

# The High-Risk Neonatal Hearing Screening Program in Songklanagarind Hospital

Wandee Khaimook MD\*,  
Satit Chayapham MA\*\*, Supaporn Dissaneevate MD\*\*\*

\* Division of Otolology, Department of Otolaryngology, Faculty of Medicine, Prince of Songkla University, Hat Yai, Songkhla

\*\* Department of Otolaryngology, Faculty of Medicine, Prince of Songkla University, Songkhla

\*\*\* Department of Pediatrics, Faculty of Medicine, Prince of Songkla University, Songkhla

---

**Objectives:** Determine the prevalence and risk factor of neonatal hearing loss in the high-risk group

**Material and Method:** A prospective descriptive study, using the criteria of "high-risk" as defined by the Joint Committee of Infant Hearing 1994, American Academy of Pediatrics, 465 newborn in Songklanagarind Hospital were screened with portable otoacoustic emissions (OAEs) before being discharged between July 1<sup>st</sup>, 2004 and December 31<sup>st</sup>, 2006. Based on the examinations, the results were divided into two groups, "pass" and "refer". The neonates who failed the screening test were referred for further checks with conventional OAEs and if they failed again, then the authors reassessed them with auditory brainstem responses (ABR).

**Results:** Four hundred fifty eight infants (98.5%) in the high-risk group passed the primary screen for both ears. One infant (0.21%) was confirmed with unilateral sensorineural hearing loss and three infants (0.64%) were confirmed with bilateral hearing impairment above 30 dB. Three infants (0.64%) were lost to follow up. High-risk factors of hearing loss in the present study included 226 infants from premature birth (48.6%), 159 infants exposed to ototoxic medications (34.2%), and 61 infants with respiratory distress syndrome that required mechanical ventilation for at least five days (13.1%).

**Conclusion:** Otoacoustic emissions are a very quick and noninvasive technique, and suitable for hearing screening in infants.

**Keywords:** Neonatal hearing screening, High risk, Otoacoustic emissions

*J Med Assoc Thai* 2008; 91 (7): 1038-42

**Full text. e-Journal:** <http://www.medassocthai.org/journal>

---

Ideally, identification of all the children with hearing impairment should be done as early in life as possible to initiate an appropriate early intervention when necessary. The importance of early hearing screening has been recognized as the predictor of hearing impaired children. Hearing is measurably improved when an early diagnosis is made accompanied with an immediate intervention or one begun as soon as possible. In 1993, the goal of universal newborn hearing screening was to identify hearing impairment within the first three months of life and provide appro-

priate amplification and intervention between 3-6 months of age. Hearing screening is advocated in the first three years of life to minimize the impact of hearing loss on educational, social and emotional development as it is the most important period for speech and language acquisition<sup>(1,2)</sup>.

The present study represents an initial report for high-risk neonatal hearing screening in Songklanagarind Hospital, the largest tertiary care center in the south of the country. All of the high-risk infants within their "golden period" were screened, as recommended by the Joint Committee of infant hearing<sup>(3)</sup>.

It has been proved that otoacoustic emissions (OAEs) are a good screening test because it is easy to administer, the patient finds it easy to tolerate, is cost

---

Correspondence to: Khaimook W, Division of Otolology, Department of Otolaryngology, Faculty of Medicine, Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand. Phone: 074-429-620, Fax: 074-429-620, E-mail: khwandee@yahoo.com

effective and quick, and has good performance characteristics (*i.e.* sensitive, specific, and predictive). 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 testing.

OAEs are absent or reduced in amplitude in the presence of peripheral hearing impairment, especially reflex activity of the outer hair cells in the cochlear. Hearing impairment is found in 1-3 out of 1,000 newborn<sup>(1-6)</sup>, but the incidence increases to affect 2%-5%<sup>(1,2)</sup> in the high-risk group that includes infants with low birth weight, craniofacial anomaly, and suffering the effects of ototoxic medication.

Among low-risk infants, the prevalence of hearing impairment was very low. The present study was designed to determine the prevalence of hearing impairment in high-risk infants.

## Materials and Method

### Study design

This prospective study aimed to determine the incidence of hearing impairment in critically ill neonates with high risk factors. Patients were all from the Neonatal Intensive Care Unit (NICU) in Songklanagarind Hospital and were tested between July 1<sup>st</sup>, 2004 and December 31<sup>st</sup>, 2006.

### Study population

Infants with at least one of the risk factors were enrolled in the study using the "High-risk" criteria stated by the American Academy of Pediatrics Joint Committee on Infant Hearing 1994<sup>(3)</sup>.

### 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 zero to four at one minute or zero to six at five minutes
9. Mechanical ventilation for at least five days
10. Stigmata or other findings associated with a syndromes associated with congenital hearing loss

### Study procedure

The present research was approved by the Songklanagarind Hospital Ethics Committee and informed consent was obtained in all cases.

