Bangladesh Med Res Counc Bull 2014; 40: 1-5

Newborn hearing screening: what are we missing?

Mannan MA[1], Choudhury SM[2], Dey AC[1], Dey SK[1], Naher BS[3], Shahidullah M[1]

[1]*Department of Neonatology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka,* [2]*Department of Neonatology, Dhaka Medical College, Dhaka,* [3]*Sir Salimullah Medical College & Mitford Hospital, Dhaka. Email: drmannan64@yahoo.com*

Abstract

The objectives of the study were to demonstrate hearing status in newborns at first screening by Transient Evoked Otoacoustic Emissions and to find out the relationship between abnormal hearing screening and known risk factors. This study was conducted in the department of neonatology of Bangabandhu Sheikh Mujib Medical University in collaboration with department of otolaryngology and department of obstetrics and gynaecology. This prospective observational study included **a** cohort of 168 neonates from Neonatal Intensive Care Unit and neonatal Nursery (Minimal care unit). All were screened for hearing impairment using Transient Evoked Otoacoustic Emissions in out-patient department of otolaryngology by a trained audiologist before discharge from hospital. Risk factors analysed were according to the criteria of American Academy of Pediatrics. Of the total neonates screened, Refer rate was 32.7% irrespective of presence or absence of risk factors. Small for gestational age, in-utero infections, ototoxic medications, birth weight <1500, sepsis/meningitis, hyperbilirubinemia were found to be significant risk factors ($p<0.0001$). It can be recommended that hearing screening should be universally done for all newborns.

Introduction

Congenital or perinatally acquired hearing disorders affects 1 to 2 of 1000 newborns[1-3]. This prevalence of hearing loss rises to 2.5% and 10% among high-risk infants[4-6].

In developing world extent of the problem of permanent childhood hearing loss has not been accurately established due to the dearth of appropriate epidemiological studies in the region[7]. World Health Organisation (WHO) estimated that of the 78 million people suspected to have disabling hearing impairment in the developing world, 8 million were children under the age of 18 years[8]. From these reports, it was difficult to determine what proportion was congenital, of early-onset or acquired as the study population was predominantly over the age of 2 years.

Moderate to severe bilateral hearing loss at or shortly after birth distorts the developing child's perception of his or her attempt at speech production and if undetected, will impede speech, language, and cognitive development[9-15]. So identification of hearing loss prior to 6 months of age has a better chance of developing skills equivalent to their peers by the time they enter kindergarten. Children not identified until later may ultimately suffer from irreversible and permanent impairments in speech, language, and cognitive abilities when compared to their peers. Therefore the American Academy of Pediatrics, has recommended that hearing loss in infants be identified, and when possible be treated, prior to 6 months of age.

Newborn infant hearing screening (NHS) programs are designed to identify hearing loss in infants shortly after birth. Such screening programs implemented in most of the developed countries are carried out within hospitals and birthing clinics by trained audiologists, nurses or medical assistants usually prior to discharge from the hospital or birthing clinics. Failure to pass the first newborn hearing screening does not necessarily mean that the baby has hearing loss. Follow- up testing is the best way to be sure about baby's hearing status. Prior to the implementation of universal hearing screen programs, it was customary to only test those newborns who had known significant risk factors for hearing loss. Screening by high risk registry alone (eg, family history of deafness) can only identify 50% of newborns with significant congenital hearing loss[16,17].

Various tools have been used for newborn hearing screening. Currently, the most promising technique for newborn hearing screening is the measurement of otoacoustic emission (OAE), first described by Kemp in 1978[18]. OAE screening test is a fast, easy, accurate, noninvasive, automated test that does not require any observable response from the infant. It does not require highly-trained personnel to operate, and the test can be conducted without any sedation given to the newborn. An otoacoustic emission test (OAE) also known as transient

otoacoustic emission test (TOAE) measures an acoustic response that is produced by the inner ear (cochlea), which in essence bounces back out of the ear in response to a sound stimulus. The test is performed by placing a small probe that contains a microphone and speaker into the infant's ear. As the infant rests quietly, sounds are generated in the probe. Once the cochlea processes the sound, an electrical stimulus is sent to the brainstem. In addition, there is a second and separate sound that does not travel up the nerve but comes back out into the infant's ear canal. This "byproduct" is the otoacoustic emission. The emission is then recorded with the microphone probe and represented pictorially on a computer screen. The audiologist can determine which sounds yielded a response/emission and the strength of those responses. If there is an emission present for those sounds that are critical to speech comprehension, then the infant has "Passed" the hearing screen. Testing generally takes about five to eight minutes.

