Benefit and Pitfalls of Newborn Hearing Screening

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SUMMARY

The importance of universal newborn hearing screening (UNHS) in identifying hearing-impaired infants as early as possible is already well recognized. Transient evoked otoacoustic emissions (TEOAE) have been established as a reliable method for UNHS in full term infants. This is a cross sectional study between April 2003 – December 2005. Thirteen thousand five hundred and ninety eight (13,598) newborns were screened for hearing loss with portable otoacoustic emission (OAE) before discharge. The initial coverage rate during the 3 years study period was 85.9% (13,598) with 89.2% (3,762), 79.0% (4,480) and 90.3% (5,356) for 2003, 2004 and 2005 respectively. The mean age when hearing loss was diagnosed using ABR were 3.56 months old, 3.08 months old, and 2.25 months old and 3.01 months old for 2003, 2004, 2005 respectively and it was statistically significant. The defaulter rate at the third stage during the 3 years study period was 35% (21), 15.2% (7) and 18.2% (2) for 2003, 2004 and 2005 respectively. This study showed significant improvement in initial referral rate, coverage rate and age of diagnosis. However, we need to improve on high defaulter rates.

KEY WORDS:
Otoacoustic emission, Newborn hearing screening, Hearing loss, Brainstem-evoked response

INTRODUCTION

Hearing loss is one of the most common problems found in newborns. The prevalence of mild to profound hearing loss is reported to be between 1.1 to 6 per 1000 life birth [1,2,3]. Furthermore the prevalence of hearing loss is estimated to be between (2.5-10%) among high-risk infants[4]. Our local study showed a prevalence of 0.42% (16/3,762)[5]. This invisible problem occurs more often then all other health problems in newborns that are screened for at birth. It is indisputable that early diagnosis and treatment of hearing impairment in newborns is of paramount importance.

Universal hearing screening of newborns has become one of the most recent developments in healthcare. In the program, newborns are screened as soon as possible to identify hearing loss. Yoshinago-Itano (1999) found that early identification and intervention of children with hearing loss demonstrates higher receptive and expressive language[6]. Children with all degrees of hearing loss benefit from early identification and intervention. Late detection leads to a number of developmental and academic setbacks that may affect these individuals for the rest of their life. Studies have shown that infants who were identified to have hearing loss and seek intervention before six months of age performed significantly better in language development compared to those identified after six months[7].

There are two neonatal hearing screening techniques that are widely used namely the automated auditory brain-stem response (AABR) and otoacoustic emissions (OAE)[8]. Both OAE and AABR are non-invasive, quick and easy to perform on newborns. OAE measures emissions generated by the motion of the outer hair cells in the cochlear while AABR measures the hearing pathway along the auditory nerve.

The Joint Committee on Infant Hearing (JCIH) year 2000 position statement recommends some quality indicators for Universal Newborn Hearing Screening (UNHS) which include achieving a screening rate of at least 95% within six months of program initiation, referral rate not greater than 4% and achieving return for follow up rate of at least 70%.

This study aims to assess the benefits and to determine the pitfalls of newborn hearing screening. The indicators include the coverage rate, follow up rate, initial failure rate, age of diagnosis and intervention.

MATERIALS AND METHODS

This is a cross sectional study between April 2003 - December 2005. Thirteen thousand five hundred and ninety eight (13,598) newborns were screened for hearing loss with portable otoacoustic emission (OAE) before discharge. In the postnatal ward, OAE test were carried out at the bedside or inside the nursery room within 24 hours of life. In the NICU, the test was conducted in an isolation room before these newborns were discharged.

After ear inspection and removal of any vernix or fluid in the external ear canal (EAC), the probe was inserted into the EAC and adjusted. The OAE was then performed and the result of "pass" or "fail" recorded. In newborns with a "fail" result, a second test was immediately performed after appropriate adjustment of the position of the probe. When a "fail" was obtained on the second attempt, the newborn was considered as having failed the screening test. Parents were notified of the screening result immediately.

Newborns who failed screening test were given an appointment at the age of two months when a repeat OAE

This article was accepted: 19 August 2008
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was performed. Those who failed this stage were again tested at three months of age with OAE. If they failed the OAE test then, brainstem evoked response (BSER) test will be performed immediately. In this study, the data of 13,598 babies were analyzed.

RESULT

DISCUSSION

A three-stage hearing screening for newborns using OAE was implemented at our hospital since 2003. All newborns were screened at the postnatal ward or NICU before discharge. Those who failed were screened at the second stage at two months. The third-stage of screening for those who failed the second stage was done at three months. From April 2003 to December 2005, there were 15,823 deliveries at our hospital.

