

Neonatal Hearing Screening in a Neonatal Intensive Care Unit Using Distortion-product Otoacoustic Emissions

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Objective—To determine pass and refer rates, and identify risk factors relating to refer responses, in neonates screened using distortion-product otoacoustic emissions (DPOAEs).

Material and Methods—A total of 435 neonates admitted to the neonatal intensive care unit (NICU) of the Philippine General Hospital between May and October 2000 were screened using DPOAEs within 48 h of admission.

Results—The male:female ratio in the sample was 1.05. In total, 56% of neonates were born preterm, the mean birthweight was 2428.39 ± 710.39 g and 8.9% weighed <1500 g. In total, 47.9% were delivered by Caesarian section and 44.9% were delivered vaginally. Almost 14% of neonates had 1-min Apgar scores of <6, and 4% had 5-min Apgar scores of <7. Approximately 95% of neonates had a poor perinatal history. Using pediatric aging it was noted that 46% of these neonates were born preterm, and 30.4% were small for gestational age. At least one neonatal disease was found in 42% of neonates, whilst 95.7% had to be given medication. The bilateral refer rate was 29.1%. Two-by-two analysis of risk factors for hearing loss and DPOAE measurements showed that only male sex seemed to have a significant association with a refer response. Neonates weighing <1500 g at birth showed a marginally significant association with a refer response ($p = 0.07$). All other neonates showed no crude association with DPOAE measurements.

Conclusion—These preliminary data show that a high proportion of NICU patients may have poor outer hair cell function, and thus poor hearing. In order to develop an effective neonatal hearing screening program, further studies of prevalence and risk factors should be pursued in the same setting. *Key words: distortion-product otoacoustic emissions, neonatal hearing screening, risk factors.*

INTRODUCTION

In recent decades a great deal of effort has been expended in the development of hearing screening programs. Early identification of deaf children at the neonatal stage would result in early treatment and rehabilitation, and prevent language, developmental and social problems (1).

The prevalence of bilateral hearing impairment does not vary much, as reported in various studies: (i) 2.18/1,000 births per year (1); (ii) 1.2/1,000 births per year over the period 1983–88 (2); and (iii) 1–2/1000 well babies and 4–5% of neonates with one or more audiologic risk factors (3), as summarized in the Joint Committee on Infant Hearing (JCIH) Position Statement in 1993 (4). Early diagnosis of hearing loss has been made possible by means of auditory brainstem responses (ABRs) and otoacoustic emission testing. Universal neonatal hearing screening has been proposed and instituted in developed countries, in which even a single case of permanent hearing loss is a cause for concern. In spite of increased costs [screening of each infant may cost US\$17–26 (4), US\$19.88 (5) or US\$24.48 (2), and the cost of identifying 1 case of sensorineural hearing loss may range from US\$22,114 (4) to US\$56,045 (2) or US\$5,000–\$17,750 (4)], consensus statements supporting the need for universal neonatal hearing screening have

been proposed by the different specialties and committees (4, 6–8).

In most developing countries, such as the Philippines, both the government and the general population lack an awareness of the importance of preventing bilateral permanent hearing loss. The prioritization and allocation of resources for hearing prevention programs, if any exist, are lacking. Active case identification through hearing screening programs cannot be pursued if most patients with hearing loss are diagnosed at a later age, when treatment and rehabilitation may no longer be of value. Among local medical specialists, however, there has been much concern about the possible effects on the quality of life of neglected cases of bilateral permanent hearing loss. There is a need to conduct local studies on the epidemiology of hearing loss and the validity of different hearing screening equipment in our setting, in order to be able to design an available, appropriate and affordable hearing screening program.

For the last 10 years, diagnostic ABR testing has been employed to screen babies for hearing loss on a referral basis in our otorhinolaryngology department. Active ABR screening of babies in the neonatal intensive care unit (NICU) may not be feasible because it is time-consuming and expensive. In contrast, otoa-

oustic emissions testing, which is less time-consuming, automated and has great promise as a mass screening tool among neonates, has yet to be introduced in our country. This preliminary study aims to determine the pass and refer rates for distortion-product otoacoustic emissions (DPOAEs) testing among neonates in the NICU and the factors associated with refer responses.

