Original article

Results of the Sawanpracharak Newborn Hearing Screening Program

Rungjai Chareonsil

Department of Otorhinolaryngology, Sawanpracharak Hospital, Nakhonsawan

Objective To determine the prevalence of congenital hearing loss and evaluate the benefit of the Sawanpracharak Newborn Hearing Screening Program.

Materials and methods A prospective descriptive study of congenital hearing loss was carried out in 2,773 newborns using the Sawanpracharak Newborn Hearing Screening Program between January 2012 and March 2013. The results were based on the 2-screening test and transient-evoked otoacoustic emission test (TEOAE) at <1 month and 3 months of age, and the newborn participants were divided into two groups, "pass" and "refer". Newborns who failed the second screening test ("refer") were assessed for hearing threshold, with auditory brainstem response (ABR) at 6 months of age.

Results Two hundred and eleven of 2,773 (7.6%) newborns failed the first TEOAE and 63 of 1,831 (3.4%) failed the second, with 942 newborns lost to follow-up for the second screening. Fifty-one of the 63 newborns (81%) were assessed for hearing loss with ABR (12 newborns were lost to assessment). Finally, four and three newborns had bilateral and unilateral hearing loss, respectively. All of them were at high risk of hearing impairment.

Conclusion The prevalence of congenital hearing loss was 2.5:1,000 and screening with 2-TEOAE decreased missing "refer" cases that need confirmation of hearing status with ABR. **Chiang Mai Medical Journal 2015;54(2):81-8.**

Keywords: Newborn hearing screening, congenital hearing loss, transient-evoked otoacoustic emission test

Introduction

Congenital hearing loss (CHL) is a relatively frequent problem. It is defined generally as permanent, bilateral or unilateral and sensory or conductive, and averages 30 decibels or more in the frequency region important for speech recognition. Children with permanent congenital hearing loss (PCHL) have not only increased difficulties with verbal and nonverbal communication skills, but also increased behavioral problems, decreased psychosocial well-being, and lower educational attainment compared with children with normal hearing. Depending on regions, the overall prevalence of PCHL ranges from 0.7 to 4.2 per 1,000 live births per annum[1,2] is higher than prevalence in newborns having hypothyroidism (1 in 4,000),

Address correspondence to: Rungjai Chareonsil, M.D., Department of Otorhinolaryngology, Sawanpracharak Hospital, Nakhonsawan, Thailand. E-mail: rungjai@hotmail.com

Received: December 29, 2014, Accepted: July 3, 2015.

phenylketonuria (1 in 15,000) and sickle cell anemia[3]. In Thailand, the detection of neonatal hearing impairment was 1.7 per 1,000 live births[4] and approximately 0.5 per 1,000 non-intensive care unit newborns at Ramathibodi Hospital and Rajavithi Hospital, respectively[5].

Risk factors associated with PCHL include several congenital syndromes, craniofacial abnormalities, family history of hereditary childhood sensorineural hearing loss, intrauterine infections (TORCHS), low birth weight (<1,500 g), low Apgar score (0-4 at one minute or 0-6 at five minutes), hyperbilirubinemia (18 mg/dL in term and 15 mg/dL in preterm), bacterial meningitis, and ototoxic drug exposure (esp. aminoglycosides). However, half of the infants with PCHL have no identifiable risk factors. Universal hearing screening for newborns has been proposed since 1993 to enable early detection and prompt intervention for infants with PCHL in order to diminish associated morbidity[6].

The equipment used in many centers world-wide for newborn hearing screening includes automated auditory brainstem response (AABR), and both types of otoacoustic emission (OAE): transient evoked otoacoustic emission (TEOAE) and distortion product otoacoustic emission (DPOAE).

A statement from the Joint Committee on Infant Hearing 2000 (JCIH 2000) recommended that all newborns be screened for hearing loss by 1 month of age, have diagnostic follow-up by 3 months, and receive appropriate intervention services by 6 months of age[7].

Hearing screening programs should be conducted using a validated protocol. Equipment should be well maintained, personnel thoroughly trained, and quality control programs put in place to reduce avoidable false-positive test results. Programs should develop protocols that ensure infants have positive screening test results, and receive appropriate audiologic evaluation and follow-up.