Table I: Return for follow-up rate and defaulter rate

Numbers of babies	Year		
	2003	2004	2005
"Fail" OAE screening at first stage	620	507	126
Return for second stage follow-up	506 (81.6%)	239 (47.1%)	78 (61.9%)
Defaulted the appointment at ENT clinic at the second stage	114 (18.4%)	268 (52.9%)	48 (38.1%)
"Fail" OAE screening at second stage	60	46	11
Return for third stage follow-up	40 (65%)	39 (84.8%)	9 (81.1%)
Defaulted the appointment at ENT clinic at the third stage	21 (35%)	7 (15.2%)	2 (18.2%)

Table I shows return for follow-up rate and defaulter rate from 2003 to 2005.

Table II: Outcomes of diagnostic assessment

Numbers of babies	Year		
	2003	2004	2005
Tested for OAE Screening during the first stage	3,762	4,480	5,356
Diagnosed to have abnormal ABR (ABR threshold > 20 dB HL at least in one ear or both ears) during the third stage at ENT clinic.	16 (0.43%)	16 (0.36%)	13 (0.24%)

Table II shows the number of babies who was diagnosed to have abnormal ABR (ABR threshold more than 20dBnHL at least in one ear) during the diagnostic assessment (third stage) at ENT clinic.

Table III: Age of diagnosis

Age when hearing loss was diagnosed using ABR (month old)	Year		
	2003	2004	2005
Mean	3.56	3.08	2.25
S.D.	1.33	1.26	0.64

Table III shows the mean age when hearing loss was diagnosed using ABR. Results showed the mean age were 3.56 months old, 3.08 months old and 2.25 months old for 2003, 2004 and 2005 respectively. Anova test showed there was significant difference between the mean age of diagnosis for 2003, 2004 and 2005 respectively ($p<0.05$).

Table IV: Intervention

Intervention (Number of babies)	Year		
	2003	2004	2005
Normal hearing bilaterally during hearing assessment < 1 year old	2 (12.5%)	2 (12.5%)	4 (30.8%)
Under hearing monitoring	4 (25%)	4 (25%)	5 (38.5%)
Fitted with hearing aid	1 (6.25%)	0 (0.0%)	0 (0.0%)
Defaulted audiological follow-up	9 (56.25%)	10 (62.5%)	4 (30.8%)

Table IV shows intervention of all babies who had abnormal ABR threshold for 2003, 2004 and 2005 respectively. All babies who had abnormal ABR thresholds were scheduled for further audiological follow-ups and possible intervention at pediatric audiology clinic. The percentage of babies who defaulted audiological follow-ups was quite high for 2003 (56.5%), 2004 (62.5%) and 2005 (30.8%) respectively.

Table V: OAE SCREENING in HUKM (January - December 2004)

Month	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec	Total (Jan-Dec)
Total Newborn HUKM	459	458	506	462	456	457	438	471	495	556	421	475	5,672
OBS Ward & Gynae	363 pass 36 refer	377 pass 43 refer	319 pass *92 refer	333 pass 74 refer	319 pass 60 refer	43 pass 0 refer	183 pass 33 refer	319 pass 32 refer	330 pass 40 refer	433 pass 26 refer	293 pass 14 refer	280 pass 15 refer	3,592 pass 465 refer
NICU	29 pass 4 refer	14 pass 1 refer	25 pass 4 refer	30 pass 3 refer	25 pass 7 refer	19 pass 0 refer	52 pass 2 refer	42 pass 2 refer	30 pass 7 refer	36 pass 6 refer	28 pass 1 refer	41 pass 5 refer	381 pass 42 refer
Total (Phase I)	392 pass 40 refer 27 ND	391 pass 44 refer 23 ND	344 pass 96 refer 66 ND	363 pass 77 refer 22 ND	344 pass 67 refer 45 ND	72 pass 0 refer *403 ND	235 pass 35 refer *168 ND	361 pass 34 refer 76 ND	360 pass 47 refer 88 ND	469 pass 32 refer 55 ND	321 pass 15 refer 85 ND	321 pass 20 refer *134 ND	3,973 pass 507 refer 1,192 Not Done
ENT Clinic (Phase 2)	14 pass 0 refer	14 pass 6 refer	39 pass 10 refer	30 pass 9 refer	31 pass 7 refer	No data	17 pass 5 refer	15 pass 2 refer	18 pass 3 refer	15 pass 3 refer	5 pass 0 refer	6 pass 1 refer	204 pass OEAE 46 refer
Defaulters (Fasa 2)	26	24	50	45	32	No data	13	17	26	14	10	11	268
ENT Clinic (Phase 3)	No data	3 pass OAE 1 BSER N 1 BSER AN	3 pass OAE 4 BSER AN	4 pass OAE 4 BSER AN	2 pass OAE 2 BSER N 2 BSER AN		3 pass OAE 1 BSER N 1 BSER AN	1 BSER AN	1 pass OAE 2 BSER AN	3 pass OAE	No data	1 BSER AN	19 pass OAE 4 BSER Normal 16 BSER Abnormal
Defaulters (Phase 3)	No data	1	3	1	1	No data	1	No data	No data	No data	No data	No data	7
Grand Total (Phase 3)													4,196 pass OAE 1,192 Not Done 16 BSER Abnormal 4 BSER Normal 268 defaulters (Phase 2) 7 defaulters (Phase 3)