MATERIAL AND METHODS

All neonates admitted to the NICU between May and October 2000 were subjected to DPOAE testing using the Welch Allyn® AudioPath EOAE Screener 29230, after obtaining maternal consent. A trained research assistant monitored all admissions using the NICU logbook. Before each test, the screener performed a calibration test. The background noise was measured and if there was a 10 dB difference detected in response to two tonal stimulations, the machine automatically showed a “pass” response. Otherwise, a “refer” response was shown. “Fail” responses necessitated checking for vernix or obstruction in the canal, or inappropriate probe fitting. The hearing test was repeated 24 h later once the vernix or cerumen in the canal had been cleared. Determinations were done in the afternoon to minimize noise. Appropriate ear probe tips were used to fit the ears of the subjects. The following variables were determined: pass and refer rates for DPOAE; birthweight; gestational age; sex; maternal factors; perinatal factors; method of delivery; Apgar scores at 1 and 5 min; pediatric aging; medication; and history of rubella, syphilis, TORCH (toxoplasmosis, other, rubella, cytomegalovirus and herpes), mumps and chickenpox. Data from the hearing screening and the patient’s charts were retrieved using a data abstraction sheet. The data gathered were encoded, processed and analyzed using EPI-INFO software, version 6.05.

RESULTS

A total of 435 neonates were screened in the NICU during the study period (Table I). Seven had incomplete data and were excluded from the analysis. There were approximately equal numbers of boys and girls (male:female ratio = 1.05). In total, 56% of neonates were born preterm, the mean birthweight was 2428.39 ± 710.39 g and 8.9% weighed < 1500 g. In total, 47.9% were delivered by Caesarian section and 44.9% were delivered vaginally. Almost 14% of neonates had 1-min Apgar scores of < 6, and 4% had 5-min Apgar scores of < 7. Approximately 95% of neonates had a poor perinatal history. Using pediatric aging it was noted that 46% of these neonates

Table I. Risk factors for hearing loss among neonates

Neonatal risk factor	n (%)
Gestational age ≤ 37 weeks	178/406 (43.8)
Birthweight < 1500 g	39/428 (8.9)
Caesarian section	199/421 (47.1)
Apgar score at 1 min in range 1–5	58/360 (13.9)
Apgar score at 5 min in range 1–6	17/401 (4.1)
Poor perinatal history (at least one of hypotonia, jaundice, poor lacrimation, cyanosis, birth trauma, cord coil, meconium staining)	346/365 (94.8)
Small for gestational age	111/369 (30.1)
Presence of neonatal disease	133/347 (38.3)
Medication administered	289/302 (95.7)
Maternal age < 33 years	86/155 (55.5)

were born preterm, and 30.4% were small for gestational age. At least one neonatal disease was found in 42% of neonates, whilst 95.7% had to be given medication (antibiotics in almost all cases). Maternal diseases that may cause hearing loss in neonates included rubella ($n = 9$; 2.1%), TORCH ($n = 2$; 0.5%), syphilis ($n = 1$; 0.2%) and trauma ($n = 1$; 0.2%).

DPOAE measurements showed that the bilateral refer rate (which connotes permanent congenital hearing impairment) was $\approx 29\%$, and the overall refer rate, which includes unilateral refer responses in either ear, was $\approx 49.2\%$ (Fig. 1).

Two-by-two analysis of risk factors for hearing loss and DPOAE measurements showed that only male sex seemed to have a significant association with a refer response (Table II). Neonates weighing < 1500 g at birth showed a marginally significant association with a refer response ($p = 0.07$). All other neonates showed no statistically significant association with DPOAE measurements.

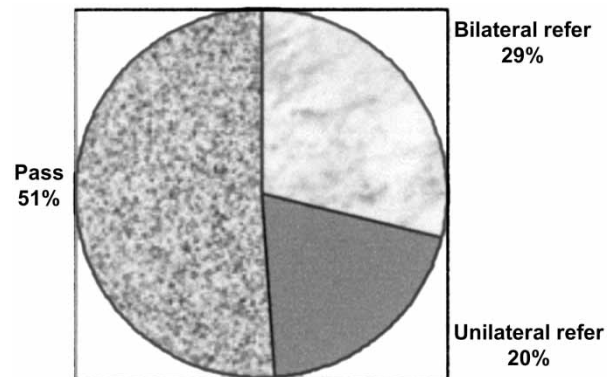


Fig. 1. Distribution of results of DPOAE measurements among neonates.

