Incidence and Risk Factors Associated with Hearing Loss in High-Risk Neonates in Srinagarind Hospital

Pakaphan Kiatchoosakun MD*,
Wichitra Suphadun MD*, Junya Jirapradittha MD*,
Kwanchanok Yimtae MD**, Panida Thanawirattananit MA**

** Department of Pediatrics, Faculty of Medicine, Khon Kaen University, Khon Kean, Thailand*
*** Department of Otorhinolaryngology, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand*

Objective: *To determine incidence and risk factors associated with hearing loss in high-risk neonates in Srinagarind Hospital.*
Study design: *Prospective cohort study.*
Material and Method: *High-risk neonates were screened with TEOAE/AABR. All infants were followed for hearing and developmental evaluation until one year of age.*
Results: *Four hundred twenty five neonates underwent hearing screening tests. Nine infants (2.1%) had abnormal TEOAE, AABR and ABR tests. During follow-up, two of the nine infants that had abnormal initial hearing tests were found to have normal hearing at eight and nine months of age. Therefore, seven high-risk neonates (1.6%) had permanent hearing loss. Significant risk factors for permanent hearing loss were craniofacial anomalies, very low birth weight, low Apgar scores at 5 minute and mechanical ventilation usage for more than five days.*
Conclusion: *Continuing evaluation of hearing and development during follow-up is important in children with abnormal hearing tests. Invasive procedures as early intervention during the first six months of life should be considered with caution because some premature infants can have false positive tests or transient hearing loss and subsequently have normal hearing and development.*

Keywords: *Hearing loss, Hearing screening test, High-risk neonates*

J Med Assoc Thai 2012; 95 (1): 52-7
Full text. e-Journal: *http://www.jmat.mat.or.th*

It has been recognized that congenital hearing loss can have an adverse affect on speech and language development as well as educational and psychosocial development[1,2]. Early diagnosis of hearing impairment, especially in the first six months of life, is important because early intervention can prevent acoustic deprivation and improve language deve1opment[3]. The average age for identification of hearing loss in children who were not screened at birth was 2.5 to 3 years[4]. The American Academy of Pediatrics Joint Committee on Infant Hearing 1994 has endorsed the goal of universal detection of infants with hearing loss as early as possible. All infants with hearing loss should be identified before three months and receive appropriate intervention by six months of age[5]. In Thailand, there are some reports of incidences of hearing loss in high-risk infants[6-9]. However, a universal newborn hearing screening program has not been implemented nationwide so the overall incidence of neonatal hearing loss in Thai infants is not yet available.

The present study is a report of hearing screening in high-risk neonates in Srinagarind Hospital, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand. All of the high-risk neonates were screened as recommended by The Joint Committee on Infant Hearing using transient evoked otoacoustic emissions (TEOAE)/automated auditory brainstem response (AABR) which has been proved to be a good screening tool, as it is non-invasive, easy to operate, less time consuming than conventional ABR and effective[10]. The objective of the present study was to determine the magnitude of the problem of neonatal hearing impairment by estimating incidence and identify significant risk factors of neonatal

Correspondence to:
Kiatchoosakun P, Department of Pediatrics, Faculty of Medicine, Khon Kaen University, Khon Kaen 40002, Thailand.
Phone & Fax: 043-348-382
E-mail: pakkia@kku.ac.th

hearing loss in high-risk infants. Furthermore, the present study was a step toward the implementation of universal hearing screening and establishment of multidisciplinary care programs to ensure normal speech and language development for infants and children with hearing loss.

Material and Method

Study design

This was a prospective cohort study designed to determine the prevalence and risk factors associated with hearing impairment as well as to evaluate developmental outcome of high-risk neonates admitted to the neonatal unit of Srinagarind Hospital, Khon Kaen University, Khon Kaen, Thailand between April 2006 and March 2007.

