Universal Neonatal Hearing Screening: An Experience at Tertiary Care Hospital

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Citation

Shrestha BL, Karmacharya S, Dhakal A, KC AK, Shrestha KS, Pradhan A, et al. Universal Neonatal Hearing Screening: An Experience at Tertiary Care Hospital. *Kathmandu Univ Med J.* **Online First.**

ABSTRACT

Background

Hearing loss among neonates is one of the important health issue in pediatric population which may remain unnoticed until the child reaches a certain age. The importance of universal early screening, diagnosis and intervention in reducing the negative impact of congenital hearing loss has been described all over the world.

Objective

To observe the outcome of hearing screening by Automated Auditory Brainstem Response (AABR) in newborns delivered in Dhulikhel Hospital and neonates admitted in an intensive care unit (NICU) of Dhulikhel Hospital.

Method

A prospective study was done in neonates who were born at Dhulikhel Hospital, Kathmandu University Hospital from February 15th, 2017 to October 30th, 2019. AABR was used for their hearing assessment within 24 hours of birth and again at about 6 weeks of age in those neonates who failed the initial test. All the neonates admitted in NICU were studied regarding the risk factors based on Joint committee on Infant Hearing. Those who failed the test for the second time were referred for detailed audiological diagnostic work up.

Result

The screening rate was 92.6% of the total deliveries. A total of 5517 neonates comprising of 2800 males and 2717 females were screened from total deliveries of 5956 neonates in the study period. Among them, NICU (sick) babies were 422 (7.7%) and well babies were 5095 (92.3%). Out of them, 1675 failed the test in the first screening and 374 failed in the second screening. So, the total number of referred babies in second screening was 6.7% (374) out of 5517 screened. Amongst them, well babies were 6.59% (336), out of 5095 screened and sick babies were 9% (38) out of 422 screened.

Low birth weight and prematurity were found to be the commonest risk factor present among them, followed by the use of ototoxic medications, hyperbilirubinemia and prolonged use of mechanical ventilation.

Conclusion

Automated Auditory Brainstem Response (AABR) is a very useful tool for hearing screening which should preferably be done in all the neonates where possible. It should be done within one month of life and those with confirmed hearing loss should receive early appropriate intervention for better hearing in future.

KEY WORDS

Automated Auditory Brainstem Response (AABR), Congenital Hearing Loss, Joint Committee on Infant Hearing, Universal Neonatal Hearing Screening (UNHS).

INTRODUCTION

It is a well established fact that unidentified hearing loss can adversely affect optimal speech and language development which further affects acquisition of literacy skills, and social and emotional development.[1] The risk is even more in a developing country like Nepal where resources is limited for prevention and remediation.

Different studies have shown that at least one in 1000 newborns are affected by hearing impairment, so there is benefit of early diagnosis and intervention because early intervention helps in the early development of language and speech outcomes as well as cognition and socio emotional development.[2-7]

American Academy of Pediatrics (AAP) in 1999 advocated universal new-born hearing screening programme (UNHSP) and early intervention which is being practiced in most of the developed countries.[8]

Universal newborn hearing screening is recommended by international committees, and recommendations from the Joint Committee on Infant Hearing include screening before 1 month of age, establishing a diagnosis before 3 months, and initiating interventions as soon as possible after diagnosis (no later than 6 months).[2,8,9] A universal newborn hearing screening programme is essential to meet these goals.[9]

The lack of large-scale studies in newborn hearing screening in developing countries leaves a vacuum of actual incidence of hearing impairment amongst the new born babies. In a developing country like Nepal, the risk of newborns to develop these disabilities may be more because of lack of Universal hearing screening programme.

Hence, hearing screening even in small scale in our hospital is a good beginning and we are the first tertiary center in Nepal to start the UNHS. With this, our main aim is to observe the outcome of hearing screening by automated auditory brain stem response (AABR) in newborns delivered in Dhulikhel Hospital and neonates admitted in the neonatal intensive care unit.