In 2006, Sawanpracharak Hospital reported that 38 months was the age for detecting hearing impairment, with a high incidence in infants having low birth weight[8]. Until now, there has been no government policy for universal screening of CHL in Thailand. This study implemented the Sawanpracharak Hearing Screening Program for newborns in 2009, with the aim of determining the prevalence of congenital hearing loss, and evaluating the hearing program for further improvement.

Materials and methods

This prospective study aimed to determine the prevalence of hearing impairment at Sawanpracharak Hospital. The newborns that enrolled had been delivered at Sawanpracharak Hospital, and were referred from a nearby hospital for hearing screening from January 2012 to March 2013. The Sawanpracharak Hearing Screening Program is a 2-step process adopted from the JCIH 2000. The first step is the transient-evoked otoacoustic emission test (TEOAE), performed at 0-1 month, and followed-up at 3 months of life, with results of the test categorized as “pass” or “refer”. The second step is auditory brainstem response (ABR), performed before 6 months of age in the “refer” group of newborns in order to detect hearing level. TEOAE for well-babies born at Sawanpracharak Hospital was performed by well-trained nurses in a quiet room at the postnatal ward. TEOAE and ABR for referred and sick babies were tested by an audiologist in an audiological testing room.

Data on the prenatal and neonatal period, hearing loss risk factors, and hearing screening results were collected for each of the enrolled children.

The protocol of this study was approved by the Ethical Committee at Sawanpracharak Hospital. Each parent of the enrolled infant was informed of the benefits regarding detection and early treatment of CHL, and the safety of testing.

Results

This study screened hearing in 2,773 newborns from January 2012 to March 2013. There were 2,633 babies born in Sawanpracharak Hospital and 2,056 of them were screened. The first Sawanpracharak screening rate was 78.1% (2,056/2,633). The remaining 717 newborns were referred for hearing screening and medical care for sickness. Two hundred and eleven of the 2,773 (7.7%) newborns failed the initial screening at <1 month of age, and 1,831 (66.0%) were re-screened at 3 months of age, with 63 (3.4%) of them failing the re-screening. Fifty-one infants who failed the TEOAE

screening were evaluated for hearing status by ABR at 6 months of age. Four and three infants had bilateral and unilateral hearing loss, respectively.

There were 3,624 ears screened in 2 sessions of TEOAE. Of 3,367 ears that entered the "pass" group in the first session, 3,312 and 55 entered the "pass" and "refer" group in the second one (60:1), respectively. Of the 257 ears that entered the "refer" group in the first session, 187 entered the "pass" group in the second (2.7:1) (Table 3).

Significant risk factors that influence hearing impairment are low birth weight, ototoxic drug exposure, sepsis, time on ventilator of over five days, congenital anomaly, and genetic or familial hearing loss. Gestational age and birth asphyxia might have a bad effect on hearing outcome (Table 4 and 5).

All babies with impaired hearing were managed with hearing aids, auditory rehabilitation, or referred for further management.

Table 1. General characteristic of newborns factors and maternal factors

Characteristic	Number (%)	Average±SD
Sex		
Male	1,533 (55.3)	
Female	1,240 (44.7)	
Birth weight (grams)		
<1,500	103 (3.7)	
1,500-2,500	587 (21.3)	2,864.2±657.6
>2,500	2,071 (75.0)	
Gestational age (weeks)		
<37	676 (24.7)	37.5±2.7
37-40	1,913 (69.8)	
>40	151 (5.5)	
Maternal age (years)		
<20	692 (29.2)	
20-34	1,654 (58.2)	24.5±8.6
34-39	265 (9.7)	
>40	78 (2.9)	

Table 2. Results of newborn hearing screening at 0-1 month of age

Results	Number (%)
Pass both ears	2,562 (92.4)
Pass one ear	94 (3.4)
Refer both ears	117 (4.2)

Table 3. Relationship between the result of OAE of the first and second time

		First OAE (ears)		
		Pass	Refer	Total
Second OAE (ears)	Pass	3,312	187	3,499
	Refer	55	70	125
	Total	3,367	257	3,624

Discussion

In Thailand, the government has no policy for newborn hearing screening that detects CHL early, but many academic hospitals and some regional ones have an individualized screening program. Sawanpracharak Hospital is a tertiary care hospital located in the lower-north of Thailand, which started implementing newborn hearing screening in 2009. The prevalence of congenital hearing loss in this study was 2.5 in 1,000 live births (7/2,773 infants), with the screening rate being only 78.1% of in-hospital newborns, which was lower than the JICH 2000 guideline (>95% coverage)[4]. The target of universal screening requires no more than a 5-7% failure rate. The failure rate is caused by limitation of personnel and equipment, and many newborns are discharged at weekends, when tests are available on only weekdays. Another factor, such as announcements of relevant hospital or government policies, is also important in the success of screening.