The universal newborn hearing screening (UNHS) has been widely practiced in developed countries. Successful implementations of such newborn hearing screening in developed countries have been widely published but little is known about hearing screening activities in developing countries[19].

Recently some of the developing countries of Asia like India, Malaysia[20-22] have started hospital based screening programmes and/or pilot studies in neonates to identify hearing loss shortly after birth . But in Bangladesh, unfortunately no initiative has so far been taken even in tertiary care level for implementation of newborn hearing screening .Any baseline data from screening results may be useful in formulation of proposals to policy making bodies in order to get grants to implement a national universal neonatal hearing screening program. Also private institution can take the lead in establishing self sustaining and affordable screening program in their facilities.

With this background this present study is planned to demonstrate hearing status in NICU and MCU (Minimal Care Unit) neonates by screening with Transient Evoked Otoacoustic Emissions (TEOAE) and also to find out relationship between impaired hearing and known risk factors.

Materials and Methods

A prospective observational study was carried out in the department of neonatology and neonatal nursery (MCU), Bangabandhu Sheikh Mujib Medical University (BSMMU). The study period was from January 2011 to June 2011. The study group included a cohort of 168 neonates (116 sick newborn from NICU and 52 newborns from neonatal nursery/MCU) who sought care at BSMMU during the study period. After obtaining informed parental consent the study neonates were screened for hearing impairment using Transient Evoked Otoacoustic Emissions (TEOAE) before discharge from hospital. This screening was done in out-patient department of department of Otolaryngology, BSMMU by a trained audiologist. After ear inspection and removal of any vernix or fluid in the external ear canal (EEC), the ear probe was inserted into the EEC and adjusted. The TOAE was then performed by otoacoustic emission assay machine, Fig: 2 (GSI AUDIO Screener, REF 2205-3000, Grason Stadler, 7625 Golden triangle, Drive F, Eden Prairie, MN55344, Made in USA) and the result of “Pass” or “Fail” recorded.

In newborns with Refer, a second test was immediately performed after appropriate adjustment of the positions of the probes. When a Refer was obtained on the second attempt, the newborn was considered as having failed the screening test or Refer. Parents were notified of the screening result immediately. A follow up hearing test, one month later was advised for all newborns with Refer. A prescribed form of data collection sheet containing all relevant informations was filled for each patient.

Statistical Analysis: We analyzed the variables assumed to be risk factors for neonatal hearing loss, according to the criteria of American Academy of Pediatrics[23].Uunivariate analyses with appropriate methods were performed to identify significant risk factors . Two sample z test was done to compare sample proportions and p value thus calculated was considered significant at<0.05.

Results

A total of 168 newborns including 116 from NICU and 52 from neonatal nursery (MCU) underwent hearing screening by TEOAE before discharge from hospital.

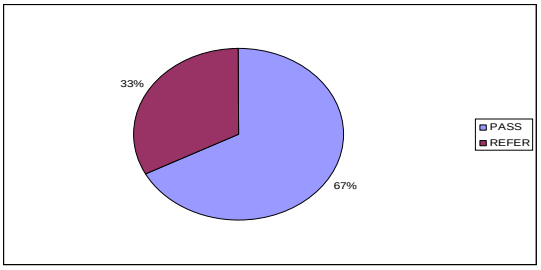

Fig 1: Results of TEOAE in study group

Of the 168 neonates screened, results were abnormal (Refer, bilateral or unilateral) in 55 cases which constitutes 32.7% (Fig 1).

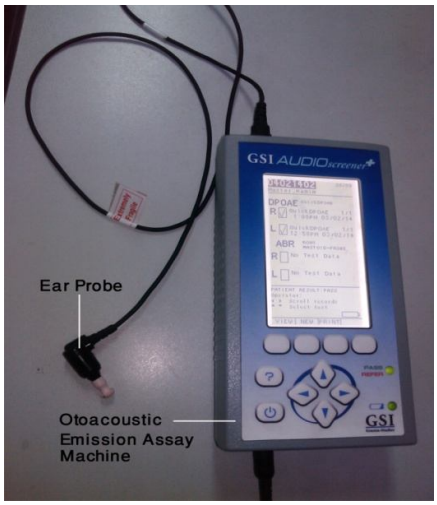

Fig.2: Otoacoustic Emission Assay Machine

Table I: Results of TEOAE in NICU and MCU group.