Study population

All infants who met the criteria of high-risk neonates defined by American Academy of Pediatrics Joint Committee on Infant Hearing 1994 were enrolled in the present study[11]. The risk factors were as follows:

1. Family history of hereditary childhood sensorineural hearing loss
2. *In utero* infection, such as cytomegalovirus, rubella, syphilis, herpes and toxoplasmosis
3. Craniofacial anomalies, including those with morphological abnormalities of the pinna and ear canal
4. Birth weight less than 1,500 grams
5. Hyperbilirubinemia at serum level requiring exchange transfusion
6. Ototoxic medications, including but not limited to the aminoglycosides, used in multiple courses or in combination with loop diuretics
7. Bacterial meningitis
8. Apgar scores of 0 to 4 at 1 minute or 0 to 6 at 5 minutes
9. Mechanical ventilation lasting 5 days or longer
10. Stigmata or other finding associated with a syndrome known to include a sensorineural and/or conductive hearing loss

Study procedure

The present study was approved by The Khon Kaen University Ethic Committee for Human Research and consent form was obtained from parents. AccuScreen (GN Otometrics, Denmark) was used as a device for hearing screen. Each screening procedure was carried out by one of the trained researchers. The auditory screening was done in three-stages using transient evoked otoacoustic emissions (TEOAE) in the first two stages and automated auditory brainstem response (AABR) in the third stage. High-risk neonates were evaluated by portable TEOAE technique before discharge and given a result of 'pass' or 'refer'. Infants who initially failed the first TEOAE were re-examined with a second TEOAE and if the results were still abnormal, they were reassessed by AABR within 1 to 2 days. Infants who had abnormal AABR results referred to otologists and audiologist for further evaluation with tympanogram and conventional ABR. All infants were received ongoing surveillance for developmental evaluation regardless of initial hearing screening outcome. Normally hearing infants were followed-up to ensure normal development until one year of age. Abnormal hearing infants were followed by neonatologists, otologists, audiologists and other specialists according to the infants' problems. Data were collected for baseline characteristics, risk factors, results of screening test and information on follow-up.

Statistical analysis

The frequencies and percentages of the categorical data are presented. Risk factors for hearing loss were selected from clinical variables based on the results from other studies and analysis for risk factor and association with hearing loss by using Chi-square and Fisher-exact test where appropriate. A p-value of less than 0.05 was considered statistically significant. Relative risks with 95% confidence interval were presented.

Results

Between April 2006 and March 2007, four hundred twenty five high-risk neonates were screened with TEOAE/AABR before discharge. There were 252 male and 173 female infants. One infant in the present study group was lost to follow-up due to the geographical location. Three hundred seventy one infants (87.3%) were screened within 30 days after birth and 54 infants (12.7%) were screened after 30 days of age due to prolonged hospitalization. Three hundred eighty nine infants (91.5%) passed the first TEOAE test while 36 infants failed twice. Of the infants who failed TEOAE, seventeen pass AABR while 19 infants did not passed and were referred for further evaluation. Nine infants (2.1%) were found to have abnormal ABR, which were performed at mean age of four and six months. Two of nine infants who had initial abnormal hearing tests were later confirmed by

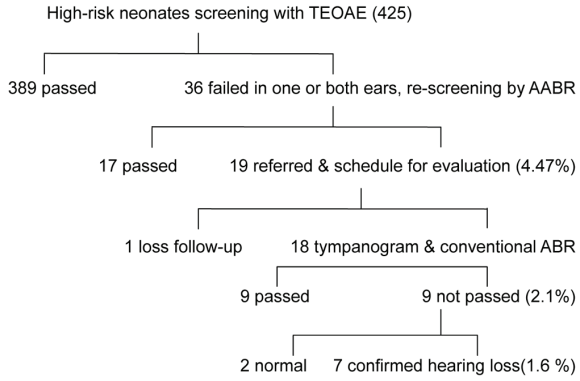

Fig. 1 Diagram illustrating methods and results of neonatal hearing screening

ABR to have normal hearing at eight and nine months of age with normal development. Finally, there were seven high-risk infants (1.6%) with permanent hearing loss (Fig. 1). All infants received ongoing developmental surveillance regardless of initial hearing screening outcomes. None who had normal hearing tests at the time of initial screening was found to have hearing impairment or delayed development at one year of age.

The common risk factors ranked in order of frequency are ototoxic medications, hyperbilirubinemia, very low birth weight, low Apgar scores and use of mechanical ventilation for more than five days (Table 1). Risk factors in infants with hearing loss are shown in Table 2. The most significant risk factor of hearing loss was craniofacial anomalies (RR = 94.09, 95% CI 20.44-433.05). Other significant risk factors were very low birth weight (RR = 6.17, 95% CI 1.42-26.75), low Apgar score at 5 minutes (RR = 15.05, 95% CI 3.27-69.28) and use of mechanical ventilation more than five days (RR = 15.83, 95% CI 3.69-67.80) as shown in Table 3.

