Prevalence and Risk Factors of Hearing Impairment in Newborns Under Universal Hearing Screening Program in Northern Thailand

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Abstract

To determine the hearing impairment in newborns under universal hearing screening program in Northern Thailand. This was the prospective analytic study conducted from November 1st, 2010 to May 31st, 2013. The hearing of all newborns was screened with transitory evoked otoacoustic emissions (TEOAE), automated auditory brainstem responses (AABR) and conventional auditory brainstem responses (ABR). All infants were followed up for hearing and developmental evaluation until 18 months of age. Three thousand one hundred and twenty newborns underwent the universal hearing screening tests. One hundred and three infants (3.3%) had abnormal results at 6 months of age. After 18 months follow up, there were only 14 cases (0.4%) who had permanent hearing loss, 2 of them belonged to normal newborn group and another were from high risk group. Significant risk factors for permanent hearing loss were craniofacial anomalies, ototoxic exposure, hyperbilirubinemia, low APGAR scores and sepsis. Universal hearing screening program in this study can detect the hearing impairment in 0.4% of all newborns, with 2 cases from normal and 12 cases from high risk group. These findings confirmed the benefit of universal hearing screening test which will detect early hearing loss in both normal and high risk newborns. TEOAE/ABR are fast and pleasant procedures, and appropriate for hearing evaluating in newborns.

Keywords: *Hearing impairment, Universal hearing screening, Risk factors*

บทคัดย่อ

เพื่อการค้นหาการสูญเสียการได้ยินในทารกแรกเกิดภายใต้โปรแกรมการตรวจคัดกรองแบบสากลในภาคเหนือตอนล่าง การศึกษาเชิงวิเคราะห์ โดยเก็บข้อมูลแบบไปข้างหน้า โดยทำการศึกษาวิจัยระหว่างวันที่ 1 พฤศจิกายน พ.ศ.2553 ถึงวันที่ 31 พฤษภาคม พ.ศ.2556 การตรวจคัดกรองการได้ยินทารกแรกเกิดทุกราย ตรวจด้วยเครื่องวัดเสียงสะท้อนจากหูชั้นใน เครื่องวัดเสียงสะท้อนจากก้านสมองแบบอัตโนมัติ และเครื่องวัดเสียงสะท้อนจากก้านสมองแบบทั่วไป เด็กทุกคนจะได้รับการตรวจประเมินติดตามการได้ยินและพัฒนาการจนถึงอายุ 18 เดือน จากผลการศึกษาพบว่าทารกแรกเกิด 3,120 รายได้รับการตรวจคัดกรองการได้ยินแบบสากล 103 ราย (3.3%) มีผลการตรวจที่ผิดปกติเมื่ออายุ 6 เดือน หลังจากติดตามไปจนถึงอายุ 18 เดือนพบว่ามีสูญเสียการได้ยินทั้งสองข้างแบบถาวร 14 ราย (0.4%) มี 2 รายที่มาจากทารกแรกเกิดที่ปกติ และที่เหลือมาจากทารกกลุ่มเสี่ยงสูง ปัจจัยเสี่ยงที่สำคัญที่ทำให้มีการสูญเสียการได้ยินแบบถาวรนี้คือ ทารกที่มีความพิการของใบหน้าและศีรษะตั้งแต่เกิด ทารกที่ได้รับยาปฏิชีวนะที่มีผลต่อเส้นประสาทการได้ยิน ทารกที่มีภาวะตัวเหลืองมาก ทารกที่มีคะแนนการวัดสัญญาณชีพต่ำและทารกที่มีการติดเชื้อในกระแสเลือด โปรแกรมการคัดกรองการได้ยินแบบสากลในการศึกษานี้สามารถตรวจพบการสูญเสียการได้ยิน 0.4% จากทารกแรกเกิดทั้งหมด มี 2 รายที่มาจากทารกกลุ่มปกติและ 12 รายมาจากทารกกลุ่มเสี่ยงสูง การค้นพบนี้ได้ยืนยันแล้วว่าการตรวจคัดกรองการได้ยินแบบสากลนี้สามารถค้นพบทารกที่มีการสูญเสียการได้ยินได้ในตั้งแต่ระยะแรกทั้งในทารกกลุ่มปกติและทารกกลุ่มเสี่ยงสูง เครื่องวัดเสียงสะท้อนจากหูชั้นในและเครื่องวัดเสียงสะท้อนจากก้านสมองเป็นเครื่องมือที่สามารถตรวจการได้ยินได้อย่างรวดเร็วและสะดวก และเหมาะสมสำหรับใช้ในการประเมินการได้ยินในทารกแรกเกิด