In the USA, about 95% of all newborns are screened for hearing loss shortly after birth, but only about half of them actually receive recommended hearing evaluation. The remainder are "lost to the system" and one-third of confirmed hearing losses do not have any intervention[9,10]. This study had 34% (942/2,773) of its newborns lost to the first follow-up at 3 months, and 19% (12/63) after 6 months testing with ABR. The parents concerned about hearing status were familiar with the hearing test process, and their confidence in hospital personnel was an important factor in improving the success rate of the screening program. The personnel and location for

Table 4. Results of newborn hearing screening at 0-1 month of age and maternal factors

	Pass both ears	Pass one ear	Refer both ears	*p**
Gestational age (weeks)				
<37	593 (23.4)	34 (37.4)	49 (42.6)	
37-39	1,802 (71.1)	50 (54.9)	61 (53.0)	
≥40	139 (5.5)	7 (7.7)	0 (0)	**0.001**
Maternal age (years)				
<20	718 (28.9)	33 (36.3)	34 (30.6)	
20-34	1,451 (58.4)	50 (54.9)	65 (58.6)	
34-39	244 (9.8)	7 (7.7)	9 (8.1)	
>40	74 (2.9)	1 (1.1)	2 (2.7)	**0.229**
Type of delivery				
Normal delivery	1,389 (54.9)	47 (5.1)	58 (50.5)	
Forceps extraction	3 (0.1)	0 (0)	0 (0)	
Vacuum extraction	96 (3.8)	10 (10.9)	2 (1.7)	
Cesarean section	1,044 (41.2)	35 (38.0)	55 (47.8)	**0.267**

*Kruskal-Wallis test

Table 5. Results of newborn hearing screening at 0-1 month of age and newborn factors

	Pass both ears	Pass one ear	Refer both ears	*p**
Birth Weight (grams)				
< 1,500	83 (3.3)	10 (10.8)	10 (8.5)	
1,500-2,500	514 (20.1)	26 (27.9)	47 (40.2)	
>2500	1,954 (76.6)	57 (61.3)	60 (51.3)	<0.001
Ototoxic drugs exposure				
No	2,034 (79.8)	58 (62.4)	75 (65.2)	
Yes	514 (20.2)	35 (37.6)	40 (34.8)	<0.001
Septicemia/Sepsis				
No	2,446 (95.9)	85 (91.4)	97 (84.3)	<0.001
Yes	102 (4.0)	8 (8.6)	18 (15.7)	
Ventilator used				
No	2,450 (96.2)	87 (93.5)	102 (88.7)	
Yes	98 (3.8)	6 (6.5)	13 (11.3)	<0.001
Anomaly				
No	2,476 (97.2)	83 (89.2)	97 (84.4)	
Yes	72 (2.8)	10 (10.8)	18 (15.6)	<0.001
Genetic/Familial deafness				
No	2,546 (99.9)	93 (100)	111 (96.5)	
Yes	2 (0.1)	0 (0)	4 (3.5)	<0.001
Apgar's score**				
Normal	2,467 (97.1)	82 (92.5)	107 (93.0)	
Abnormal	74 (2.9)	7 (7.5)	8 (7.0)	0.003
Intrauterine infection				
No	2,535 (99.5)	90 (96.8)	115 (100)	
Yes	13 (0.5)	3 (3.2)	0 (0)	0.514
Meningitis				
No	2,545 (99.9)	93 (100)	115 (100)	
Yes	3 (0.1)	0 (0)	0 (0)	0.927

* Kruskal-Wallis test, **Apgar's score: normal means >0-4 at 1-minute or 0-6 at 5-minute