The auditory screening was carried out in three stages. The portable and conventional OAEs were assessed in the first two stages and conventional Auditory Brainstem Responses (ABR) was assessed in the third stage. Patients 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 was re-screened by conventional OAEs at one month. If the patient was given yet another "refer", then they were reexamined with ABR.

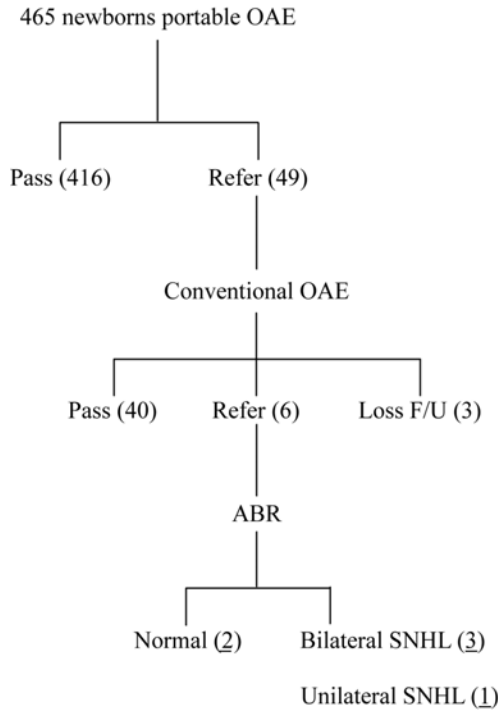
Patient identification, risk factors of hearing loss, screening results with portable OAEs, conventional OAEs, and ABR were gathered and reviewed.

### Results

Between July 1<sup>st</sup>, 2004 and December 31<sup>st</sup>, 2006, 465 high-risk neonates were screened with Accuscreen PRO in stabilized neonates or before being discharged from the NICU. There were 253 (50.5%) boys and 212 (45.5%) girls. Three infants (0.64%) in the referred group were lost to follow up. The ages when screening took place ranged from one day to 93 days. Forty-nine (10.5%) infants failed the portable OAEs results test and only four (0.86%) infants were confirmed by ABR to have pathological hearing screening results. Unilateral hearing loss was found in one infant (0.21%) and bilateral sensorineural hearing loss in three infants (0.64%) as shown in Table 1 and Fig. 1.

Three bilateral sensorineural hearing loss infants were later confirmed by ABR at age 2-3 months. The risk factors of these infants were cleft palate, bilateral choanal atresia, and Goldenhar syndrome. Two infants had moderate sensorineural hearing loss and one infant had severe sensorineural hearing loss (Table 2).

The most common risk factors, ranked in order of frequency, included 226 (48.6%) infants from



SNHL, sensorineural hearing loss

**Fig. 1** Block diagram illustrating the methods of neonatal hearing screening by OAE and ABR

premature birth, 159 (34.2%) infants who were exposed to ototoxic medications, and 61 (13.2%) infants who had respiratory distress syndrome that required mechanical ventilation for at least five days (Table 3). Of the group of 465 high-risk infants, 403 (86.7%) had only one risk factor, 57 (12.2%) had two risk factors, four (0.9%) had three risk factors and only one (0.2%) had four risk factors (Table 4).

## Discussion

To identify infants with a hearing impairment within an appropriate period of time is very important<sup>(1)</sup>. Definite diagnosis for hearing impairment within the first six months of life increases the possibility of appropriate speech and language development and reduces neuromental problems<sup>(2)</sup>. TEOAEs hearing screening for newborn is feasible and can help to detect hearing impairment earlier than has been the case in the past<sup>(7)</sup>. The higher incidence of moderate to severe sensorineural hearing loss in high-risk newborn is an indication that screening the high risk group before healthy neonate must be started. The presence

**Table 1.** Distribution of the results of portable, conventional OAE and ABR

Tests (n = 465)		
Portable OAE n (%)	Conventional OAE n (%)	ABR n (%)
Refer = 49 (10.5)	Refer = 6 (0.86%)	Bilateral SNHL = 3 (0.64%) Unilateral SNHL = 1 (0.24%)
Pass = 416 (89.5)	Pass = 40 (8.60%)	Pass = 2 (0.4%)

**Table 2.** Severity of sensorineural hearing loss

Severity of bilateral SNHL	Number of infants
Severe SNHL, 80 dB	1
Moderate SNHL, 60 dB	2

**Table 3.** Risk factor of sensorineural hearing loss

Risk factor (n = 465)	No.	%
Family history	0	0
In utero infection	6	1.29
Craniofacial anomaly	11	2.36
Low birth weight	54	11.6
Hyperbilirubinemia	6	1.29
Ototoxic medication	159	34.2
Premature birth	226	48.6
Low apgar score	0	0
Prolong intubation	61	13.1
Heart disease	0	0
Syndrome	6	1.29

**Table 4.** Number of risk factors per infants (n = 465)

No. of risk factors/infant	No.	%
1 factor	403	86.7
2 factors	57	12.2
3 factors	4	0.9
4 factors	1	0.2

of TEOAEs in at least one ear has been suggested as criteria for passing the screening, since one hearing ear does allow normal speech and language development<sup>(8)</sup>. On the other hand, TEOAEs may give false

passes in infants with brain damage or central hearing deficits. However, 20% of children with normal hearing and middle ear function did fail a TEOAEs screening that had to be rechecked with ABR<sup>(9)</sup>.