METHODS

This was a prospective study done in all the newborns delivered at Dhulikhel Hospital, Kathmandu University Hospital from February 15th 2017 to October 30th, 2019. Newborns in NICU of more than 5 days stay were also included in the study. This study was conducted at Post Natal ward in Obstetrics and Gynecology Department, Neonatal Intensive Care Unit (NICU) of Pediatrics Department and Audiology Unit of ENT (Ear, Nose and Throat) Department of Dhulikhel Hospital, Kathmandu University Hospital.

Those neonates whose parents did not give consent and those who were lost to follow up were excluded from the study. Those neonates who were very sick and whose vital signs were unstable were also excluded. Ethical approval was taken from the institutional review committee of Kathmandu University Hospital, Kavre Nepal (IRC 07/17). All the respondents were informed about the study in detail and informed written consent was taken from the parents of the neonates.

Mothers of all babies were counselled regarding the benefits of hearing screening, procedure of the test, need for follow up and further tests if neonates failed the screening test, and the interventions available if hearing loss was confirmed.

Detailed methodology

All the newborns fulfilling inclusion criteria mentioned were screened using AABR. Newborns admitted in the Neonatal Intensive Care unit (NICU) were screened prior to discharge from NICU (once their general condition was stable).

For the test

The Automated Auditory Brainstem Response (AABR) was carried out using the MB11 BERAphone® (fig 1). A quiet area was chosen for screening in both obstetrics and gynecological ward and pediatrics ward.

Figure 1. Showing the MB11 BERAphone®.

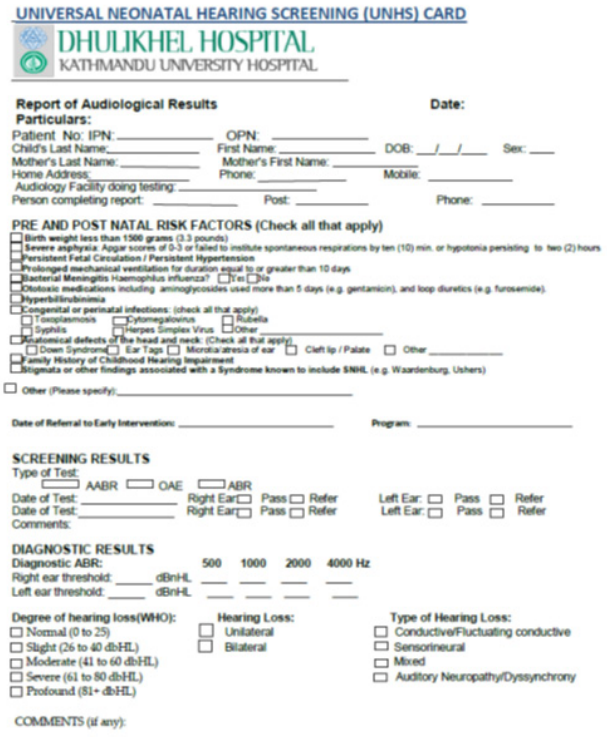
When the neonate was asleep or quiet, the special handheld headphone unit of MB11 BERAphone® which emits a series of soft clicks was positioned over the newborn's ears after application of electrode gel. The vertex electrode is adjustable to ensure its proper placement on various head sizes. These electrodes pick up the neural activity in response to the stimulus. Comparison of the neural responses with normal response templates is done by the software and a "pass" or "refer" result is displayed. If a response is detected and verified at 35 dBnHL, the test result is "pass." The machine indicates a "refer" when there is no response at 35 dBnHL at all frequencies.

The first screening test was done in the Gynecology and Obstetrics ward or post-natal wards or NICU after obtaining informed consent from the mother.

Parents of babies who failed (refer) screening test once were counselled and asked to return after 6 weeks for second screening during their visit for immunization. These babies underwent a second testing in a quiet room. Those who passed on the second screening were discharged from the study while those who failed second time were referred for diagnostic ABR. (fig. 2)

Figure 2. Showing the flow chart of UNHS methodology.