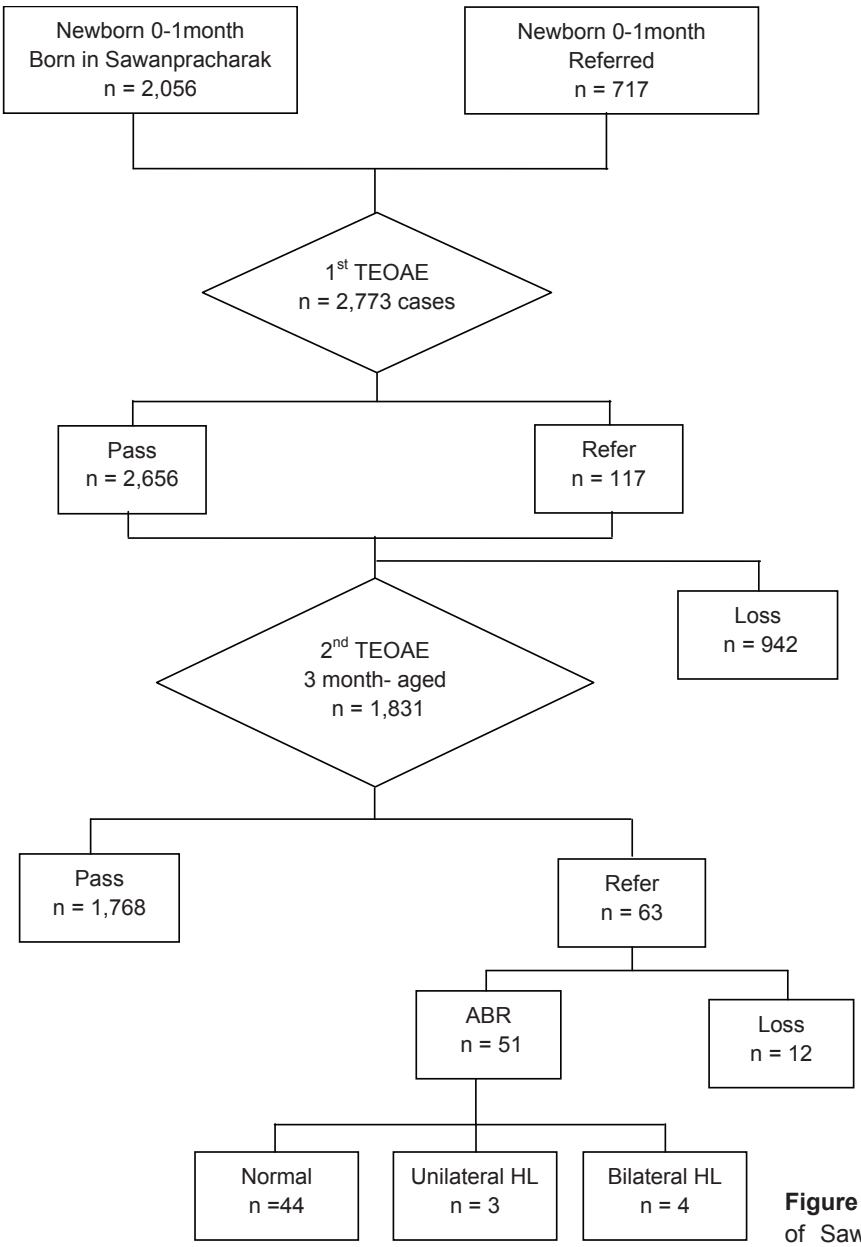

Figure 1. Flow chart indicating process of Sawanpracharak newborn hearing screening.