The most common risk factors in the newborn group with positive screening results were premature birth and low birth weight<sup>(8)</sup>, craniofacial anomalies and ototoxic drugs. Premature birth and low birth weight need not be important factors if the authors can improve the medical treatment in NICU so that the probability of hearing impairment can be reduced. 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 loss<sup>(8)</sup>. Aminoglycosides are considered a risk factor when used in multiple courses or in combination with loop diuretics<sup>(5)</sup>. Some studies<sup>(10,11)</sup> suggest that indicate aminoglycosides are not an important risk factor for hearing impairment when the infant's serum levels are continuously monitored. Other high risk factors<sup>(6,12,13)</sup> considered are severe asphyxia 40%, hyperbilirubinemia 26.37%, premature infant 34.09%, mechanical ventilation 40%, and ototoxic drug 41.30%. Vohr et al<sup>(14)</sup>, in their study, found 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%. There were indications that bacterial meningitis caused persistent bilateral sensorineural hearing loss, which was found in 33% of the patients<sup>(13)</sup>.

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 who hears normally. 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 that confirm electrophysiologic diagnosis.

Some infants may be identified with delayed-onset or previously undiagnosed sensorineural hearing loss. To overcome this situation, a screening protocol for infants at high-risk might include TEOAEs testing every four months during their first year of life and behavioral audiometry every six months until the age of five years<sup>(5,15)</sup>.

The infants in the referred group had a higher prevalence of premature birth and low birth weight, craniofacial anomalies, and ototoxic drugs. However, it was proven 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.

TEOAEs testing are highly suitable as a screening test because it can be carried out very easily. However, when interpreting the results, doctors should consider the possibility of some defect in the central auditory pathway.

## References

1. Yoshikawa S, Ikeda K, Kudo T, Kobayashi T. The effects of hypoxia, premature birth, infection, ototoxic drugs, circulatory system and congenital disease on neonatal hearing loss. *Auris Nasus Larynx* 2004; 31: 361-8.
2. Wroblewska-Seniuk K, Chojnacka K, Pucher B, Szczapa J, Gadzinowski J, Grzegorowski M. The results of newborn hearing screening by means of transient evoked otoacoustic emissions. *Int J Pediatr Otorhinolaryngol* 2005; 69: 1351-7.
3. Joint Committee on Infant Hearing 1994 Position Statement. American Academy of Pediatrics Joint Committee on Infant Hearing. *Pediatrics* 1995; 95: 152-6.
4. Vatovec J, Velickovic PM, Smid L, Gros A. Otoacoustic emissions and auditory assessment in infants at risk for early brain damage. *Int J Pediatr Otorhinolaryngol* 2001; 58: 139-45.
5. Yoon PJ, Price M, Gallagher K, Fleisher BE, Messner AH. The need for long-term audiologic follow-up of neonatal intensive care unit (NICU) graduates. *Int J Pediatr Otorhinolaryngol* 2003; 67: 353-7.
6. Srisuparp P, Gleebbur R, Ngercham S, Chonpracha J, Singkampong J. High-risk neonatal hearing screening program using automated screening device performed by trained nursing personnel at Siriraj Hospital: yield and feasibility. *J Med Assoc Thai* 2005; 88(Suppl 8): S176-82.
7. Geal-Dor M, Levi H, Elidan Y, Arad I. The hearing screening program for newborns with otoacoustic emission for early detection of hearing loss. *Harefuah* 2002; 141: 586-90, 668.
8. Valkama AM, Laitakari KT, Tolonen EU, Vayrynen MR, Vainionpaa LK, Koivisto ME. Prediction of permanent hearing loss in high-risk preterm infants at term age. *Eur J Pediatr* 2000; 159: 459-64.
9. Nozza RJ, Sabo DL, Mandel EM. A role for otoacoustic emissions in screening for hearing impairment and middle ear disorders in school-age children. *Ear Hear* 1997; 18: 227-39.