คำสำคัญ: *การสูญเสียการได้ยิน การตรวจคัดกรองการได้ยินแบบสากล ปัจจัยความเสี่ยง*

1. Introduction

Hearing impairment is one of the most common clinical anomalies in newborns of developing countries. World Health Organization estimates revealed that there are 250 million people worldwide with disabled hearing impairment in 2000, this composes about 4.2% of the world's population and 2/3 of which arises from developing countries such as Srilanka, Mynmar, Indonesia, Philippines and Thailand. In most of the world, the incidence of hearing impaired newborns ranges from 0.1-0.3% (Nie et al.,2007; Santos-Cortez & Chiong, n.d.). In the study of Charengprasert, Lertsukprasert, Kasemsuwan & Nunnarumit (2003)

at Ramathibodi Hospital, Bangkok Thailand found prevalence of newborns congenital hearing loss of 1.7 per 1,000 (Charengprasert, Lertsukprasert, Kasemsuwan & Nunnarumit, 2003). Early detection can prevent further disabilities in speech, language and cognition in the child's development (Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998). In comparison, there are consistent indications of the high prevalence of newborn hearing loss in Asian children (Fortum & Davis, 1997), and in Pakistani groups as derived from cohorts living in the United Kingdom (Morton, Sharma, Nicholson, Broderick, & Poyser, 2002). Universal hearing screening has dramatically improved outcomes for babies born with detectable hearing abnormalities (Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998; US Preventive Services Task Force, 2008). Ideally, identification of all newborns with hearing impairment should be done as early in life as possible to initiate an appropriate early intervention when necessary (Nelson, Bougatsos, Nygren, & 2001 US Preventive Services Task Force, 2008; Northern & Downs, 2002; Joint Committee on Infant Hearing: American Academy of Audiology, American Academy of Pediatrics, American Speech-Language-Hearing Association, & Directors of Speech and Hearing Programs in State Health and Welfare Agencies, 2000). The goal of universal newborn hearing screening was to identify hearing impairment within the first month of life and provide appropriate amplification and intervention between 3-6 months of age to reduce the impact of hearing impairment on educational, emotional and social development as it is the most important period for speech and language acquisition (Colorado Infant Hearing Advisory Board, Membership of the Screening, & Assessment and Early Intervention Task Forces, n.d.; Carney & Moeller, 1998; Geal-Dor, Levi, Elidan, & Arad, 2002; Sun, Li, & Huang, 2003; Joint Committee on Infant Hearing: American Academy of Audiology, American cademy of Pediatrics, American Speech-Language-Hearing Association, & Directors of Speech and Hearing Programs in State Health and Welfare Agencies, 2008; White, Vohr, & Behrens, 1993). This study represents an initial report for universal hearing screening in Uttaradit Hospital, Budhachinarat Hospital and Sawanpracharuk Hospital, the tertiary care center located in the north of the country. All of the newborns within that period were screened, as recommended by the Joint Committee on Infant Hearing. It has been shown that otoacoustic emissions (OAEs) are a good screening test because it is easy to administer, easy to tolerate, is cost-effectiveness, quick and has good performance characteristics (i.e. sensitive, specific, and predictive; Nelson, Bougatsos, Nygren, & 2001; US Preventive Services Task Force, 2008; Geal-Dor, Levi, Elidan, & Arad, 2002; Joint Committee on Infant Hearing 1994 Position Statement & American Academy of Pediatrics Joint Committee on Infant Hearing, 1995). The test is performed under one minute and can be achieved without audiological expertise. The results are a pass or fail method in which those who pass are presumed to have a hearing loss no greater than 35 dB and those who fail are referred to undergo further Automated ABR (Geal-Dor, Levi, Elidan, & Arad, 2002; Sun, Li, & Huang, 2003; Joint Committee on Infant Hearing: American Academy of Audiology, American cademy of Pediatrics, American Speech-Language-Hearing Association, & Directors of Speech and Hearing Programs in State Health and Welfare Agencies, 2008; White, Vohr, & Behrens, 1993; Wroblewska-Seniuk et al., 2005; Joint Committee on Infant Hearing 1994 Position Statement, & American Academy of Pediatrics Joint Committee on Infant Hearing, 1995; Vatovec, Velickovic, Smid, & Gros, 2001; Prasansuk, 2000). While hearing impairment is found in 1-3 out of 1,000 newborns (Thompson et al., 2001; Mehl & Thomson, 2002; Yoon, Price, Gallagher, Fleisher, & Messner, 2003), there is a high-risk group that includes infants with low birth weight, craniofacial anomaly, severe hyperbilirubinemia and suffering the effects of ototoxic medication (Srisuparp, Gleebbur, Ngerncham, Chonpracha, & Singkampong, 2005; Valkama et al., 2000; Finckh-Kramer et al., 2000; Hess et al., 1998; Kochhar, Hildebrand, & Smith, 2007; American Academy of Pediatrics, 2007). This study was designed to determine the prevalence and risk factors of hearing impairment in all newborns.