A detailed case history, which included questions relating to mother's history, pre, peri and post-natal birth history and family history was obtained. In addition to this, a detailed history regarding the high risk factors was also taken as per prepared proforma. (fig. 3)


UNIVERSAL NEONATAL HEARING SCREENING (UNHS) CARD

DHULIKHEL HOSPITAL
KATHMANDU UNIVERSITY HOSPITAL

Report of Audiological Results **Date:**

Particulars:

Patient No: IPN: _____ OPN: _____
Child's Last Name: _____ First Name: _____ DOB: __/__/____ Sex: ___
Mother's Last Name: _____ Mother's First Name: _____
Home Address: _____ Phone: _____ Mobile: _____
Audiology Facility doing testing: _____
Person completing report: _____ Post: _____ Phone: _____

PRE AND POST NATAL RISK FACTORS (Check all that apply)

- Birth weight less than 1500 grams (3.3 pounds)
- Severe asphyxia: Apgar scores of 0-3 or failed to institute spontaneous respirations by ten (10) min. or hypotonia persisting to two (2) hours
- Persistent Fetal Circulation / Persistent Hypertension
- Prolonged mechanical ventilation for duration equal to or greater than 10 days
- Bacterial Meningitis Haemophilus influenza? ☐Yes ☐No
- Ototoxic medications including aminoglycosides used more than 5 days (e.g. gentamicin), and loop diuretics (e.g. furosemide).
- Hyperbilirubinimia
- Congenital or perinatal infections: (check all that apply)
  - ☐Toxoplasmosis ☐Cytomegalovirus ☐Rubella
  - ☐Syphilis ☐Herpes Simplex Virus ☐Other _____
- Anatomical defects of the head and neck: (Check all that apply)
  - ☐Down Syndrome ☐Ear Tags ☐Microtia/atresia of ear ☐Cleft lip / Palate ☐Other _____
- Family History of Childhood Hearing Impairment
- Stigmata or other findings associated with a Syndrome known to include SNHL (e.g. Waardenburg, Ushers)

☐ Other (Please specify): _____

Date of Referral to Early Intervention: _____ Program: _____

SCREENING RESULTS

Type of Test:
☐ AABR ☐ OAE ☐ ABR
Date of Test: _____ Right Ear ☐ Pass ☐ Refer Left Ear: ☐ Pass ☐ Refer
Date of Test: _____ Right Ear ☐ Pass ☐ Refer Left Ear: ☐ Pass ☐ Refer
Comments:

DIAGNOSTIC RESULTS

Diagnostic ABR: 500 1000 2000 4000 Hz
Right ear threshold: ____ dBnHL ____ ____ ____ ____
Left ear threshold: ____ dBnHL ____ ____ ____ ____

Degree of hearing loss(WHO):
☐ Normal (0 to 25)
☐ Slight (26 to 40 dbHL)
☐ Moderate (41 to 60 dbHL)
☐ Severe (61 to 80 dbHL)
☐ Profound (81+ dbHL)

Hearing Loss:
☐ Unilateral
☐ Bilateral

Type of Hearing Loss:
☐ Conductive/Fluctuating conductive
☐ Sensorineural
☐ Mixed
☐ Auditory Neuropathy/Dyssynchrony

COMMENTS (if any):

Figure 3. Showing the proforma of UNHS

The neonate underwent an examination by the ENT surgeon for outer and middle ear anomalies.

RESULTS

The total number of deliveries was 5956. Out of which 5517 (92.6%) babies were screened. The male babies were 2800 and female babies were 2717. So the male to female ratio was 1.03:1. Among 5517 babies screened, the sick babies were 422 (7.7%) whereas well babies were 5095 (92.3%) as shown in figure 4.

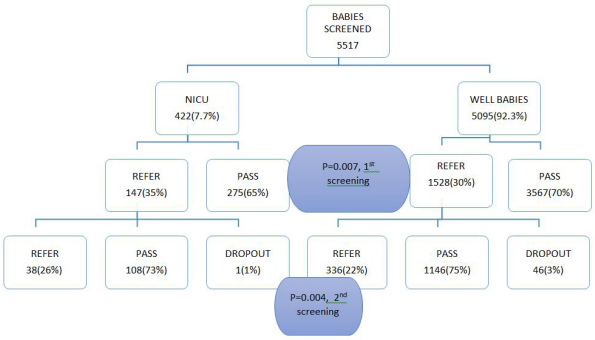


Figure 4. Showing the results of hearing screened babies (n=5517)

The referral rate as shown by AABR was significantly high for the NICU (sick babies) as compared to well babies with p-value 0.007 on 1st screening and 0.004 on 2nd screening (Chi square test) as shown in figure 4.