testing may have impact on this study. If the test is performed for the first time by an audiologist or a physician in the audiometric room, errors in the test might be reduced and outcomes improved successfully. Other methods may involve improvement of the appointment system, such as fast track OAE/ABR, and calling every newborn to follow up on their test. This study screened the enrolled newborns using 2-TEOAE in order to reduce errors in the test and evaluate the benefit of this program. The total loss to the system was 954 of 2,773 cases (34.4%), which was a high rate of loss. Therefore, this study could not conclude that a second OAE would decrease the errors in a test, but a higher rate of "pass" was noticed in the case of 2 times testing in the second OAE, especially when the first OAE had a 60 times chance of a "pass" compared to the 2.7 times chance of "refer". The false positives in the first TEOAE were 2.7 after rescreening, due to a more reliable method when testing older in-

fants[11]. The fluid and debris in external auditory meatus should be clear, which enhances a good response to OAE, especially when testing in newborns aged less than 24 hours[7]. In hospitals that have no universal newborn hearing screening, JCIH 2000 suggests screening newborns with high risk of hearing loss for up to 28 days[7]. Delayed OAE at 3 months of life may gain benefit when testing "refer" cases, especially in detecting hearing loss in high risk groups. This study showed a CHL prevalence of 2.5:1,000, which was higher than that at Ramathibodi Hospital (1.7:1,000)[4]. The overall prevalence of mild to profound hearing loss was 1.6-6/1,000 live births, and that increased to 2.5-10% among high risk infants[11]. Some cases of referred newborns had one or more risks of hearing loss, such as use of aminoglycosides, low birth weight, hyperbilirubinemia and sepsis. Therefore, these babies should be screened as high risk newborns and not given universal screening. Many mechanisms may facilitate newborns with hearing screening, including hearing screening programs, educating parents, fast track screening and a good referral system.

This study showed that the total referral rate was 7.6% (211/2,773) and unilateral referral rate 3.4% (94 cases). Many studies have not mentioned unilateral or bilateral "pass" or "refer". Some studies included unilateral referral outcome, within the passing outcome, because unilateral hearing loss had smaller impact on speech development[2,12]. This study had newborns with unilateral hearing loss at 1:1,000 (3/2,773), which was in the range of the literature that reported unilateral hearing loss at 0.8 to 2.7:1,000 newborns[13,14].

Children with unilateral hearing loss make more errors in sound location, and have more difficulty with speech discrimination in noisy places. At school, a poor signal-to-noise ratio can mask a teacher's voice, and so children with unilateral hearing loss appear to have increased grade failures[2] that create a need for additional educational assistance and perceived behavioral issues in the classroom[12]. Newborns with unilateral "refer" should be managed with a similar protocol to those with bilateral "refer".

The result of the 0-1 month test was "refer" at a high rate of 7.6%, which might include high-risk newborns and well-babies. In 2005, S. Korres reported a 1.9% referral rate in well-babies and 17% in high-risk groups[3]. The second OAE was carried out in older infants, who had more chance of a "pass" (Table 3). It was reported that OAE has a high false positive rate (15%) at the first screening on day-1, which is reduced by about 50% with each retest. Vohr *et al* reported an increasing "pass" rate in OAE results from tests before and after 24 hours[11].

Screening with 2-TEOAE may decrease missing "refer" cases that need confirmation of hearing status by ABR, and this should be applied to babies at risk of hearing loss, including the unilateral "refer" group, which is followed throughout childhood. Although a false positive screening test may lead to parental misunderstanding and anxiety, some infants had delayed onset of hearing loss. JCIH estimated that 2% of children with permanent hearing loss by 12 months of age had normal hearing at birth. Others reported that nearly 5% of children with permanent hearing loss at the time of entering school had already passed the newborn hearing screening test. Periodic monitoring should be carried out for 3 years in infants with risk indicators such as prematurity, low birth weight, ototoxic drug exposure, sepsis, time on a ventilator of more than 5-days, congenital anomaly, and familial hearing loss.

Newborns with respiratory failure that need a ventilator for more than 5 days may decrease oxygenation and perfusion of the cochlear, which develop in the first 2-4 years of life. Over recent years, the number of hyperbilirubinemia cases has decreased, due to early detection and double phototherapy treatment. This disease has selective damage to the brainstem auditory nuclei, and also may damage the auditory nerve and spiral ganglion cells, called "auditory neuropathy"[15,16]. Physicians suggest detection of hearing loss from auditory neuropathy in high-risk newborns, even when passing OAE.

Gentamicin and amikacin were the most frequent ototoxic drugs used in this study. Aminoglycosides have selective toxicity to the cochlear, and produce irreversible hearing loss by causing hair cell death. The damage affects high-frequency hearing initially and progresses towards lower frequencies. The toxicity correlates with duration of exposure, and rising peak and trough concentration, concurrent loop diuretics or vancomycin, underlying states, and previous exposure to aminoglycosides[15]. Physicians who recognize these outcomes should lower the rate of hearing impairment caused by these ototoxic drugs.