2. Objective

To determine the hearing impairment in newborns under universal hearing screening program in Northern Thailand.

3. Methods

This was a prospective study designed to determine the prevalence and risk factors associated with hearing impairment of all newborns in Uttaradit Hospital, Budhachinarat Hospital and Sawanpracharuk Hospital, the tertiary hospital located in northern Thailand from November 1st, 2010 to May 31st, 2013.

3.1 Ear Examination

After the interview, study participants underwent ear examination performed by ENT doctors. An examination form was provided to determine the presence or absence of outer, middle and inner ear infections using otoscopic examination. All findings were recorded in the examination form provided by the medical and nursing staff. All those had any form of ear infections were not be allowed to proceed to the audiometric examination. The hearing of all newborns was screened in a three stages: transitory evoked otoacoustic emissions (AccuScreen GN Otometrics, PATH medical GmbH, Germering, Germany) followed by automated auditory brainstem responses (Madsen AccuScreen Otometrics, PATH medical GmbH, Germering, Germany) examination in case they failed TEOAE. Infants who had abnormal AABR results were referred to otologists and audiologist for further evaluation with conventional ABR, Sentiero (Advanced Otometrics, Germany). TEOAEs (Transient or click-evoked Otoacoustic Emissions) employ click stimulation and averaging similar to screening ABR. Before positioning the earphone, the external ear canal should be checked for any easily removable debris or blockage before placement of the earphone. Earphones should be carefully positioned so that the ear canal is not occluded by any excess pressure. The screening test on each ear is indicated by ABR and evaluation method is Noise-Weighted Averaging and Template matching. The click and chirp stimuli are 5-90 dB nHL with rate of 10-89.9 Hz, alternating polarity, positive condensation and negative rarafaction average stimuli of 1,000 –20,000 time/sec, Impedance Test : 1 – 99 kΩ, Statistic graph, EEG,and with ABR detection probability is present. Comparing latency and interwave of wave I, III, IV with normative age. The abnormal hearing infants were managed with early intervention (hearing aid fitting, auditory training, counselling and combine) and followed for hearing and developmental evaluation until 18 months of age. This screening involved both normal group and high risk group criteria stated by the American Academy of Pediatrics Joint Committee on Infant Hearing (Kochhar, Hildebrand, & Smith, 2007; American Academy of Pediatrics, 2007).

Risk factors for hearing impairment were as follows:

1. Family history of hereditary childhood sensorineural hearing loss.
2. In utero infection: cytomegalovirus, rubella, syphilis, herpes, or toxoplasmosis
3. Craniofacial anomalies, including those with morphological abnormalities of the pinna and ear canal excluding isolated ear pits and tags
4. Low birth weight < 1,500 g, premature birth
5. Hyperbilirubinemia at a serum level requiring exchange transfusion (18 mg/dl in term and 15 mg/dl in preterm)
6. Ototoxic medication, including but not limited to the aminoglycosides, used longer than seven days duration or in combination with loop diuretics
7. Bacterial meningitis
8. Low Apgar scores of 0-4 at 1 minute or 0-6 at 5 minutes
9. Mechanical ventilation for at least five days
10. Stigmata or other findings associated with a syndromes associated with congenital hearing loss

