.7	243	89.3	272		
Sepsis						2.5	0.1
Yes	18	10.5	153	89.5	171		
No	14	6.1	215	93.9	229		
Meningitis						0.03	0.8
Yes	3	8.8	31	91.2	34		
No	29	7.9	337	92.1	366		
Ventilator >7 days						42.2	<0.001 *High*
Yes	19	27.1	51	72.9	70		
No	13	3.9	317	96.1	330		
Ototoxic drugs >7 days						8.3	0.004 *Sig*
Yes	29	10.7	242	89.3	271		
No	3	2.4	126	97.6	129		
Hyperbilirubinemia requiring phototherapy or exchange transfusion						0.4	0.5
Yes	19	8.8	197	91.2	216		
No	13	7.1	171	92.9	184		
Exchange transfusion required						0.01	0.9
Yes	3	7.5	37	92.5	40		
No	29	8.1	331	91.9	360		

Discussion:

Completeness of children auditory system is an essential requirement and one of the prerequisites for earning a complete oral language and intellectual development by communicating with their families, understanding the world, interaction with other children, thoughts and feeling development and acquisition of knowledge [10]. In the current study 32 (8%) of the neonates were referred to AABR after screening with two steps of TEOAE. This prevalence of suspected HL is close to results of Oliveira et al in Brazil who reported that among 1146 screened neonates, 82 (7.2%) failed TEOAE and were referred to AABR [11]. The prevalence is higher than that found by Gouri et al in India (5.3%) [12], but lower than that found by Pourarian et al in Iran (13.7%) [13] and Olusanya et al in Nigeria (4.1%) [14]. High prevalence of suspected neonates with HL might be attributed to the fact that CWTH is a tertiary center mainly receiving complicated cases from other governorates. The current study revealed 58 (14.5%) neonates were referred to step-2 TEOAE, from whom 32 (55.2%) were referred to AABR. These findings are higher than the results of Habib et al in Saudi Arabia[15],who found that among 11986 neonates screened with step 1-TEOAE, 1043 (8.7%) neonates were referred to step-2 TEOAE, from whom 300 (27%) failed and were referred to AABR. The higher rate of referrals to step-2 TEOAE test (false positive step-1) could be due to local causes like wax accumulation or otitis media (with or without effusion) or due to an improper external environment like noise. Kumar et al[16] stated that TEOAE had a high accuracy in early detection of congenital HL, in spite of the high false negative rate found by many studies.[17,18] TEOAE has limited activity in the categorization of risk factors for HL among high risk population[19] in addition to many disadvantages of screening use among neonates [16,20]. Despite these findings, TEOAE represents the major non-invasive instrument for early detection of HL of cochlear origin, as it focuses on mechanical function in addition to TEOAE cost-effectiveness that facilitates its application in developing countries.[21] Low GA of neonates was significantly associated with failed step-2 TEOAE hearing test (p=0.02). This finding coincides with the results of Waters et al [22] in the USA. Infants born with lower GA were exposed to delayed myelination of the central nervous system and hearing bones development [23]. Some studies suggested that the main causes of hearing impairment among low GA infants are cochlear immaturity in

