

Evaluation of Transient Evoked Otoacoustic Emission in the Newborn Hearing Screening Program in Neonatal Intensive Care Unit

Ji Hoon Kim, Ki Bong Lee, Yong Chul Koo, Seong Ah Hong, Yuree Lee and Eun Jin Son

Department of Otorhinolaryngology, Yonsei University College of Medicine, Seoul, Korea

Received August 13, 2011
Revised September 1, 2011
Accepted September 3, 2011

Address for correspondence

Eun Jin Son, MD, PhD
Department of Otorhinolaryngology,
Yonsei University
College of Medicine,
211 Eonju-ro, Gangnam-gu,
Seoul 135-720, Korea
Tel +82-2-2019-3460
Fax +82-2-3463-4750
E-mail ejson@yuhs.ac

Background and Objectives: Newborn Hearing Screening (NHS) program aims to identify babies at risk of hearing loss and provide appropriate rehabilitation within the crucial period for language development. The risk of hearing loss is increased in babies discharged from neonatal intensive care unit (NICU) compared to wellbaby nursery. Transient evoked otoacoustic emission (TEOAE) or automated auditory brainstem response tests are utilized. The purpose of this study is to assess the outcome of NHS using TEOAE as initial evaluation method in NICU graduates. **Subjects and Methods:** TEOAE was performed as initial screening method for NHS in NICU neonates born between February 2010 and November 2011. Babies referred from TEOAE were reevaluated with repeated TEOAE or auditory brainstem response. Referral rates were estimated and quality indicators for screening (Joint Committee on Infant Hearing position statement, 2007) were evaluated. **Results:** Among 149 neonates graduated from NICU, 50 (33.6%) babies failed initial TEOAE ('refer'). A second stage TEOAE testing was performed in 41 (82.0%) of these babies: 35 (85.4%) passed and 6 (14.6%) were referred for diagnostic testing. From 2-stage TEOAE screening program, 6 neonates were referred for diagnostic audiological evaluation: sensorineural hearing loss was identified in 2 babies and 3 babies were lost to follow up. Quality indicators for screening were as follows: 1) 94.0% of all newborn infants admitted to NICU completed screening by 1 month of age, and 2) 4.0% of all newborn infants who fail initial screening and fail any subsequent rescreening before comprehensive audiological evaluation. **Conclusions:** Timely and adequate screening of hearing loss is prerequisite for accurate diagnosis and appropriate rehabilitation in infants especially from NICU. Further refinement of the current NHS with additional reliable screening technology is required for more stable and successful screening program.

Korean J Audiol 2011;15:81-84

KEY WORDS: Neonates · Hearing screening · Hearing loss · Transient evoked otoacoustic emission.

Introduction

Newborn hearing screening (NHS) program has been implemented to include not only babies with identifiable risk factors for permanent hearing loss but all babies admitted in the wellbaby nursery and neonatal intensive care unit (NICU) in Korea. Evidence to support the expansion of the NHS program continues to collect. Early identification of hearing loss and appropriate intervention aims to assure adequate opportunity to maximize language development and communication for children with hearing loss.^{1,2)}

Accurate audiological evaluation of hearing in young babies requires appropriate technology and experienced manpower. For screening purposes, the screening tests should have acceptable range of sensitivity and specificity, and yet be easy to handle for use by various personnel. Automated auditory brainstem response (A-ABR) and otoacoustic emission (OAE) tests are considered as methods of choice for NHS.¹⁾ NHS protocols may vary in the choice of the tests and the number of repeated screening tests ("stages") among different institutions.^{3,4)} In the early days of NHS, the test method was recommended to be selected from either OAE or auditory brainstem response

(ABR) or both.^{5,6)} Both ABR and OAE tests can identify sensory/cochlear hearing loss. However, OAE responses may be intact in cases of neural hearing loss (auditory neuropathy/auditory dyssynchrony), that would be identifiable by abnormality in ABR. Since the babies admitted in NICU are more likely to be at risk for neural hearing loss than their counterpart in wellbaby nursery, the current recommendation for NHS testing methods are different for each group. The 2007 position statement of the Joint Committee on Infant Hearing (JCIH) updated the recommendation for test protocols: A-ABR is recommended if a single test method is chosen for screening of NICU babies.¹⁾

The aim of this study is to present the outcome of NHS using transient evoked otoacoustic emission (TEOAE) as initial evaluation method in NICU graduates to discuss the necessity of ABR to complement its limitation.

Subjects and Methods

The clinical data of all babies who were admitted in NICU at the Yonsei University College of Medicine Gangnam Severance Hospital between February 2010 and November 2011 was retrospectively reviewed. All babies were screening using a two-staged NHS program (Fig. 1). TEOAE tests were performed as initial screening method within 2–5 days from birth. If the babies “failed” the initial TEOAE screening, otoscopic examination and second stage TEOAE tests were performed. After the two stages of TEOAE, referred babies were recommended for diagnostic audiological evaluation including ABR. Referral rates were estimated and quality indicators for screening recommended in JCIH 2007¹⁾ were evaluated.