3.2 Study procedure

This research was approved by the Faculty of Medicine Ethics Committee Chiang Mai University, Thailand, with informed consent obtained in all cases. The auditory screening was carried out in three stages. The OAEs and AABR were assessed in the first two stages and conventional Auditory Brainstem Responses (ABR) was assessed in the third stage. Upon passing the otologic examination, they underwent an audiometric examination using an assessment tool using a transitory evoked otoacoustic emissions (Non linear Click stimuli of 60 Hz, intensities between 70-84 dB SPL, rate 60 time/sec rate, frequencies of 1.5 – 4.5 kHz and, Noise-Weighted Averaging evaluation method). The degree of hearing impairment will be based on the criteria developed by the World Health Organization (WHO). A "pass" result was recorded for an ear which showed a signal-to-noise ratio of 10 dB with an averaged noise floor value of -20 dB and a failure or "refer" result was recorded when the 10 dB signal-to-noise ratio was not achieved. All the infants who "referred" on initial screening were advised to follow-up for a repeat screening (re-screen) at least 1 month after discharge with AABR(linear Click stimuli of 80 Hz, intensities of 35, 40 and 45 dB nHL, rate of 80 time/sec, Impedance Test : 1 – 99 kΩ, Noise-Weighted Averaging and Template matching evaluation method). If the results are still abnormal, they will be reassessed with conventional ABR at second or third month of age.

3.3 OAEs (Otoacoustic emissions)

OAEs are physiologic measurements of the response of the cochlea's outer hair cells to acoustic stimuli. OAE measurement is done in each ear by placing a probe in the ear canal, stimulating by clicks or tone pips, and then measuring within 60 seconds or less with a microphone.13 The presence of OAE responses indicates normal or near-normal hearing. Ear canal obstruction and middle ear effusion can eliminate the OAEs, causing a positive test result (a "refer" outcome) in a normal cochlea function. As OAE responses are generated by the outer hair cells of cochlea, OAE cannot detect neural hearing loss (e.g. auditory neuropathy/dyssynchrony). Accordingly, OAEs are not a sufficient screening test in newborns who are at risk for neural hearing loss and they should undergo an ABR screening.

3.4 Auditory brainstem response (ABR)

ABR is an electrophysiologic measurement to assess the whole auditory function system from the cochlea through the auditory brainstem pathway. Because the ABR is generated by auditory neural pathways, it will detect neural hearing loss in newborns. The automated ABR (AABR) system was later developed specifically for the mass hearing screening for neonates. AABR measurements are obtained by placing disposable surface electrodes on the forehead, on the mastoid, and on the nape of the neck. The click stimulus (usually set at 35 dB hearing level) is delivered to the ear via disposable earphones. AABR systems compare an infant's responses with normal template responses developed from normative ABR infant data and shows the result as "pass" or "refer". The infant passes the AABR if reliable responses are present at the screening level of 35 dB HL or lower. AABR is practical because the machine can easily be operated by a trained nonprofessional and the screening time required to evaluate both ears is 3-10 minutes. Newborns were evaluated using the portable OAEs within 48-72 hours before discharge. The Madsen Accuscreen Pro T is the method for automatic detection of TEOAEs (Transient evoked otoacoustic emissions) and gives a "pass" or a "refer" result. If the result was a "refer", the patient is rescreen by AABR in one month. AABR systems compare an infant's responses with normal template responses developed from normative ABR infant data and shows the result as "pass" or "refer". The infant passes the AABR if reliable responses are present at the screening level of 35 dB HL or lower. Infants who had abnormal results were diagnosed and started early intervention. If the patient was given yet another "refer", then they were reexamined with conventional ABR(linear Click and Chirp stimuli at 10-89.9 Hz, intensities of 5-90 dB nHL, Polarity Alternating both Condensation (Positive) and Rarafaction (Negative), rates of 1,000-20,000 time/sec, comparative latency and interwave of wave I, III, IV with normative data of children age level) at second or third month of age. It can be used to evaluate the degree and the nature of the hearing loss but a well-trained professional is needed to do the test. It also requires a long testing time up to 25-60 minutes per newborn. The Click stimulus (usually set at 35 dB hearing level) is delivered to the ear via disposable earphones. They were followed-up hearing with ABR and developmental evaluation at 6, 12 and 18 months of age. Children identification, risk factors of hearing impairment, screening results with OAEs and AABR, and conventional ABR were gathered and reviewed.