10. Finckh-Kramer U, Gross M, Bartsch M, Kewitz G, Versmold H, Hess M. Hearing screening of high risk newborn infants. HNO 2000; 48: 215-20.
11. Hess M, Finckh-Kramer U, Bartsch M, Kewitz G, Versmold H, Gross M. Hearing screening in at-risk neonate cohort. Int J Pediatr Otorhinolaryngol 1998; 46: 81-9.
12. Sun JH, Li J, Huang P, Bu J, Xu ZM, Li J, et al. Early detection of hearing impairment in high-risk infants of NICU. Zhonghua Er Ke Za Zhi 2003; 41: 357-9.
13. Charuvanij A, Visudhiphan P, Chiemchanya S, Tawin C. Sensorineural hearing loss in children recovered from purulent meningitis: a study in Thai children at Ramathibodi Hospital. J Med Assoc Thai 1990; 73: 253-7.
14. Vohr BR, Widen JE, Cone-Wesson B, Sininger YS, Gorga MP, Folsom RC, et al. Identification of neonatal hearing impairment: characteristics of infants in the neonatal intensive care unit and well-baby nursery. Ear Hear 2000; 21: 373-82.
15. Prasansuk S. Incidence/prevalence of sensorineural hearing impairment in Thailand and Southeast Asia. Audiology 2000; 39: 207-11.

## โครงการตรวจคัดกรองการได้ยินในผู้ป่วยเด็กทารกที่มีความเสี่ยงสูงในโรงพยาบาลสงขลานครินทร์

วันดี ไช่มุกด์, สาธิต ชยาภัม, สุภาภรณ์ ดิสนีย์เวทย์

**วัตถุประสงค์:** ศึกษาความชุกและปัจจัยเสี่ยงของภาวะประสาทหูเสื่อมในกลุ่มเด็กทารกที่มีความเสี่ยงสูง

**วัสดุและวิธีการ:** เป็นการศึกษาเชิงพรรณนา จากเกณฑ์การคัดเลือกผู้ป่วยที่มีความเสี่ยงสูง นิยามโดย Joint Committee of Infant Hearing 1994, American Academy of Pediatrics เด็กทารกแรกเกิดที่มีความเสี่ยงสูงในโรงพยาบาลสงขลานครินทร์ 465 คน ได้รับการตรวจคัดกรองการได้ยินด้วยเครื่องตรวจวัดเสียงสะท้อนจากหูชั้นในแบบเคลื่อนที่ (portable otoacoustic emissions, OAEs) ก่อนจำหน่ายออกจากโรงพยาบาล ระหว่างวันที่ 1 กรกฎาคม พศ. 2547 และ ธันวาคม พศ. 2549 โดยแบ่งผลการตรวจออกเป็น 2 กลุ่มคือ ผ่าน หรือ ส่งตรวจซ้ำ กรณีที่เด็กทารกแรกเกิดไม่ผ่าน การตรวจคัดกรอง จะได้รับการตรวจซ้ำด้วยเครื่องตรวจวัดเสียงสะท้อนจากหูชั้นในแบบธรรมดา (conventional OAEs) และเครื่องตรวจเส้นประสาทการได้ยินและก้านสมอง (auditory brainstem responses, ABR)

**ผลการศึกษา:** เด็กทารกแรกเกิดที่มีความเสี่ยงสูง 458 คนคิดเป็นร้อยละ 98.5 ผ่านการตรวจคัดกรองการได้ยินทั้ง 2 หู ทารกแรกเกิด 1 คน ได้รับการตรวจยืนยันว่ามีภาวะเส้นประสาทหูเสื่อมข้างเดียวคิดเป็นร้อยละ 0.21 ทารกแรกเกิด 3 คน ได้รับการตรวจยืนยันด้วยว่ามีภาวะประสาทหูเสื่อมสองข้าง มีการสูญเสียการได้ยินมากกว่า 30 เดซิเบล คิดเป็นร้อยละ 0.64 และมีทารกแรกเกิด 3 คนไม่มาตรวจตามนัด ปัจจัยเสี่ยงที่สำคัญของภาวะประสาทหูเสื่อม คือ การคลอดก่อนกำหนด 226 คนคิดเป็นร้อยละ 48.6 มีประวัติการเข้ายามีผลต่อการได้ยิน 159 คน คิดเป็นร้อยละ 34.2 และทารกแรกเกิดที่มีปัญหาระบบหายใจที่ต้องการเครื่องช่วยหายใจอย่างน้อย 5 วัน 61 คน คิดเป็นร้อยละ 13.1

**สรุป:** การตรวจคัดกรองการได้ยินในทารกแรกเกิดที่มีความเสี่ยงสูงด้วยเครื่องตรวจวัดเสียงสะท้อนจากหูชั้นใน (otoacoustic emissions) เป็นการตรวจที่ทำได้เร็ว ไม่ก่อให้เกิดอันตรายต่อผู้ป่วย สามารถใช้ตรวจคัดกรองภาวะการสูญเสียการได้ยินเบื้องต้นในกลุ่มเด็กทารกแรกเกิดได้