Two qualified audiologists performed testing of neonates. All neonates were screened for hearing impairment using TEOAE within 5 days after birth before discharge from the hospital. TEOAEs were recorded using ILO 92 Otodynamics analyzer system (Otodynamics, England, UK) and ILO V6 software. The tests were performed in soundproof audio-booths. A click stimulus with 80 μ s duration was presented at a repetition interval of 20 msec. TEOAEs were considered present (“pass”) if the signal-to-noise ratio was 6 dB or great in at least 3 of 5 frequency bands, and absent (“fail” or “refer”) otherwise.

Results

During the study period, 149 neonates graduated from NICU and all underwent hearing screening. Initial TEOAE tests were performed within 2–5 days after birth. Fifty out of 149 (33.6%)

babies were scheduled for second stage program. However, 9/50 of them were lost to follow up. From initial screening, TEOAEs were absent unilaterally in 33/50 (66.0%) babies, and bilaterally in 17/50 (34.0%)(Fig. 2).

In the second stage screening using repeated TEOAE was performed within 1 month of birth, 35/41 (85.4%) babies were “passed” and 6/41 (14.6%) remained “fail” cases. From the two-staged NHS protocol, 6/149 (4.0%) of total NICU babies tested were referred for diagnostic audiological evaluation: the “failed” results were bilateral for 2 babies and unilateral for the remaining 4 babies (Fig. 2).

TEOAE or ABR tests were recommended for the 6 referred

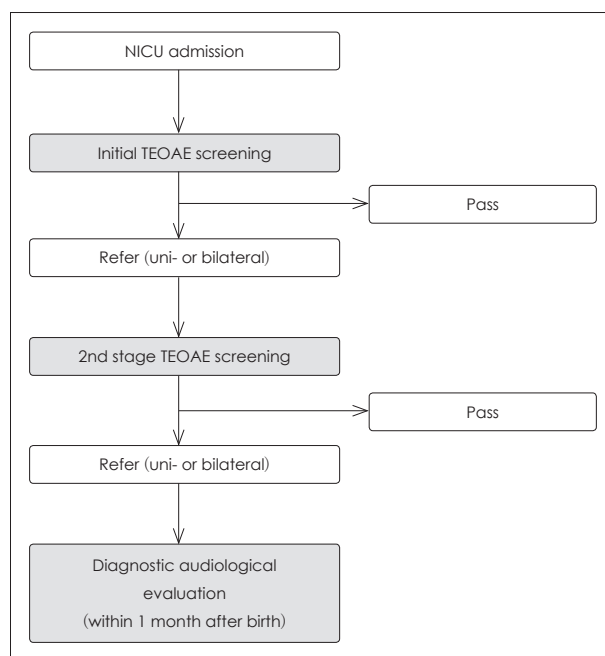


Fig. 1. A schematic overview of the two-staged newborn hearing screening protocol using transient evoked otoacoustic emission (TEOAE).

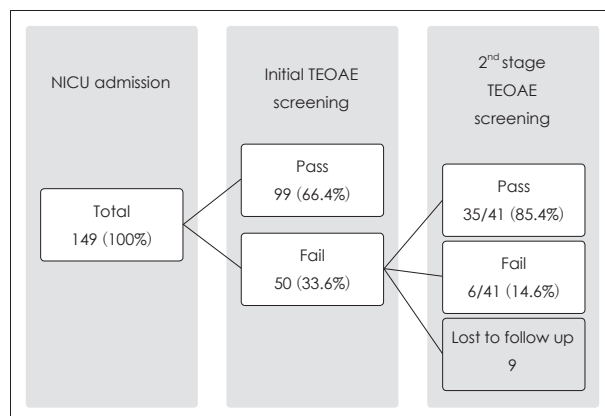


Fig. 2. Results of the two-staged newborn hearing screening protocol using transient evoked otoacoustic emission (TEOAE) in neonatal intensive care unit (NICU) babies.

babies, but 3 were lost to follow up visits. Two babies underwent otoscopic examination, tympanometry and TEOAE and were cleared for all tests. ABR test was performed on one referred baby to reveal profound hearing loss in both ears.

Almost of all babies that passed NHS from either the initial or second stage TEOAEs did not present for further evaluation. However, one baby that initially failed TEOAE but later passed the second stage test returned for audiological evaluation at 3 months of age, following our recommendation based on the prenatal history of syphilis infection. TEOAEs were still present, but the ABR test revealed hearing thresholds of 50 dBnHL in the right ear and 30 dBnHL in the left. He is scheduled for regular follow up tests.

As for any screening programs, regular monitoring and quality control are required for NHS programs. We evaluated the results of our NHS program using TEOAE in NICU patients by estimating quality indicators for screening as recommended in JCIH statement.¹⁾ First, the percentage of all newborn infants who complete screening by 1 month of age was estimated as 94.0% (140/149) for NICU graduates. Second, the percentage of all newborn infants who fail initial screening and fail any subsequent rescreening before comprehensive audiological evaluation is 4.0% (6/149) for our NICU babies.