3.5 Data analysis

Descriptive statistics was used to present characteristics of newborns included in the study. Univariate comparison of baseline characteristics between risk newborns and normal newborns group was performed using frequency, mean and standard deviation to determine the prevalence of ear and hearing impairment in the newborns, Exact probability test, independent t test or Wilcoxon rank sum test, as appropriate for variables. The risk factors were analyzed using logistic regression for risk ratio. For all statistical tests, p-value less than 0.05 were considered as significant.

The study protocol was approved by the Faculty of Medicine Chiang Mai University, Ethical Committee for Clinical Research. The name of the caregiver of newborn consent forms was required in this prospective data, which remained confidential and omitted in all process of data management. The author received no outside grants and reported no conflicts of interests.

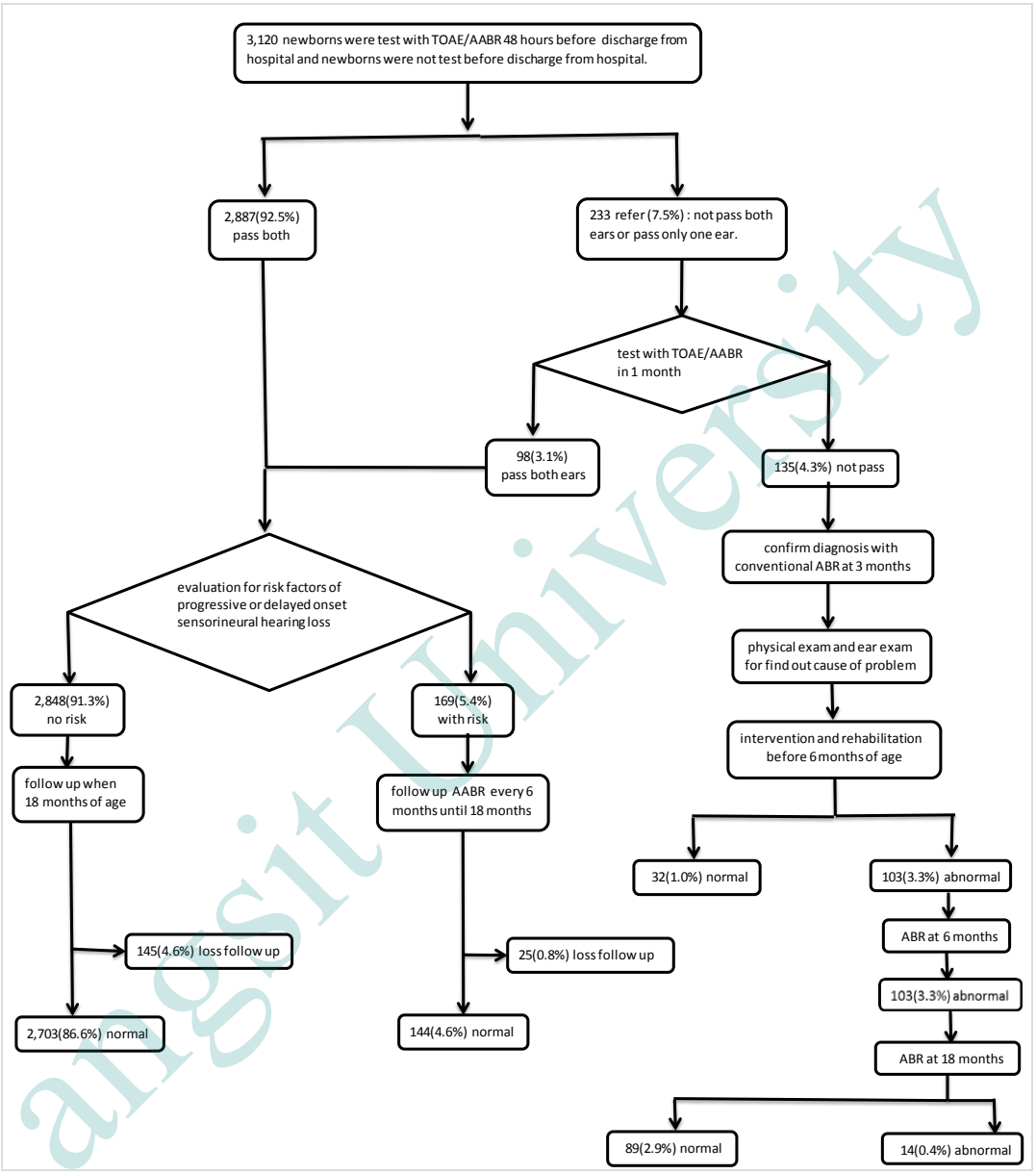

Figure 1 Block diagram illustrating the methods of universal hearing screening by OAE and ABR

Table 1 Newborn general characteristics(each characteristics n=3,120).

Characteristics	With risks n (%)		With no risks n (%)		All n (%)	
Maternal age (year)						
<20	39	(14.6)	25	(0.9)	64	(2.1)
20-35	189	(70.5)	2,799	(98.1)	2,988	(95.8)
>35	40	(14.9)	28	(1.0)	68	(2.2)
Maternal diseases						
Yes	41	(15.3)	8	(0.3)	49	(1.6)
No	227	(84.7)	2,844	(99.7)	3,071	(98.4)
Delivery route						
Normal labor	185	(69.0)	2,194	(76.9)	2,379	(76.2)