This study found six babies with genetic or familial deafness, but four of them were "refer" cases in both ears. Only one baby was confirmed by ABR to have severe sensorineural hearing loss. Familial history of CHL was the most common risk factor (75%) and the second most common was congenital anomalies in the well-baby group[3]. While ototoxic drugs were the most common factor among the neonate in intensive care unit, other common factors associated with hearing loss were mechanical ventilator >24 hours, gestational age <32 weeks, and birth weight <1,500 grams[3]. Newborns with familial deafness or known genetic hearing loss should be followed throughout childhood.

Conclusion

The prevalence of congenital hearing loss at Sawanpracharak Hospital was 2.5:1,000. The Sawanpracharak Newborn Hearing Screening Program with 2-TEOAE decreased missing "refer" cases, which need confirmation by ABR. This program may be applied for delayed testing in newborns and babies at risk of hearing loss, including unilateral loss. Familial deafness, congenital anomalies and use of ototoxic drugs were the most significant risk factors from this study.

References

1. **Anne MD.** Newborn Hearing Screening Updated: Jan. 31, 2012 Available from: URL:http://emedicine.medscape.com/article/836646-overview. Accessed January 23, 2014.
2. **Kay WC, JOL T, Mellissa P.** Evaluation of Unilateral referral on neonatal hearing screening. J Med Screen 2009;16:17-21.
3. **Korres S, Nikolopoulos TP, Komkotou V, et al.** Newborn Hearing Screening: Effectiveness, Importance of High-Risk Factors and Characteristics of Infants in the Neonatal Intensive Care Unit and Well-Baby Nursery. Otol Neurotol 2005;26:1186-90.
4. **Jariengprasert C, Lerdsukprasert K, Kasemsuwan L, Nannareumitra P.** Universal newborn hearing screening using transient otoacoustic emissions: 1 year prevalence in Ramathibodi hospital. Thai J Otolaryngol HNS 2003;4:27-41.
5. **Tungvachirakul V, Boonmee S, Nualmoosik T, et al.** Newborn hearing screening at Rajavithi Hospital, Thailand: hearing loss in infants not admitting in intensive care unit. J Med Assoc Thai 2011;94(suppl.)2:S108-12.
6. **National Institutes of Health**. NIH Concensus Statement 1993;11:1-24.
7. **Joint Committee on Infant Hearing 2000 Position Statement**. American Academy of Pediatrics Joint Committee on Infant Hearing. Pediatrics 2000;106:798-817.
8. **Chareonsil R**. Sensorineural Hearing Loss in Infant and Children at Sawanpracharak Hospital. Sawanpracharak Med J 2006;3:250-61.
9. **Joint Committee on Infant Hearing**. (2007). Year 2007 position statement: Principle and guidelines for early hearing detection and intervention. Available at www.asha.org/policy Accessed December 22,2013.
10. **NCHAM**. The Impact of Privacy Regulations: How EDHI, Part C, and Health Providers can Ensure that Children and Families Get Needed Services. (2008) Available at http://www.infanthearing.org/privacy/dcs/Final_Fed_PrivacyEDHI_White_paper.pdf. Accessed November 10, 2014.
11. **Abdullah A, Hazim MYS, Almyzan A, et al**. Newborn Hearing Screening: Experience in a Malaysian Hospital. Singapore Med J 2006;47:60-4.
12. **Judith E, Cho L**. Speech-Language and Educational Consequences of Unilateral Hearing Loss in Children. Arch Otolaryngol Head Neck Surg 2004; 130:524-30.
13. **Dalzell L, Orlando M, MacDonald M, et al**. The New York State Universal Newborn Hearing Screening Demonstration Project: ages of hearing loss identification, hearing aids fitting, and enrollment in early intervention. Ear Hear 2000;21:118-30.