Infant cohort (no)	Refer (%) (unilateral/bilateral)	Pass (%)
NICU infant (116)	47(40.5%)	69(59.5%)
MCU infant (52)	8(15.4%)	44(84.6%)

Forty seven of 116 NICU neonates yielded Refer which constituted 40.5% of sick neonates (Table I) ; it was bilateral in 41 cases and unilateral in 6 cases. Among the 52 neonates of MCU, 8 did not Pass the screening test and it comprised 15.4% of the screened.

Table II: Neonatal characteristics of study infants (*n=168*)

Characteristics	NICU	MCU	*p* value
Gestational age, week (mean±SD)	34.5±2.7	37.7±2.4	<0.001
Birth weight, gram (mean±SD)	2117.5±822	2750±716.9	<0.001
Gender, male: female	1.2:1	0.8:1	
Age at screening (mean ±SD) (days)	15±12.5	2.5±0.7	<0.001

Newborn characteristics have been shown in Table II.

Mean±SD gestational age in NICU neonates was 34.5 ±2.7 weeks and in MCU newborns it was 37.7 ±2.4 weeks. Mean ± SD birth weight of NICU and MCU healthy newborn infants under study was 2117.5±822 gram and 2750±716.9 gram respectively. Male to female ratio was 1.2:1 and 0.8:1 respectively. Mean postnatal age at which newborns underwent screening was 15±12.5 days in NICU group while it was 2.5±0.7 days in MCU group. The differences were significant between the groups (*p<0.001).*

Table III: Prenatal and Neonatal Risk Factors of Study Infants (n=168)

	N	%
A.Prenatal risk factors		
Small-for-gestational age	67	39.9
Familial history of hearing loss	07	4.2
Maternal ototoxic drugs	03	1.8
In utero infections	02	1.0
B.Neonatal risk factors		
Ototoxic medications	98	60.3
Birth weight <1500 g	82	48.8
Mechanical ventilation>5 days	13	7.7
Craniofacial anomalies	02	1.2
Perinatal asphyxia	13	7.7
Sepsis or meningitis	62	37.0
Hyperbilirubinemia	96	57.1
Stigmata and/or syndromes	01	0.6

Table III gives an overview of prenatal and neonatal risk factors in study infants. The median number of risk factors per infant was 1 (range, 1–5). The most prevalent risk factors were ototoxic medications of the babies, low birth weight (LBW) <1500g, hyperbibirubinemia, small for gestational age (SGA) and sepsis/meningitis. Though the risk factors were mostly prevalent in NICU neonates 3 healthy newborn in neonatal nursery were SGA and 2 had family H/O hearing loss.

On univariate analysis (Table IV) small for gestational age, neonatal ototoxic medications, birth weight <1500, sepsis/meningitis, hyperbilirubinemia were found to be significant risk factors associated abnormal hearing screening results (p<0.0001), in-utero infections also found to be an independent risk factor for abnormal result (*p*<0.01).

Table IV: Distribution of Risk Factors in Infants with Pass and Refer TOAEs

	Pass (n=113)		Refer (n =55)		*p*	Odds Ratio 95% CI
	n	%	*n*	%		
Small-for-gestational age	32	28.3	35	63.6	<0.0001	0.2257(0.1138-0.4478)
Familial hearing loss	05	04.4	02	03.6	0.8	1.2269(0.2304-6.5337)
Maternal ototoxic drugs	03	02.65	00	00.0	0.078	-
In utero infections	00	00.0	02	3.6	<0.01	-
Neonatal Ototoxic drugs	53	46.9	45	81.8	<0.0001	0.1963(0.0901-0.4276)
Birth weight <1500 g	42	37.1	40	72.7	<0.0001	0.2218(0.1095-0.4491)
Mechanical ventilation >5 days	08	07.07	05	9.09	0.67	0.8381(0.2617-2.6843)
Craniofacial anomalies	02	01.76	00	0	0.134	-
Perinatal asphyxia	07	06.19	06	10.9	0.33	0.5393(0.1722-1.6893)
Sepsis or meningitis	24	21.2	38	69.1	<0.0001	0.1637(.0771-0.3475
Hyperbilirubinemia	80	70.7	16	29.1	<0.0001	5.9091(2.9074-12.01)
Stigmata and/or syndromes	00	00.0	01	1.8	0.32	-

Discussion

The universal newborn hearing screening (UNHS) has been widely practiced in developed countries. The introduction of a newborn hearing screening (NHS) programme in developing countries is still considered unattainable presently for a number of reasons. However subsequent to the improvement of health care provision, growth of audiological services, and public advocacy, some developing countries like India, Malaysia[20-22] have begun implementing hospital-based newborn hearing screening programmes and performance of such newly implemented screening programme in South Asia has been evaluated in some other studies.