Vacuum extraction	4	(1.5)	27	(0.9)	31	(1.0)
Forceps extraction	10	(3.7)	67	(2.4)	77	(2.5)
Cesarean section	69	(25.8)	563	(19.8)	632	(20.3)
Newborn gender						
Male	146	(54.5)	1,388	(48.7)	1,534	(49.2)
Female	122	(45.5)	1,464	(51.3)	1,586	(50.8)
Birth weight (gram)						
<1,500	19	(7.1)	47	(1.7)	66	(2.1)
1,500-2,500	37	(13.8)	280	(9.8)	317	(10.2)
>2,500	212	(79.1)	2,525	(88.5)	2,737	(87.7)
APGAR score						
Normal	131	(48.9)	2,842	(99.7)	2,973	(95.3)
Abnormal	137	(51.1)	10	(0.3)	147	(4.7)

Table 2 Prevalence of hearing loss (assessed at 6 months) in universally screened newborn (n = 3,120).

Level of hearing loss	With risks n (%)		With no risks n (%)		All n (%)	
Normal (≤25 dBHL)	176	(65.7)	2,841	(99.6)	3,017	(96.7)
Abnormal						
Mild (26-40 dBHL)	80	(29.9)	9	(0.3)	89	(2.9)
Moderate (41-55 dBHL)	10	(3.7)	2	(0.1)	12	(0.4)
Moderate-severe (56-70 dBHL)	1	(0.4)	0	(0.0)	1	(0.0)
Severe (71-90 dBHL)	0	(0.0)	0	(0.0)	0	(0.0)
Profound (>90 dBHL)	1	(0.4)	0	(0.0)	1	(0.0)

Table 3 Prevalence of hearing loss (assessed at 18 months) in universally screened newborn(n=3,120).

Level of hearing loss	With risks n (%)		With no risks n (%)		All n (%)	
Normal (≤25 dBHL)	256	(95.3)	2,850	(99.9)	3,106	(99.6)
Abnormal						
Mild (26-40 dBHL)	6	(2.2)	1	(0.0)	7	(0.2)
Moderate (41-55 dBHL)	4	(1.5)	1	(0.0)	5	(0.2)
Moderate-severe (56-70 dBHL)	1	(0.0)	0	(0.0)	1	(0.0)
Severe (71-90 dBHL)	0	(0.0)	0	(0.0)	0	(0.0)
Profound (>90 dBHL)	1	(0.0)	0	(0.0)	1	(0.0)

Table 4 Risk factors of the hearing loss (assessed at 6 months) in universally screened newborn.