Table II. Association of DPOAE pass and refer responses with risk factors among neonates

Risk factor	Refer; n (%)	Pass; n (%)	<i>p</i>	Odds ratio (95% CI)
Male gender	121 (55.3)	98 (44.7)	0.012	1.63 (1.09–2.45)
Gestational age \leq 37 weeks	79 (44.4)	99 (55.6)	0.165	0.76 (0.50–1.15)
Apgar score at 1 min in range 1–5	25 (43.1)	33 (56.9)	0.31	0.75 (0.41–1.36)
Apgar score at 5 min in range 1–6	7 (41.2)	10 (58.8)	0.495	0.71 (0.24–2.09)
Birthweight < 1500 g	24 (63.2)	14 (36.8)	0.073	1.86 (0.89–3.94)
Poor perinatal history	203 (49.8)	205 (50.2)	0.514	1.36 (0.49–3.83)
Caesarian section/forceps	113 (48.9)	118 (51.1)	0.825	0.96 (0.64–1.44)
Small/large for gestational age	61 (49.2)	63 (50.8)	0.35	1.23 (0.77–1.95)
Presence of neonatal diseases	67 (46.2)	78 (53.8)	0.352	0.88 (0.56–1.38)
Medication administered	131 (45.3)	158 (54.7)	0.25	0.52 (0.14–1.82)
Maternal age < 33 years	131 (45.3)	158 (54.7)	0.25	0.52 (0.14–1.82)
Presence of bleeding episodes	12 (44.4)	15 (55.6)	0.56	0.79 (0.33–1.87)
Pre-eclampsia	29 (49.2)	30 (50.8)	0.94	0.98 (0.54–1.79)
Presence of maternal diseases	41 (41.2)	44 (51.8)	0.41	0.75 (0.36–1.57)

DISCUSSION

A high percentage of bilateral refer responses was found among neonates in this study; this is comparable to the result found in a parallel study conducted locally (unpublished work), but higher than those reported in other studies: 6.67% (14), 10% (9) and 5/1000 (10). This may be due to very high-risk neonates being admitted to the NICU or increased false-positives resulting from the performance of DPOAE testing in the nursery setting, with a relatively high level of background noise. Almost 95% of NICU patients had a poor neonatal history, with half having one or more risk factors associated with hearing loss. Babies admitted to our NICU may be more seriously ill compared to those in studies conducted in developed countries [family history of hearing impairment, 6.6%; perinatal infection, 3.8%; birthweight < 1500 g, 1.2% (9)]. False-positive values reported from OAE testing include 3.5% (5), 6.63% (10), 16.2% (11) and 11–35% (12). These cases may be mislabeled “refer” and cause undue anxiety to the parents, even though this worry may be unsubstantiated (13). Parents should be told that a refer response only means that their child is scheduled for OAE re-testing and ABR screening.

Risk factors that were studied but not found to be significantly associated with a refer response included those used in the JCIH registry. This may be due to two reasons: (i) only a certain proportion of high-risk babies will have hearing loss, even with the presence of risk factors; and (ii) the inadequate sample size in this study, considering the relatively low prevalence of hearing loss, even among high-risk neonates. Further studies utilizing a larger sample and multivariate techniques need to be done in order to determine a model of predictors that can predict hearing loss

among neonates with a refer response. It is necessary to determine the validity of hearing screening tests such as DPOAE. Significant barriers to the performance of ABR testing in a large sample are that it is time-consuming, difficult to do and requires sedation of the subject (12); however, it is necessary for comparison with DPOAE results. In a local study (unpublished work), involving 100 infants with bilateral refer responses from DPOAE testing, 12 were submitted for re-screening, 9 of whom (75%) converted to “pass”. Preliminary results on referral data from January to July 2002 at our Ear Unit show good concordance between DPOAE and diagnostic ABR.

Only male gender was significantly associated with a refer response, in accordance with the finding of a significant sex effect at 4 kHz, where the mean amplitude of DPOAEs was higher in female than male babies (13). Low birthweight, poor perinatal history and being small for gestational age had odd ratios above the null (> 1), consistent with other findings, but were not found to be statistically significant. The aim of universal neonatal hearing screening is to identify neonatal hearing loss before the age of 3 months, so that rehabilitation can be performed before the age of 6 months (7). This is ideal in our setting, considering the costs that may be incurred. However, because of the inherent poor follow-up of patients in our hospital, this may not be feasible at this time. Initially, in lieu of re-testing of OAE failures, the presence of a constellation of validated risk factor predictors can be used to determine whether babies should be subjected to diagnostic ABR screening. Proper follow-up of patients should be ensured, as loss to follow-up is the primary reason for failure to confirm hearing loss and institute rehabilitation before children reach the age of 1 year (14).

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