In Bangladesh, prevalence rate of 0.3% for severe hearing loss was reported in a normal school population[24]. But relevant data on congenital, early-onset or acquired hearing loss are lacking. Therefore the present study focuses on the baseline need for carrying out hearing screening in neonates soon after birth and subsequent comfirmation in follow up visits.

In this study 32.7% of neonates screened scored Refer in first screening; forty seven were bilateral and eight were unilateral. referral rate for NICU and MCU population was 40.5% and 15.4% respectively. This initial referral rate is quite high in comparison with findings demonstrated in some other studies where monthwise referral rate in a year ranged 5.1% to 14.4%[20]. Mean averages of referral rate for the MCUand NICU babies in that study were 11.98 and 11.75%, respectively. Those screening programmes did not equally cover NICU and MCU population which may explain the difference between the two studies. One main cause for including small number of cases from postnatal ward was parental refusal to perform the screening test.

All newborns were screened before discharge from hospital; this accounts for difference in age at which screening test was performed between the two groups (15±12.5 days vs 2.5±0.7 days). Although Refer in TEOAE in early postnatal days may be false positive due to presence of vernix or debris in external ear, we tried to eliminate this possibility by clearing from external ear canal & repeating it immediately and advising follow-up screening one month later.

In the present study population, small for gestational age, birth weight <1500 gram, neonatal ototoxic medication, sepsis/meningitis, hyperbilirubinemia were identified to be significant risk factors associated with abnormal screening results ($p<.0001$); in-utero infections also found to be an independent risk factor for abnormal hearing screening result ($p<0.01$) All these have been reported as risk factors for permanent congenital and early onset hearing loss (PCEHL) in the developing world[25-28]. In developed countries familial hearing loss, ie hereditary factors, sepsis and/or meningitis, and craniofacial malformations were identified to be independent significant risk factors for pathologic hearing screening results[29]. The difference in such associations with developed countries might be due to advanced care and decreased postnatal morbidities associated with LBW or SGA babies and careful monitoring of drug levels for ototoxic medications. Lack of universal preventive strategy, antenatal screening and therapeutic termination of fetuses affected by in-utero infections may explain the high association of abnormal screening results in our study in contrast to developed countries. Hereditary factors are not evaluated in most of the deaf population in our country; this may explain poor association of familial hearing loss with abnormal hearing screening results in our study.

Follow up screening advised one month later for subsequent confirmation was possible only for few cases. Of the total 55 cases only 8 patients were rescreened by TOAEA; 5 yielded Pass in both ears and 3 scored Refer. In these 3 patients bilateral hearing loss was confirmed in 2 and unilateral hearing loss in 1 by Auditory brain stem response (ABR) and they were all referred to otolaryngologist for further assessment and intervention. These follow-up results are too small in comparison to the main cohort, so this result has not been analysed for statistical inference.

Conclusion: Abnormal hearing screening is common in newborns with or without risk factors. Risk factors increase the likelihood of abnormal screening results. Abnormal screening does not signify permanent hearing loss but it opens the scope for full hearing assessment for those with abnormality on initial screening. It should be universally done for all newborns.

Acknowledgement

We gratefully acknowledge the sincere cooperation of the participating parents as well as the contribution of all the doctors & staffs of department of neonatology, obstetric & gynecology and otolaryngology BSMMU.

References

1. Mason JA, Herrmann KR. Universal infant hearing screening by automated auditory brainstem response measurement. Pediatrics 1998; 101: 221–28.

2. Mehl AL, Thomson V. Newborn hearing screening: the great omission. Pediatrics 1998; 101(1).

3. Watkin PM. Neonatal otoacoustic emission screening and the identification of deafness. Arch Dis Child 1996; 74: 16-25.

4. Bergman I, Hirsch RP, Fria TJ, et al. Cause of hearing loss in the high-risk premature infant. J Pediatr 1985; 106: 95-101.