The details of nine infants with abnormal hearing screening are shown in Table 4. Two infants who had abnormal hearing tests were later confirmed by ABR to have normal hearing and development. One was a 25 week-extremely low birth weight premature female infant who received mechanical ventilation for 28 days and developed bronchopulmonary dysplasia with grade 1 intraventricular hemorrhage. She had abnormal TEOAE, AABR and ABR at four and six months postnatal age but the results were normal at nine months postnatal age or 5.5 months corrected age with normal development (case 9). The other infant was a 30 week-very low birth weight premature

Table 1. Prenatal and neonatal risk factors (n = 425)

Risk factors	n	%
Prenatal risk factors		
Family history of hearing loss	0	0
Intrauterine infection	2	0.5
Neonatal risk factors		
Craniofacial anomalies	12	2.8
Head trauma at birth	11	2.6
Very low birth weight < 1,500 g	46	10.8
Hyperbilirubinemia	55	12.9
Ototoxic medications	251	59.0
Bacterial meningitis	2	0.5
Low Apgar scores		
0-4 at 1 minute	29	6.8
0-6 at 5 minutes	11	2.6
Mechanical ventilation > 5 days	34	8.0

Table 2. Risk factors in infants with hearing loss

Risk factors		Pass	Refer	p-value
Intrauterine infection	No	416	7	
	Yes	2	0	1.000
Craniofacial anomalies	No	412	2	
	Yes	6	5	0.000
Head trauma at birth	No	407	7	
	Yes	11	0	1.000
Very low birth weight < 1500 g	No	375	4	
	Yes	43	3	0.030
Hyperbilirubinemia	No	364	6	
	Yes	54	1	1.000
Ototoxic medications	No	171	3	
	Yes	247	4	1.000
Bacterial meningitis	No	416	7	
	Yes	2	0	1.000
Low Apgar scores				
0-4 at 1 minute	No	391	5	
	Yes	27	2	0.076
0-6 at 5 minutes	No	409	5	
	Yes	9	2	0.012
Mechanical ventilation > 5 days	No	389	3	
	Yes	29	4	0.001

Table 3. Relative risk of risk factors in infants with hearing loss

Risk factors	RR	95% confidence interval
Craniofacial anomalies	94.09	20.44-433.05
Very low birth weight	6.17	1.42-26.75
Low Apgar scores at 5 minutes	15.05	3.27-69.28
Mechanical ventilation > 5 days	15.83	3.69-67.80

Table 4. The details of nine infants with abnormal hearing tests

No.	Patient data	Risk factors	Side/severity	Type	Development
1	Male, 39 wk, 2,300 g Apgar 4, 4 ARM, spina bifida, radial deviation, preauricular skin tag left ear, ventilator 3 days	CFA, S Apg Vent	Left/moderate	CHL 60 dB	Delay
2	Female, 39 wk, 3,650 g right microtia	CFA	Right/moderate	CHL 55 dB	Delay
3	Male, 39 wk, 3,290 g Apgar 4, 9 congenital hydronephrosis, hydroureter maternal drug abuse (amphetamine)	S, Apg drug	Left/mild	CHL 45 dB	Delay
4	Male, twin A 30 wk, 1,290 g Apgar 4, 9 RDS, sepsis, ventilator 8 days, gentamicin 7 days	BW, Apg Med Vent	Right/mild	SNHL 45 dB	Normal
5	Female, 36 wk, 2,250 g FFEM, choanal atresia, left microtia, ventilator 14 days	CFA, S Vent Med	Both/severe	Mixed 80 dB	Delay
6	Female, 30 wk, 1,220 g Apgar 2, 6 polycystic kidney, ventilator 6 days	BW, Apg Vent Med	Both/severe	SNHL 85 dB	Delay
7	Female, 39 wk, 3,300 g complete cleft lip/palate, hyperbilirubinemia 28 mg/dL	CFA hyperbili	Both/moderate	CHL 55 dB	Delay
8	Male, 35 wk, 2,530 g right microtia, cup shape, pneumonia	CFA Med	Right/mild	CHL 45 dB	Delay
9	Female, 25 wk, 830 g Apgar 5, 7 RDS, BPD, IVH grade 1, ventilator 28 days	BW Vent Med	Both/moderate	CHL 65 dB	Normal

CFA = craniofacial anomalies; S = syndrome; Apg = Apgar scores; Vent = ventilator; Med = medications; BW = BW < 1,500 g; hyperbili = hyperbilirubinemia; CHL = conductive hearing loss; SNHL = sensorineural hearing loss; mild = mild hearing loss (30-49 dB); moderate = moderate hearing loss (50-69 dB); severe = severe hearing loss (> 70 dB)

male infant who had low Apgar score at 1 minute, respiratory distress syndrome, received mechanical ventilation for eight days and developed Klebsiella septicemia, bronchopul-monary dysplasia and grade 1 intraventricular hemorrhage. He had abnormal ABR results at four and six months postnatal age but the results were normal at eight months postnatal age or 5.5 months corrected age with normal development (case 4).