BSER N=BSER Normal Test; BSESER AN = ABNORMAL
*portable OAE in ward brokken down ND=NOT DONE

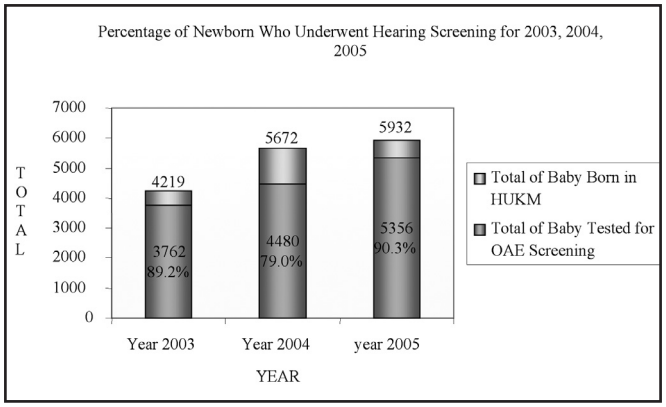

Fig. 1: Shows the total number of babies born in HUKM and the total number of babies screened during the first stage for 2003, 2004 and 2005 respectively.

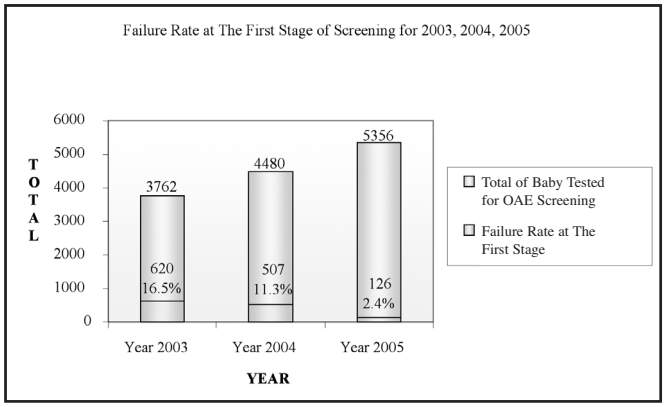

Fig. 2: Shows the total of babies tested for OAE Screening at the first stage and the failure rate at the first stage for 2003, 2004 and 2005 respectively.

The coverage rate of screening is defined as the percentage of babies born during the study period who underwent the initial (first-stage) hearing screening. The initial coverage rate during the 3 years study period was 85.9% (13,598) with 89.2% (3,762), 79.0% (4,480) and 90.3% (5,356) for 2003, 2004 and 2005 respectively.

The initial coverage rate for 2004 is the lowest because out of 475 babies born in June 2004, 403 babies were not screened due to faulty machines (Table V). In our hospital we have four portable OAE machines however in Jun 2004 two machine were sent for repair and another machine had unfortunately broken down. The last machine had battery problem. In July 2004 we had one machine on loan from the company. Fortunately in August the coverage rate improved after we had all four machines in working condition. Therefore to overcome future recurrence of this problem we currently have five machines.

There are three main factors to improve the coverage rate and that includes dedicated personnel, enough portable OAE machines and the committed OAE co-coordinator. The hospital administrator also need to help the OAE screening team by allocating budget to purchase computer equipment and diagnostic machines for universal hearing screening. In general we managed to improve the coverage rate from 89.2% in 2003 to 90.3% in 2005. Overall, there were 13,598 babies tested for OAE screening during the first stage of the study period. The improvement of the coverage rate in 2005 was because as our dedicated staff nurses and good teamwork in the program. We also have three monthly regular meetings and held an annual gathering event during the festive season to show appreciation to all the members for their hard-work and commitment.

The referral rate of the first stage-screening test is defined as the percentage of babies who failed the test in either one or both ears. The initial referral rate at the first stage during the three years study period was 9.2% (1,253) with 16.5% (620), 11.3% (507) and 2.4% (126) for 2003, 2004 and 2005 respectively. Our referral rate in 2005 showed an excellent result of 2.4%. This fulfilled the benchmark for successful hearing screening program (referral rate <4%). However it is not the only parameter to conclude the overall benefits of the program. We shall endeavor to maintain the low referral rate and to achieve early intervention for our babies who diagnosed to have hearing loss.