So, the total number of referred babies in second screening was 6.7% (374) out of 5517 screened. Amongst them, well babies were 6.59% (336), out of 5095 screened and sick babies were 9% (38) out of 422 screened.

The distribution of different risk factors showed low birth weight and prematurity were found to be the commonest risk factor present among them, followed by the use of ototoxic medications as shown in table 1.

Table 1. Distribution of risk factors among the sick babies (SB) and their status in UNHS.

Risk Factors	Number screened	Total Pass (including 1st and 2nd screening)	Total fail (in 2nd screening)
Low birth weight	175	164	11
Ototoxic medication use	99	87	12
Hyperbilirubinemia	23	20	3
Mechanical Ventilation	14	13	1
Prematurity	104 (1 fail in 1st screening but dropout in 2nd screening)	95	8
In utero infection	5	2	3
Alcohol/Smoking	2	2	0
Total	422	383	38

DISCUSSION

Universal Hearing Screening is one of the best method to recognize hearing loss in newborns. We have used the AABR for screening as it is less susceptible to false positive results unlike OAE (Otoacustic emission) and has adequate sensitivity and specificity. Considering the large number of deliveries, implementation of the "universal screening program" in the ideal setting (sound treated room) was not possible; hence, the screening was undertaken in the postnatal and pediatric ward setting. Studies showed that the screening could be done in the ward setting without disturbance from ambient noise and during oxygen therapy.[10]

Hearing screening immediately after birth often results in high false positive due to vernix caseosa in the external canals. Therefore, an effective way of minimizing false positive is to implement a two-stage screening protocol.[10,11] This method also improves the specificity. The two-step screening protocol is a standard way of the universal screening program in western countries.[11] Study performed by Benito-Orejas et al. followed a two-stage screening protocol, where the first screening was performed during the first 48 hours of life or before discharge from the hospital.[12] The infants referred from the first screening underwent a second screening before 1 month of life.[12] This study showed that 2.6% of neonates were referred for second screening. And in the second screening 0.32% were referred. They concluded that two-step screening with AABR had a significantly less referral rate than two-step screening with OAE and was therefore more cost-effective. Another study by Lin et al. showed a significant reduction in referral rate with a two-stage protocol.[13] The referral rate of 5.8% in the first screening was reduced to 1.8% after the second screening. Yet, another study by Iley and Addis concluded that the AABR as an initial screening is less expensive, more practical, and acceptable to the parents.[14]

Our study showed that in the first screening, the referral rate was 30% which decreased to 6.59% in the second screening in well babies and it was 35% in first screening which decreased to 9% in the second screening in sick babies. This data was similar to the different studies, in which the values ranged from 6-9%.[15,16] However, this data differed to some studies in which the values ranged from 0.3 to 5.5%.[12-14,17,18] The referral rate in our study was higher in comparison to the above studies. The higher referral rate seen in our study might be due to use of AABR instead of ABR and OAE combined, so there are high chances of false positive rate. If OAE was used in combination with ABR then the referral rate might have decreased.

Comparing the prevalence of hearing loss (HL) which we quantify by the referral rate in our study, we found that the HL was more in the SB admitted to NICU for real indications than in WB i.e. 35% and 30% in 1st screening and 9% and 6.59% in 2nd screening respectively, which was statistically significant. The referral rate for SB or for the ones admitted to NICU were higher in almost all the studies which showed 9-13% which was quite similar to our study.[19-22]

Infants with a longer length of stay in NICU and those with neonatal infections had an increased likelihood of a false-negative results, which indicates that targeted follow-up among these infants is important to ensure the earliest diagnosis possible. The findings related to the high false-negative rate may be unusually high, given the increased risk of delayed onset of hearing loss amongst sick babies.[23]

From these findings, it can be ascertained that HL is definitely more in the high risk neonates than in normal neonates which is the basis for few targeted screening approaches used in some countries. Our study showed that there is significant statistical difference in the referral rate between well babies and sick babies. Similarly in literature, it is generally accepted that a universal hearing screening(UHS) is more relevant than the high risk screening in neonates of NICU.[24]