Risk factors	RR	95%CI	*p*-value*
Maternal risks			
Maternal diseases	1.34	0.58-3.13	0.491
Intrauterine infection	4.19	1.29-13.62	0.017*
Family history of congenital sensorineural hearing loss	1.93	0.93-3.99	0.077
Maternal age (year)			
Teenage (<20)	2.32	0.90-5.97	0.080
Old age (>35)	0.78	0.40-1.54	0.474
Neonatal risks			
Birth weight (gram)			
Very low birth weight(<1,500)	0.84	0.24-2.99	0.787
low birth weight (1,500-2,500)	1.01	0.57-1.79	0.971
Low APGAR score at 5 minutes	1.33	0.65-2.75	0.433
Craniofacial anomalies	3.15	1.72-5.78	<0.001*
Use of breathing machine >5 days	1.26	0.65-2.43	0.498
Meningitis	0.62	0.29-1.34	0.225
Sepsis	1.78	0.89-3.54	0.100*
Ototoxic exposure	6.74	3.34-13.61	<0.001*
Severe hyperbilirubinemia	3.57	1.67-7.66	0.001*

**p*-value from regression for risk ratio, less than 0.05 are considered as significant.

4. Results

For one and a half year from November 1st, 2010 to May 31st, 2012, 3,120 newborns were screened with the TEOAE. There were 1,534 boys (49.2%) and 1,586 girls (50.8%). The ages when screening took place ranged from one day to 30 days. There were 233 infants (7.5%) that failed the OAEs, 175 right ears (5.6%) and 190 left ears (6.1%). After following with AABR at the third month of age, 135 infants (4.3%) failed and were confirmed with conventional ABR at 6 months of age. One hundred and three infants (3.3%) had abnormal hearing result as shown in Figure 1 and Table 2. All hearing loss infants were later confirmed by ABR at age 18 months. Eighty-nine infants passed the test and left only 14 infants (0.4%) with hearing loss, 7 mild loss (0.2%), 5 moderate loss (0.1%), 1 severe and 1 profound deafness (Table 3). The most common risk factors include craniofacial anomaly (RR 2.57, 95%CI 1.49-4.43, *p*-value 0.001), ototoxic exposure (RR 4.71, 95%CI 1.94-11.46, *p*-value 0.001), severe hyperbilirubinemia (RR 2.10, 95%CI 1.08-4.06, *p*-value 0.028), low Apgar scores (RR 2.42, 95%CI 1.03-5.68, *p*-value 0.042), and sepsis (RR 2.02, 95%CI 1.01-4.03, *p*-value 0.046;Table 4).

5. Discussion:

In this study we found that 103 infants (3.3%) had hearing loss at 6 months of age. After follow up until 18 months of age, 89 of 103 infants who had initial abnormal hearing tests were later confirmed by ABR to have normal hearing. Continuing evaluation of infant's development during follow-up and completion of the hearing screening process through to diagnosis is important (Thompson et al., 2001). However it has been shown that the screening protocol based on the JCIH risk factors identifies only 50-75% of infants with hearing loss. As a result, it is now recommended that hospitals/doctors/medical practitioners/clinics perform universal hearing screening in all infants before their third month of life for detection of hearing loss not only in high risk newborns but also in normal newborns. TEOAE testing are highly suitable as a screening tests because they can be easily carried. However, when interpreting the results, physicians should consider the possibility of some defect in the central auditory pathway. The early detection of hearing loss and early intervention by 6 months of age as recommended should be considered with caution since there is evidence from this study that some infants with initial abnormal hearing tests results have normal hearing and development later in life. The clinically and statistically important indicators resulted from this study may be helpful for future preventions and reduction of handicap people.