14. **White KR, Vohr BR, Maxon AB, et al**. Screening all newborns for hearing loss using transient evoked otoacoustic emissions. Int J Pediatr Otorhinolaryngo 1994;29:203-17.
15. **Cristobal R, Oghalai JS**. Hearing loss in children with very low birth weight: current review of epidermiology and pathophysiology. Arch Dis Child Fetal Neonatal Ed 2008;93:F462-8.
16. **Meredith LP, Beth L.** Dennis Hyperbilirubinemia in the Term Newborn. Am Fam Physician 2002; 65:599-607.

การตรวจคัดกรองการได้ยินในทารกแรกเกิดที่โรงพยาบาลสวรรค์ประชารักษ์

รุ้งใจ เจริญศิลป์
กลุ่มงานโสต ศอ นาสิก โรงพยาบาลสวรรค์ประชารักษ์

วัตถุประสงค์ เพื่อประเมินผลวิธีการตรวจคัดกรองการได้ยินและศึกษาอุบัติการณ์ของการเกิดภาวะการได้ยินบกพร่องในทารกแรกเกิดที่เข้ารับบริการ ที่โรงพยาบาลสวรรค์ประชารักษ์

วิธีการ ทำการศึกษาแบบไปข้างหน้าในทารกแรกเกิดที่เข้ารับบริการที่โรงพยาบาลสวรรค์ประชารักษ์ 2,773 ราย ระหว่างเดือนมกราคม 2555 ถึงเดือนมีนาคม 2556 ทารกทุกรายจะได้รับการตรวจคัดกรองการได้ยินทั้ง 2 ข้างด้วย วิธีการตรวจวัดการสะท้อนกลับของคลื่นความถี่เสียงจากหูชั้นในชนิด transient evoked otoacoustic emission (TEOAE) จำนวน 2 ครั้งคือ ที่อายุตั้งแต่แรกคลอดถึง1 เดือนและที่อายุ 3 เดือน โดยเก็บข้อมูลทางประชากร ปัจจัยเสี่ยงที่เกี่ยวข้องกับการเกิดการได้ยินบกพร่อง บันทึกผลเป็น “ผ่าน” และ“ส่งต่อ” ทารกที่ผลตรวจเป็น “ส่งต่อ”ในครั้งที่ 2 จะได้รับการตรวจการได้ยินเพิ่มเติมด้วยเครื่องตรวจวัดการได้ยินระดับก้านสมอง (auditory brainstem response) เพื่อวัดระดับการได้ยินที่อายุ 6 เดือน ประเมินผลการตรวจคัดกรองการได้ยินในด้านปัจจัยเสี่ยง ความสัมพันธ์และอุบัติการณ์การเกิดการได้ยินบกพร่อง

ผลการศึกษา ทารกแรกเกิด 117 ราย จาก 2,773 ราย มีผลการตรวจคัดกรองการได้ยินเป็น ไม่ผ่าน ในครั้งแรกคิดเป็นร้อยละ 4.2 และได้รับการตรวจครั้งที่ 2 จำนวน 1,858 ราย ไม่ผ่าน 63 ราย และในจำนวนนี้ได้รับการตรวจวัดระดับการได้ยินด้วย ABR 51 ราย (ร้อยละ 81) พบว่ามีภาวะเสื่อมการได้ยินทั้งสิ้น 7 ราย เป็นการเสื่อมการได้ยิน 2 ข้าง 4 ราย โดยพบว่าทั้ง 7 รายมีปัจจัยเสี่ยงต่อการสูญเสียการได้ยินทุกราย ในจำนวนนี้ 4 ราย เป็นการบกพร่องทั้ง 2 ข้าง

สรุป จากการศึกษานี้พบว่า อัตราการเกิดการได้ยินเสื่อมในทารกแรกเกิดที่โรงพยาบาลสวรรค์ประชารักษ์เป็น 2.5 ราย ต่อ 1,000 ราย และการตรวจคัดกรองการได้ยินโดยวิธีการตรวจ 2 ครั้ง สามารถคัดกรองทารกแรกเกิดที่มีปัญหาทางการได้ยินได้แม่นยำขึ้น **เชียงใหม่เวชสาร 2558;54(2):81-8.**

คำสำคัญ: การตรวจคัดกรองการได้ยินในทารกแรกเกิด การได้ยินบกพร่องในทารกแรกเกิด การตรวจวัดการสะท้อนกลับของคลื่นเสียงจากหูชั้นใน