Different studies also suggested that up to 50% of all the children with congenital hearing loss have no risk factors. And they would be missed if screening of only high risk neonates are performed.[25-27] It's worthwhile to note that well babies had 6.5% referral rate whereas sick babies had 9% referral rate. If only high risk hearing screening had been done, then we would have missed the well babies with hearing problems which was 6.5%. Although the incidence of hearing problems in well babies is less than the incidence in the sick babies, the magnanimity of newborn population in "well babies" group is large, leading to a large number of hearing impaired being missed by high risk screening alone.[1]

Hence universal hearing screening is the ideal way of hearing screening for neonates. It is worthwhile and mandatory to implement and incorporate universal neonatal screening in our country to secure normal development of the child by detecting hearing loss at birth and providing earliest intervention.

So, it is useful to implement the two staged screening and the screening timing can be planned along with timing of discharge from hospital after birth and with the timing of immunization of the 1st dose of triple antigen vaccination at 6 weeks. Those who fail this second screening should undergo a confirmatory BERA (brainstem evoked response audiometry) and referred for detailed audiological evaluation if necessary.[1]

So, it is very useful to create awareness among parents about the importance of UNHS and its role in early detection of hearing loss in newborns so that early intervention can be started.

This UNHS programme is a regular, ongoing screening programme in Dhulikhel Hospital. We are proud to be a pioneer in developing the UNHS protocol and implement this programme in Nepal.

CONCLUSION

This study has shown that two-stage AABR hearing screening can be successfully implemented as neonatal hearing screening programme, for early detection of hearing impairment. It should be implemented in all hospitals for the benefit of the newborns. It should be done within one month of life and those with confirmed hearing loss should receive early appropriate intervention. Adequate follow up services and rehabilitation should be started as early as possible. This is a simple, reliable and cost effective method which can be successfully implemented in all hospitals. We recommend that, this method of universal screening of newborn for detection of hearing impairment be started in all the hospitals of Nepal.

ACKNOWLEDGEMENT

We are very grateful to the Department of Obstetrics and Gynecology and Department of Pediatrics for unconditional support throughout the study. We are also grateful to Prof Seung Ha Oh and the team of Seoul National University, Department of ENT-HNS for their consistent support in UNHS programme.