It must be remembered that the OAEs test just like other hearing tests can be affected by environmental noise, internal noise (chewing and jaw movements, noisy breathing) and debris and fluid in the ear canal and middle ear, respectively, resulting in false positive results. The 9 out of 12 babies who "referred" on both ears on initial screening and then "passed" on both ears on follow up gives us an idea that the prevalence rate is probably lower than calculated. The universal hearing screening test of newborns with hearing impairment within an appropriate period of time is very important. Auditory, speech and language development cannot develop without adequate sound stimulation to the auditory pathway (Nie et al.,2007; Northern & Downs, 2002; Joint Committee on Infant Hearing: American Academy of Audiology, American Academy of Pediatrics, American Speech-Language-Hearing Association, & Directors of Speech and Hearing Programs in State Health and Welfare Agencies, 2000; Colorado Infant Hearing Advisory Board, Membership of the Screening, & Assessment and Early Intervention Task Forces, n.d.). TEOAE hearing screening for newborns is feasible and can help to detect hearing impairment earlier than has been the case in the past (Nelson, Bougatsos, Nygren, & 2001; US Preventive Services Task Force, 2008; Carney & Moeller, 1998). On the other hand, TEOAE may give false positives in infants with brain damage or central hearing deficits. However, 20% of children with normal hearing and middle ear function did fail a TEOAE screening that had to be rechecked with ABR (Joint Committee on Infant Hearing: American Academy of Audiology, American Academy of Pediatrics, AmericanSpeech-Language-Hearing Association, & Directors of Speech and Hearing Programs in State Health and Welfare Agencies, 2000; Colorado Infant Hearing Advisory Board, Membership of the Screening, & Assessment and Early Intervention Task Forces, n.d.). The most common risk factors in the newborn group with positive screening results were premature birth, low birth weight, craniofacial anomalies and ototoxic drugs (Wroblewska-Seniuk et al., 2005; Mehl & Thomson, 2002; Yoon, Price, Gallagher, Fleisher, & Messner, 2003; Srisuparp, Gleebbur, Ngerncham, Chonpracha, & Singkampong, 2005; Valkama et al., 2000; Finckh-Kramer et al., 2000). Premature birth and low birth weight need not be important factors if there were improvement in medical treatment in NICU. In view of the high proportion of preterm infants who have developmental difficulties, not only a clinical follow up but also a hearing screening method is needed to detect infants with hearing impairment (Joint Committee on Infant Hearing: American Academy of Audiology, American Academy of Pediatrics, American Speech-anguage-Hearing Association, & Directors of Speech and Hearing Programs in State Health and Welfare Agencies, 2000). Aminoglycosides are considered a risk factor when used in multiple courses or in combination with loop diuretics (Joint Committee on Infant Hearing: American Academy of Audiology, American Academy of Pediatrics, American Speech-anguage-Hearing Association, & Directors of Speech and Hearing Programs in State Health and Welfare Agencies, 2000; Mehl & Thomson, 2002). Other high risk factors considered are severe asphyxia (147, 4.7%), hyperbilirubinemia (64, 2.1%), mechanical ventilation (128, 4.1%), and sepsis(88, 2.8%). In the study by White, Vohr, and Behrens (1993;Joint Committee on Infant Hearing: American Academy of Audiology, American Academy of Pediatrics, American Speech-anguage-Hearing Association, & Directors of Speech and Hearing Programs in State Health and Welfare Agencies, 2000), it was found that the four most common high risk factors for hearing impairment are ototoxic medication (44.4%), very low birth weight (17.8%), assisted ventilation >5 days (16.4%), and birth asphyxia (13.9%). For any screening program, false positive test results may lead to adverse effects such as parental misunderstanding and anxiety, and lead to unnecessary surgery or other treatment in a baby whose hearing is normal. However, the final diagnosis of permanent hearing loss is a combination of otolaryngological, audiological and extensive audiologic examination as well as diagnostic ABR, and behavioral evaluation at 6-9 months to confirm electrophysiologic diagnosis. The infants in the referred group had a higher prevalence of severe hyperbilirubinemia, low Apgar scores at 5 minute, mechanical ventilation >5 days, low birth weight, craniofacial anomalies and ototoxic drugs.

6. Conclusion

This study reported the prevalence of hearing impairment in all newborns. Universal hearing screening program reveal hearing impairment in two cases (0.1%) of normal newborns. If we use only the high risk newborn hearing screening program, we will lose the normal newborn hearing loss group. There are some infants with initial abnormal hearing test with confirmed to have normal hearing later, so continuing researches and development to improve techniques for detection of hearing loss and identifying the most appropriate time for intervention are necessary. Physicians should familiarize themselves with

local referral resources for hearing impaired children. According to the AAP, pediatric otolaryngologists, audiologists, and speech and language pathologists with special training and experience caring for children should be consulted for diagnosis, counseling, and treatment, if needed. Communication among professionals is essential to ensure appropriate management of the hearing impaired child. This program is an easy and noninvasive technique, and suitable for hearing screening in infants for early diagnosis and early intervention of hearing loss.

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