Discussion

Hearing loss is a common congenital condition, occurring in approximately 0.1% of the normal population, and can result in detrimental effect on speech and language development in children without early intervention.²⁾ NHS program was initiated for early detection of hearing loss in infants and encompasses identification of hearing loss soon after birth, persistent follow up evaluation of hearing and language development, and appropriate intervention for hearing rehabilitation.¹⁾ As clinical experience and long term results of initial NHS programs are collected, special attention is directed to neonatal population with higher risk for hearing impairment. It is estimated that the prevalence of unilateral or bilateral hearing loss incidence of hearing impairment higher is as high as 3.2% in NICU population from a national cohort study.⁷⁾ Also, established risk factors for hearing loss are more frequently encountered in NICU graduates than wellbaby nursery infants.⁸⁾ Higher incidence of auditory neuropathy/auditory dyssynchrony (AN/AD) in NICU babies was also reported. The 2007 position statement of JCIH has outlined distinct protocols for hearing screening in wellbaby nurseries and NICU, and specified the usage of automated ABR in NICU infants.

Traditional TEOAE tests have been utilized for a two-staged protocol for NHS program in all neonates admitted in

wellbaby nursery and NICU in our hospital. As the demand for more comprehensive and definitive diagnostic evaluation is in demand for babies with various medical conditions in tertiary referral centers, a review of the current NHS program was attempted. It was encouraging to note that the results of the TEOAE screening protocol were in accordance with previous reports of referral rates.⁹⁻¹²⁾ Also, the rate of follow up loss of 6.04% was comparable. Possible explanations for follow up loss during the NHS programs are considered similar to other institutes. Some neonates may be transferred to other hospitals before completion of hearing screening. Parents or even medical staff may prioritize management of other conditions more importantly than evaluation of hearing. Further efforts are needed to provide more information about the risk of hearing impairment and importance of early detection and intervention to parents and the medical staff. Also, the results or the lack of NHS should be noted in medical records for transfer to other hospitals.

A significant finding concerns the false-negative case from the NHS protocol. Follow up audiological evaluation revealed normal TEOAE results, but delayed waves and increased threshold in ABR. The case correlates with AN/AD, where the usage of TEOAE as the sole hearing screening method is limited. Since the prevalence of AN/AD is considered higher in NICU infants, it may be speculated that there were other cases of false negative.

Although a prospective cohort study of NICU graduates with longterm follow-up of audiological evaluations is prerequisite for accurate assessment of our two-staged TEOAE test protocol, even a general overview of the NHS program results supports the addition of ABR or A-ABR into the NHS program for NICU babies with higher risk for hearing impairment.

Conclusion

Timely and adequate screening of hearing loss is prerequisite for accurate diagnosis and appropriate rehabilitation in infants especially from NICU. Our data suggests that in selected population of NICU babies, NHS program utilizing TEOAE as two-stage testing method presents potential risk of failing to identify cases of neural hearing loss that may exert adverse effect on language development. Further refinement of the current NHS with additional ABR testing is required for more accurate and successful screening program.

REFERENCES

- 1) American Academy of Pediatrics, Joint Committee on Infant Hear-

- ing. Year 2007 position statement: principles and guidelines for early hearing detection and intervention programs. *Pediatrics* 2007;120: 898-921.
- 2) Yoshinaga-Itano C, Gravel JS. The evidence for universal newborn hearing screening. *Am J Audiol* 2001;10:62-4.
- 3) Korres SG, Balatsouras DG, Gkoritsa E, Eliopoulos P, Rallis E, Ferrekidis E. Success rate of newborn and follow-up screening of hearing using otoacoustic emissions. *Int J Pediatr Otorhinolaryngol* 2006; 70:1039-43.
- 4) van Straaten HL, Hille ET, Kok JH, Verkerk PH; Dutch NICU Neonatal Hearing Screening Working Group. Implementation of a nation-wide automated auditory brainstem response hearing screening programme in neonatal intensive care units. *Acta Paediatr* 2003;92: 332-8.
- 5) Joint Committee on Infant Hearing. 1994 position statement. *ASHA* 1994;36:38-41.
- 6) 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. 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.
- 7) Hille ET, van Straaten HI, Verkerk PH; Dutch NICU Neonatal Hearing Screening Working Group. Prevalence and independent risk factors for hearing loss in NICU infants. *Acta Paediatr* 2007;96:1155-8.
- 8) Vohr BR, Widen JE, Cone-Wesson B, Sininger YS, Gorga MP, Fol-som 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.
- 9) Lim HW, Han MW, Lee HS, Kim KS, Chung JW, Kim YJ, et al. The validity using two-stage automated auditory brainstem response as a universal newborn hearing screening protocol: experiences in Asan medical center. *Korean J Otolaryngol-Head Neck Surg* 2007;50:108-14.
- 10) Park HJ, Park KH, Oh JH, Lee JS. TEOAE as a Newborn Hearing Screening. *Korean J Otolaryngol-Head Neck Surg* 1999;42:565-9.
- 11) Ohl C, Dornier L, Czajka C, Chobaut JC, Tavernier L. Newborn hearing screening on infants at risk. *Int J Pediatr Otorhinolaryngol* 2009;73:1691-5.
- 12) 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.