pre-term neonates and middle ear effusion due to prolonged tracheal intubation [16, 18]. Similarly, the current study showed a significant association between low birth weight (<1500 gm) and failed step-2 TEOAE (p=0.01). This finding is consistent with results of Onoda et al in Brazil [24]. Many authors found a strong relationship between birth weight and failed hearing screening tests in addition to HL[25].The very low birth weight has multiple risk factors for hearing problems like birth asphyxia which needs long NICU admission, mechanical ventilation and ototoxic medications[26]. Gender of the neonate was not significantly associated with failing TEOAE. This finding is similar to results of Karaca et al in Turkey[27].Consanguinity and family history of HL were not found to be related to neonatal hearing problems, in contrast to the results of Shrikrishna et al in India who reported that consanguinity and family history are common risk factors of genetic neonatal HL[28]. Neonates with craniofacial malformations had significantly higher rates of failed TEOAE (p=0.001), similar to report of Lunardi et al in Italy [29]. Craniofacial malformation is related mainly to developmental abnormalities of the first and second branchial arches, which contribute to development of the hearing system (skeletal, muscular and nervous) [29]. NICU stay duration was significantly related to failed TEOAE hearing tests (p=0.004), in consistence with the results of Barboza et al in Brazil [30]. Long NICU stay duration is usually relevant to deteriorated health of infants, prematurity, mechanical ventilation and ototoxic antibiotic use [31]. Use of ventilators for more than 7 days was significantly related to failed TEOAE screening test (p<0.001), in consistence with results of Amini et al in Iran [32]. Continuous nasal positive airway pressure applied as a respiratory support for preterm neonates proved to be a risk factor for prolonged exposure to high levels of noise [33]. The current study revealed that ototoxic drugs used for neonates were significantly associated with failed TEOAE screening (p=0.004), which is in agreement with the results of So et al in the USA [34], who documented that the use of bolus doses of ototoxic drugs especially aminoglycosides is highly related with neonatal HL and that over therapeutic serum levels of aminoglycosides have shown an increased possibility of ototoxicity. Since aminoglycoside serum concentrations were not measured in our study, there is a high probability that those neonates who had failed TEOAE screening might have had high serum levels while receiving aminoglycosides and eventually had an increased risk of ototoxicity, especially when these drugs were given for long periods. The concern of many literatures was the delayed effect of aminoglycosides in development of sensory neural HL [35]. Although no significant relationship was demonstrated between failing TEOAE and each of sepsis, meningitis, hyperbilirubinemia and exchange transfusion, many studies had reported neonatal sepsis and high bilirubin level of neonates as independent risk factors for HL among neonates [36, 37]. This inconsistency with our findings might be due to differences in health services in addition to differences in study design.

Conclusions:

Prematurity, low birth weights, craniofacial malformation, long NICU stay duration, mechanical ventilation and drugs ototoxicity were found to be risk factors for failed transient evoked otoacoustic emissions hearing test in screened neonates in Children Welfare Teaching Hospital. The study recommends encouraging routine hearing screening programs for neonates especially those at risk like preterm, low birth weight, malformation and admission to NICUs. Larger national longitudinal multi-center studies applying other screening and diagnostic hearing tests must be supported.

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عوامل اختطار عيوب السمع وعلاقتها بنتيجة فحص السمع بين الولدان

الاستاذ الدكتور نعمان نافع حميد الحمداني- فرع طب الاطفال- كلية الطب – جامعة بغداد ومستشفى حماية الاطفال – مدينه الطب
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الخلاصة:
خلفية: يؤدي التعرض المتزايد لعوامل الخطر لفقدان السمع إلى زيادة التعرض للصمم بين الولدان المولودين في البلدان النامية.
اهداف الدراسة: تهدف هذه المقالة إلى دراسة مدى انتشار عوامل الاختطار لعيوب السمع عند الأطفال حديثي الولادة وتحديد تأثيرها على نتيجة اختبار السمع الصوتي الناتج عن الانبعاثات.
الطريقة: أجريت هذه الدراسة الطوليه لمدة سنة واحدة. تم تسجيل الخصائص الديموغرافية وبعض عوامل الاختطار. وإذا لم يتمكنوا من اجتياز خطوتين، فقد تمت إحالتهم إلى الاستجابة الدماغية السمعيةللولدانتم إجراء اختبار(AABR).
النتائج: من أصل 400 حديث الولادة، اجتاز 342 (85.5٪) الخطوة الأولى من اختبار السمع الصوتي الناتج عن الانبعاثات، في حين تمت إحالة 58 (14.5٪) إلى الخطوة الثانية. ولقد اجتاز 26 (44.8٪) الخطوة الثانية بينما لم يجتز الخطوه الثانيه 32 (55.2٪) وقد احيلوا الى فحص الاستجابة الدماغية السمعية.وكانت اهم عوامل الاختطار الرئيسية لعيوب السمع في 32 مريض هي مدة البقاء في وحدة العنايه المركزة لاكثر من 7 ايام, استعمال ادوية سامه للاذن لاكثرمن 7 ايام, وضع حديث الولادة في جهاز الانعاش لاكثر من 7 ايام, الوزن عند الولادة اقل من 1500 غم,والتشوهات القحفية الوجهية وبالنسب الاتية على التوالي (90,6%) (90,6%) (59,4%) (40,6%) و (21,9%).
الاستنتاجات: إن انخفاض الوزن عند الولادة والإقامة الطويلة في العناية المركزة والتهوية الميكانيكية والتسمم ألأذني للأدوية والتشوه القحفي للولدان هي عوامل الاختطار الرئيسية لفشل اختبار السمع الصوتي الناتج عن الانبعاثات
الكلمات المفتاحية: عيب السمع، فحص السمع، الولدان، الانتشار، عوامل الاختطار.