REFERENCES

1. Yenamandra KK, Sahu PK, Kumar A, Rai N, Thakur PK. Universal hearing screening of newborn to detect hearing loss and aid in early intervention: multicentre study. *Int J Contemp Pediatr.* 2018; 5: 2114-8.
2. European consensus statement on neonatal hearing screening. Finalized at theEuropean consensus development conference on neonatal hearing screening. Milan, 15-16 May 1998. *Acta Paediatr.* 1999;88:107-8.
3. Erenberg A, Lemons J, Sia C, Trunkel D, Ziring P. Newborn and infant hearing loss: detection and intervention. American academy of pediatrics. Task force on newborn and infant hearing, 1998-1999. *Pediatrics.* 1999;103:527-30.
4. Yoshinaga-Itano C. Early intervention after universal neonatal hearing screening: impact on outcomes. *Mental Retard Dev Disabil Res Rev*. 2003;9:252-66.
5. Meinzen-Derr J, Wiley S, Choo DI. Impact of early intervention on expressive and receptive language development among young children with permanent hearing loss. *Am Ann Deaf.* 2011;155:580-91.
6. Yoshinaga-Itano C. From screening to early identification and intervention: discovering predictors to successful outcomes for children with significant hearing loss. *J Deaf Stud Deaf Educ*. 2003;8:11-30.
7. Vohr B, Jodoin-Krauzyk J, Tucker R, Topol D, Johnson MJ, Ahlgren M, et al. Expressive vocabulary of children with hearing loss in the first 2 years of life: impact of early intervention. *J Perinatol*. 2010;31:274-80.
8. American Academy of Pediatrics. Newborn and infant hearing loss: detection and intervention. *J Pediatr.* 1999;103:527-30.
9. World Health Organization. Newborn and Infant Hearing Screening. Current Issues and Guiding Principles for Action. Geneva (Switzerland): World Health Organization, 9-10 November 2009.
10. Van Straaten HL. Automated auditory brainstem response in neonatal hearing screening. *Acta Paediatr Suppl.* 1999;88:76-9.
11. Cebulla M, Shehata-Dieler W. ABR-based newborn hearing screening with MB11 BERAphone® using an optimized chirp for acoustical stimulation. *Int J Pediatr Otorhinolaryngol.* 2012;76:536-43.
12. Benito-Orejas JI, Ramírez B, Morais D, Almaraz A, Fernández-Calvo JL. Comparison of two-step transient evoked otoacoustic emissions (TEOAE) and automated auditory brainstem response (aABR) for universal newborn hearing screening programs. *Int J Pediatr Otorhinolaryngol.* 2008;72:1193-201.
13. Lin HC, Shu MT, Lee KS, Ho GM, Fu TY, Bruna S, et al. Comparison of hearing screening programs between one step with transient evoked otoacoustic emissions (TEOAE) and two steps with TEOAE and automated auditory brainstem response. *Laryngoscope*. 2005;115:1957-62.
14. Iley KL, Addis RJ. Impact of technology choice on service provision for universal newborn hearing screening within a busy district hospital. *J Perinatol.* 2000;20 (8 Pt 2):S122-7.
15. Yang HC, Sung CM, Shin DJ, Cho YB, Jang CH, Cho HH. Newborn hearing screening in prematurity: fate of screening failures and auditory maturation. *Clin Otolaryngol.* 2017;42(3):661-7.
16. Dommelen P, Straaten HLM, Verkerk PH. NICU Neonatal Hearing Screening Working Group. Ten-year quality assurance of the nationwide hearing screening programme in Dutch neonatal intensive care units. *Acta Paediatr Oslo Nor.* 2011;100(8):1097-103.
17. Li PC, Chen WI, Huang CM, Liu CJ, Chang H, Lin HC. Comparison of Newborn Hearing Screening in Well-Baby Nursery and NICU: A Study Applied to Reduce Referral Rate in NICU. *PloS One*. 2016;11(3):92-6.
18. Mason JA, Herrmann KR. Universal infant hearing screening by automated auditory brainstem response measurement. *Iran J Otorhinolaryngol.* 1998;101(2):221-8.
19. Abramovich SJ, Gregory S, Slemick M, Stewart A. Hearing loss in very low birthweight infants treated with neonatal intensive care. *Arch Dis Child.* 1979;54(6):421-6.
20. Pourarian S, Khademi B, Pishva N, Jamali A. Prevalence of hearing loss in newborns admitted to neonatal intensive care unit. *Iran J Otorhinolaryngol*. 2012;24(68):129-34.
21. Farhat A, Ghasemi MM, Akhondian J, Mohammadzadeh A, Esmaeili H, Amiri R. Comparative Study of Hearing Impairment among Healthy and Intensive Care unit Neonates in Mashhad, North East Iran. *Iran J Otorhinolaryngol*. 2015;27(81):273-7.
22. Chiong CM, Llanes EGD, Tirona-Remulla AN, Calaquian CME, Reyes-Quintos MRT. Neonatal hearing screening in a neonatal intensive care unit using distortion product otoacoustic emissions. *Acta Otolaryngol (Stockh)*. 2003;123(2):215-8.
23. 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(4):353-7.
24. Grill E, Hessel F, Siebert U, Schnell-Inderst P. Comparing the clinical effectiveness of different new-born hearing screening strategies. A decision analysis. *BMC Public Health.* 2005;31:5-12.
25. White KR, Vohr BR, Behrens TR. Universal Newborn Hearing Screening Using Transient Evoked Otoacoustic Emissions: Results of the Rhode Island Hearing Assessment Project. *Seminars in Hearing.* 1993: 4; 18-29.
26. Isaacson G. Universal Newborn Hearing Screening and Intervention. *Advances in Otolaryngology-Head and Neck Surgery*. 2001:15;1-19.
27. White K, Maxon A. Universal Screening for the Hearing Impairment: Simple, Beneficial and Presently Justified. *Int J Pediatr Otorhinolaryngol.* 1995:32(3);201-11.