Discussion

Speech and language development cannot develop without adequate sound stimulation to the auditory pathway. Early diagnosis of hearing impairment at appropriate age is important because early intervention can improve the outcome. However, the cost of hearing screening and follow-up has been a subject of concern particularly for a developing country[13]. Because of a higher incidence of hearing loss in high-risk infants, it is recommended to start hearing screening in this group even if universal screening is not feasible. Combined physiologic measurement by TEOAE and AABR is reported as a tool for hearing screening with good sensitivity and specificity[14-16]. The hearing screen using TEOAE and AABR performed in the neonatal unit by trained personnel was feasible, reliable and less time consuming than behavioral and conventional ABR.

The incidence of hearing loss in high-risk neonates in the present study is comparable with reports from other tertiary care centers in Thailand[6-9]. The most significant risk factor in the neonates with positive hearing screening results from the present study were craniofacial anomalies, very low birth

weight, low Apgar score at 5 minutes and use of mechanical ventilation more than 5 days.

All infants received ongoing developmental surveillance, regardless of initial hearing screening outcomes. None of those infants who had normal hearing screen was found to have hearing impairment or delayed development at one year of age. The fact that two of nine infants who had initial abnormal hearing tests were later confirmed by ABR to have normal hearing with normal development may be explained by prematurity. Continuing evaluation of child's development during follow-up and completion of the hearing screening process through to diagnosis is important[17]. The goal of detecting significant congenital and early-onset hearing loss before 3 months of age with a follow-up intervention by 6 months of age as recommended should be considered with caution since there is evidence from the present study that some premature infants with initial abnormal hearing tests results have normal hearing and development later in life.

Conclusion

The present study reported the incidence of hearing loss in high-risk infants at Srinagarind Hospital. Significant risk factors in the neonates with hearing loss were craniofacial anomalies, very low birth weight, low Apgar score at 5 minutes and use of mechanical ventilation more than five days. There are premature 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.

Acknowledgment

The present study was financially supported by the Faculty of Medicine, Khon Kaen University, Thailand. The authors wish to thank Professor Robert Peter Mills for contributions and suggestions.

Potential conflicts of interest

None.

References

1. Ramkalawan TW, Davis AC. The effects of hearing loss and age of intervention on some language metrics in young hearing-impaired children. Br J Audiol 1992; 26: 97-107.
2. Robinshaw HM. The pattern of development from non-communicative behaviour to language by hearing impaired and hearing infants. Br J Audiol 1996; 30: 177-98.
3. Yoshinaga-Itano C, Sedey AL, Coulter DK, Mehl AL. Language of early- and later-identified children with hearing loss. Pediatrics 1998; 102: 1161-71.
4. Serious hearing impairment among children aged 3-10 years-Atlanta, Georgia, 1991-1993. MMWR Morb Mortal Wkly Rep 1997; 46: 1073-6.
5. 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; 120: 898-921.
6. Prasansuk S. Incidence/prevalence of sensorineural hearing impairment in Thailand and Southeast Asia. Audiology 2000; 39: 207-11.
7. Jariengprasert C, Sriwanyong S, Kasemsuwan L, Supapannachart S. Early identification of hearing loss in high-risk newborns and young children by using otoacoustic emissions (OAES): a comparison study with auditory brainstem response (ABR). Asia Pac J Speech Lang Hear 2002; 7: 1-9.
8. Srisuparp P, Gleebbur R, Ngerncham 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.
9. Khaimook W, Chayarpham S, Dissaneevate S. The high-risk neonatal hearing screening program in Songklanagarind Hospital. J Med Assoc Thai 2008; 91: 1038-42.
10. Atipas S, Chongkolwatana C. Newborn hearing screening: overview. Siriraj Med J 2009; 61: 224-7.
11. Joint Committee on Infant Hearing 1994 Position Statement. American Academy of Pediatrics Joint Committee on Infant Hearing. Pediatrics 1995; 95: 152-6.
12. Year 2000 position statement: principles and guidelines for early hearing detection and intervention programs. Joint Committee on Infant Hearing, American Academy of Audiology, American Academy of Pediatrics, American Speech-Language-Hearing Association, and Directors of Speech and Hearing Programs in State Health and Welfare Agencies. Pediatrics 2000; 106: 798-817.
13. Olusanya BO, Luxon LM, Wirz SL. Benefits and challenges of newborn hearing screening for developing countries. Int J Pediatr