5. Hall JW. Handbook of Auditory Evoked Response. Boston: Allyn and Bacon; 1992.

6. Salamy A, Eldredge L, Tooley WJ. Neonatal status and hearing loss in high-risk infants. J Pediatr 1989; 114: 847-52.

7. Mencher GTA, Devoe SJ. Universal newborn screening: a dream realized or a nightmare in the making? Scand. Audiol 2001; 30 (Suppl 53): 15-21.

8. Smith AW. WHO activities for prevention of deafness and hearing impairment in children. Scand. Audiol. Suppl 2001; 53: 93-100.

9. Northern JL, Downs MP. Hearing Disorders in Children. In: Julet TL, Napora LS, Williams PC, editors. Hearing in Children. 3rd ed. Baltimore, Maryland: Lippincott Williams & Wilkins; 2002. 1984-89.

10. Centers for Disease Control and Prevention.Serious hearing impairment among children aged 3-10 years-Atlanta, Georgia, 1991–1993. MMWR. 1997; 46: 1073-76.

11. Parving A. Detection of the infant with congenital/early acquired hearing disability. Acta Otolaryngol Suppl (Scand) 1991; 482: 111-16.

12. Sorri M, Rantakallio P. Prevalence of hearing loss at the age of 15 in a birth cohort of 12 000 children from northern Finland. Scand Audiol 1985; 14: 203-7.

13. Yoshinaga-Itano C, Sedey AL, Coulter DK, Mehl AL. Language of earlyand later-identified children with hearing loss. Pediatrics 1998; 102: 1161-71.

14. Robinshaw HM. Early intervention for hearing impairment. Br J Audiol 1995; 29: 315-34.

15. Robinshaw HM. The pattern of development from non-communicative behavior to language by hearing-impaired infants. Br J Audiol 1996; 30: 177-98.

16. Davis A, Wood S. The epidemiology of childhood hearing impairment:factors relevant to planning of services. Br J Audiol 1992; 26: 77-90.

17. Watkin PM, Baldwin M, McEnery G. Neonatal at risk screening and the identification of deafness. Arch Dis Child 1991; 66: 1130-35.

18. Kemp PT. Stimulated acoustic emissions form the human auditory system. J Acous Soc Am 1978; 64: 1386-91.

19. Olusanya BO. Early detection of hearing impairment in developing countries: what options? Audiology 2001;40: 141-47.

20. Kumar S , Mohapatra B. Status of newborn hearing screening program in India. International Journal of Pediatric Otorhinolaryngology 2011; 75: 20-26.

21. Mukari SZ, Tan KY, Abdullah A. A pilot project on hospital-based universal newborn hearing screening: Lessons learned. International Journal of Pediatric Otorhinolaryngology 2006; 70: 843-51.

22. Nagapoornima P, Remesh A, Srilakshmi, Rao S, Patricia PL, Gore M, Dominic M, Swarnarekha. Universal Hearing Screening. International Journal of Pediatric Otorhinolaryngology 2006; 70: 843-51.

23. American Academy of Pediatrics. Joint Committee on Infant Hearing 1994 position statement. Pediatrics 1995; 95: 152-56.

24. Datta PG, Khan HS, Chakraborty MR, Samad A, Amin MN. Screening a unique way of better health care delivery for ENT patients. Med. Res. Counc. Bull 1995; 21 (3): 99-103.

25. J. D'Mello, High-risk register: an economical tool for early identification, Indian J. Pediatr 1995; 62 (6): 731-35.

26. S. Elango, R.P. Chand, G.N. Purohit, Childhood deafness in Malaysia, Int. J. Pediatr. Otorhinolaryngol 1992; 24(1): 11-17.

27. V.K. Paul, S. Radhika, A.K. Deorari, M. Singh, Neurodevelopmental outcome of 'at risk' nursery graduates. Indian J. Pediatr 1998; 65 (6): 857—62.

28. K. Singh, S.B. Mann, A.K. Gupta, L. Kumar, Auditory profile in children recovering from bacterial meningitis. Indian J. Pediatr 1996; 163 (2): 210—16.

29. Dommelen PV, Mohangoo AD, Verkerk PH, van der Ploeg CPB, van Straaten HLM, Risk indicators for hearing loss in infants treated in different Neonatal Intensive Care Units. Acta Paediatrica 2010; 99: 344-49.