There were 1,253 babies who failed OAE Screening at the first stage during the study period. The defaulter rate at the second stage during the three years study period was 34.3% (430). The defaulter rates for each year were 18.4% (114), 52.9% (268) and 38.1% (48) for 2003, 2004 and 2005 respectively. The possible causes for not achieving return for second stage follow up rate of at least 70% (recommendation of JCIH 2000) were perhaps; the parents were not well informed of the importance of hearing screening and the screening staff were did not properly advise the parents about the follow up. Generally the follow up rate was higher of babies' discharge from NICU as the parents were explained about the screening results from our Assistant Science Officer or the Medical Doctor. Therefore our team members had suggested that the House Doctors of the postnatal ward need to explain to the parent regarding the importance of the follow up.

There were 117 babies who failed OAE Screening at the second stage during the study period. The defaulter rate at the third stage during the three years study period was 35% (21), 15.2% (7) and 18.2% (2) for 2003, 2004 and 2005 respectively. In 2003, we were able to achieve the recommended follow up rate of more than 70%, which was 81.6% for the second stage. However, in 2004 and 2005, the follow up rate for the second stage were 47.1% and 61.9% respectively. Again the possible causes for the follow up rate of 47.1% were perhaps; the parents were not well informed of the importance of hearing screening and that they missed the initial appointment or they are too busy to bring their baby for follow up. Since January 2006 we had changed the protocol instead of three stages protocol to two stages protocol in order to reduce follow up rate.

Finally the total number of babies who was diagnosed to have abnormal ABR (ABR threshold > 20 dBnHL at least in one ear or both ears) during the three years study period was 45. This gives a prevalence of hearing loss of 0.33% (45/13,598). The prevalence for each year was 16 / 3762 (0.43%), 16 / 4,480 (0.36%) and 13 / 5,356 (0.24%) for 2003, 2004 and 2005

respectively. The average age of diagnosis in 2005 was 2.25 months with S.D. of 0.64. All failed babies at third stage were referred for audiological and medical follow up. The overall percentage of babies who default the intervention program in three years was 51%. The possible cause may be due to the parents' impression that their babies have good hearing because they could respond to normal speech sounds. Many of them were diagnosed to have unilateral hearing loss or just mild to moderate hearing loss

Our study has shown that our coverage rate for our newborn hearing screening program improved over the three years from its implementation from 89% to 90%. We believe this improvement was achieved because of the various steps taken to strengthen the program such as changes of the protocol from 3-stages to 2-stages follow up, having regular meetings with the team members to improve their motivation, dedication and commitment, providing more training to the staff and providing more diagnostic hearing tools for back up. Finitzo (2000) reported that there are four variables that can be improved for a more successful screening program. These include the staff turn over, the uncertainty of staff work schedule, staff competency, and the number of screeners being trained[8]. We support the statement that appropriate training for staff is needed to reduce the false positive outcomes. This is also includes an evaluation to insure proficiency protocol changes from 3-step to 2-step of screening[9].

However, the percentage of defaulters during the second and third stage of screening was still high and unacceptable. We believe that this can be improved by giving an appointment date before discharge, give a letter in their native language, get a general practitioner to increase awareness and to educate the public[8, 10]. A good data management system is needed to assess the compliance of this program that includes; the number of infants being screened before discharge, the number of infants referred for audiologic evaluation before three months old, the number of infants with congenital hearing loss (true positive) and the age of diagnosis and intervention[11]. The number of defaulter also can be tracked down.

Limitations of hearing screening program

Although OAE are routinely done for HUKM's NICU and postnatal ward babies, some patients missed the test probably because the technicians/staff nurses were not informed that the patient had not undergone these tests.

For these patients from NICU who had missed the screening tests, patients were called back via phone to come to NICU for OAE testing. Problems occurred if the parents immediately went back to their hometowns after delivery and missed the appointments. Therefore it is best that the OAE test to be done before discharge from NICU or postnatal wards.

The default rates in our study were quite high probably due to inadequate data system for tracking and surveillance. The other possible cause could be due to the parent's ignorance on the importance of continuous assessment and the parent's impression that their baby has good hearing as they could respond to sounds.

Follow up services are crucial for babies whose initial screening indicate hearing loss. It is important that children and families have access to 'habilitation' and intervention services as soon as possible after the diagnosis of permanent hearing loss. Delays to fitting amplification may occur due to problems with scheduling, the need for repeat tests, suspicion of auditory neuropathy/ dys-synchrony, and the cost of hearing aids. Delays in fittings are also likely for babies who are medically fragile. In our hospital set up, we provide intervention services such as hearing monitoring, hearing aid fitting, cochlear implant and referral to other professionals if required.

CONCLUSION

Hearing screening has become one of the most recent developments in hearing health care of newborn in our hospital. In the three years of the program, we had shown significant improvement in initial referral rate, coverage rate and age of diagnosis and intervention. Our pitfalls have been high defaulters, low follow up rate and poor data management system.

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