Otorhinolaryngol 2004; 68: 287-305.
14. Meyer C, Witte J, Hildmann A, Hennecke KH, Schunck KU, Maul K, et al. Neonatal screening for hearing disorders in infants at risk: incidence, risk factors, and follow-up. Pediatrics 1999; 104: 900-4.
15. Doyle KJ, Burggraaff B, Fujikawa S, Kim J. Newborn hearing screening by otoacoustic emissions and automated auditory brainstem response. Int J Pediatr Otorhinolaryngol 1997; 41: 111-9.
16. Suppiej A, Rizzardi E, Zanardo V, Franzoi M, Ermani M, Orzan E. Reliability of hearing screening in high-risk neonates: comparative study of otoacoustic emission, automated and conventional auditory brainstem response. Clin Neurophysiol 2007; 118: 869-76.
17. 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.

อุบัติการณ์และปัจจัยเสี่ยงของการเกิดความผิดปกติของการได้ยินในทารกแรกเกิดกลุ่มเสี่ยงในโรงพยาบาลศรีนครินทร์

ผกาพรรณ เกียรติชูสกุล, วิจตรา สุภาดุลย์, จรรยา จิระประดิษฐา, ขวัญชนก ยิ้มแต้, พนิดา ธนาวิรัตนานิจ

วัตถุประสงค์: *เพื่อศึกษาอุบัติการณ์และปัจจัยเสี่ยงที่สำคัญของการเกิดความผิดปกติของการได้ยินในทารกแรกเกิดกลุ่มเสี่ยงในโรงพยาบาลศรีนครินทร์*

วัสดุและวิธีการ: *ได้ทำการศึกษาอุบัติการณ์ของการเกิดความผิดปกติของการได้ยินทารกแรกเกิดกลุ่มเสี่ยง โดยใช้การตรวจกรองด้วยอุปกรณ์ transient evoked otoacoustic emissions (TEOAE)/automated auditory brainstem response (AABR) ในหอผู้ป่วยทารกแรกเกิดก่อนจำหน่ายจากโรงพยาบาล และติดตามทารกทุกรายเพื่อประเมินพัฒนาการจนอายุครบ 1 ปี*

ผลการศึกษา: *ทารกแรกเกิดกลุ่มเสี่ยงจำนวน 425 ราย ที่เข้ารับการรักษาในหอผู้ป่วยทารกแรกเกิดโรงพยาบาลศรีนครินทร์ คณะแพทยศาสตร์ มหาวิทยาลัยขอนแก่น ได้รับการตรวจกรองการได้ยิน พบว่าทารก 9 ราย (ร้อยละ 2.1) มีผลตรวจกรองผิดปกติ หลังการติดตามการรักษาพบว่าทารก 2 จาก 9 ราย ที่มีผลการตรวจการได้ยินผิดปกติในเบื้องต้นกลับมีการได้ยินและพัฒนาการปกติเมื่ออายุ 8 และ 9 เดือน ตามลำดับดังนั้นจึงพบทารก 7 ราย (ร้อยละ 1.6) ที่มีการได้ยินผิดปกติถาวร ปัจจัยเสี่ยงที่สำคัญของการเกิดความผิดปกติของการได้ยินได้แก่ ความผิดปกติแต่กำเนิดของใบหน้าและกะโหลกศีรษะ การมีน้ำหนักแรกเกิดน้อยมาก ค่าคะแนน Apgar ที่ 5 นาทีต่ำ การได้รับการช่วยหายใจมากกว่า 5 วัน*

สรุป: *การติดตามทารกที่มีผลการตรวจการได้ยินผิดปกติมีความสำคัญเนื่องจากการศึกษานี้พบว่าทารกเกิดก่อนกำหนดบางรายที่มีการได้ยินผิดปกติในระยะแรกสามารถกลับมามีการได้ยินและพัฒนาการปกติในภายหลังได้ ดังนั้นการรักษาภาวะการสูญเสียการได้ยินแบบรุกล้ำตั้งแต่ทารกอายุน้อยกว่า 6 เดือน จึงควรพิจารณาด้วยความระมัดระวัง*