

UNIVERSAL NEONATAL HEARING SCREENING: APPLICATIONS FOR A DEVELOPING COUNTRY IN THE ASIA-PACIFIC REGION

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Abstract. Various centers around the world have implemented and evaluated universal hearing screening programs as a response to the US National Institute of Health policy statement on early identification of hearing loss. Several well conducted clinical trials have been devised to examine and evaluate various factors relevant to establishing a UNHS program. This paper aims to describe some of these factors and analyze their applications and implications for a UNHS program for a developing country in the Asia-Pacific Region. Specifically, three main issues will be discussed: hospital vs community based programs, choice of technology, and choice of screening protocol.

INTRODUCTION

Various centers in the United States have implemented and evaluated Universal Neonatal Hearing Screening (UNHS) programs as a response to the National Institute of Health policy statement on early identification of hearing loss. Several well-conducted clinical trials have likewise been devised to examine and assess various factors relevant to establishing such programs. This paper aims to describe some of these factors and analyze their applications and implications for a UNHS program for a developing country in the Asia Pacific region. Specifically, three main issues will be discussed: hospital versus community based programs, choice of technology, and choice of screening protocol.

HOSPITAL VERSUS COMMUNITY BASED UNHS PROGRAMS

The earliest UNHS programs developed, including the Rhode Island Hearing Assessment Project, were hospital based. Reported successful screening rates for well baby nursery based programs range from 87%-95% and 86%-97% for NICU nursery based programs. The reasons for unsuccessful screens include inability to obtain necessary "quiet" recordings, refusal to give consent, and misses. Community based programs are conducted in community health clinics, local health centers or babies homes. Reported successful screening rates are comparable to hospital-based programs.

The choice of where a program will be based will impact on choice of technology, personnel requirements, and cost of screening. Environmental noise and physiologic noise produced by breathing, swallowing, and other normal activities affect the ability to obtain valid readings in hearing screening equipment. Conditions of increased external and internal noise may be minimized by testing in a sound proof booth or a quiet environment. In hospital-based programs, Neonatal Intensive Care Unit (NICU) nurseries are more likely to encounter problems in the presence of ventilators, suction machines, and other monitoring devices. For community based programs, especially those that involve moving from one health center or babies home to another, the screening instrument should be adaptable to a wider range of external conditions. Of the otoacoustic emission tools, Distortion Product Otoacoustic Emission (DPOAE) has been reported to be less susceptible to ambient noise. Automated ABR has also been reported to be successful even when used in less than ideal environmental conditions. Likewise, automated equipment requires less experienced personnel for testing and interpretation of results.

Attitude of parents towards the importance of hearing screening affects not only the initial testing but also the subsequent need to follow up for babies that fail the screen. Convenience and accessibility of the hospital or community center greatly affect the percent of coverage for any screening program. The ability to successfully screen the greatest number of babies will depend on the type of health care delivery, access to such services, and

the prevailing attitudes of mothers towards utilization of such services.

CHOICE OF SCREENING TOOL

A suitable screening tool should be fast, noninvasive, easy to perform, and objectively evaluable. Ideally, a test should be highly specific and sensitive, yielding very low false positive and false negative rates. Evoked otoacoustic emissions, both Transient Evoked Otoacoustic Emission (TEOAE) and DPOAE, and Auditory Brainstem Response (ABR) have all been reported to satisfactorily fulfill the aims of a UNHS program.

TEOAE are widely used in hearing screening. Several published studies indicate that TEOAE are able to detect hearing loss of >30 dB HL. Limitations include inability to provide specific information on the degree of hearing loss and inability to distinguish conductive from sensorineural hearing loss. DPOAE provide superior information regarding the frequency dependence of the hearing loss. External and middle ear conditions are accepted to significantly affect the presence of emissions. ABR, specially automated ABR, has likewise been reported to be useful in hearing screening.

Of the three tools, the TEOAE is known to have the highest false positive rate, and consequently, the highest refer rate. Literature reports a range of 2.5-8% false positive rates for TEOAE. ABR has much lower reported rates of 0.3-2.5%. Rates are often dependent on the criteria used to determine a "pass". The cost of TEOAE is the cheapest, USD 13-17/ infant screened compared to ABR, which may cost up to USD 25 if follow up costs are not included (Keziman *et al*, 2001). Thus, if the cost/ hearing-impaired infant identified is computed, for example, Vohr *et al* (2001) report costs of USD 14,347 for TEOAE and USD 16, 405 for ABR. However, if follow up costs are included, considering the lower false positive rates for ABR, costs would be comparable for the two. Another consideration is that the greater the number of babies screened, the less the cost. Gorga *et al* (2001) report that, in general, costs are cheaper for birthing centers with 400 births or more per year.

The implications for a UNHS program in a developing country is that cost considerations must be tempered with a screening tool that can adequately address the needs for that population.

CHOICE OF SCREENING PROTOCOL

The most ideal screening protocol is one that has a high successful screen rate and low refer rate. In a single step program 80% of newborns who failed the initial screen will pass a second screen. The NIH recommends a two step screening protocol of otoacoustic emissions followed by ABR. Studies that compared costs of screening protocols have reported that this indeed is the least expensive program in terms of cost/infant screened and cost/ hearing impaired infant identified. Follow up of failed infants is specially important in centers with nonhomogeneous and mobile populations. Rescreening prior to discharge reduces the refer rate. Strategies to improve follow up include timing returns with other visits such as immunization or well baby checks.

FUTURE OF UNIVERSAL NEONATAL HEARING SCREENING

The future of UNHS lies beyond screening and identification of hearing impaired infants. A database for tracking hearing-impaired infants identified must be established. UNHS programs should be linked to diagnostic follow-up, intervention, and management programs. Finally, there must also be other programs developed for early identification of the rest of hearing loss cases, which develop in late infancy or childhood.

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MASS NEWBORN SCREENING FOR HEARING IMPAIRMENT

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Abstract. Significant hearing impairment is common and impairs communication potential if not detected early. Babies born at the National University Hospital from March 1999 to February 2001 were screened at birth using the strategy of measuring Transient Evoked Oto Acoustic Emissions with the ILO 88 Otodynamics Echoport. The screening was conducted within 24 hours of birth in the majority of patients. Those testing positive were re-screened at about 2 weeks and at 6 weeks if still testing positive. Those who tested positive at 6 weeks were referred to Otolaryngology for formal evaluation of hearing. A total screening rate of 97.2% (4,387 out of 4,514 livebirths) was achieved. Of the 312 testing positive at 6 weeks, 8 were subsequently proven to have significant hearing impairment. Four of them required binaural amplification, giving a 1 in 1,096 incidence of severe hearing impairment. A specificity, positive predictive value and sensitivity of 93%, 26% and 100% respectively were obtained. In all but one, the diagnosis was made by 7 months of age and interventions set in place within 2 months of diagnosis. The screening strategy was reliable and sensitive. A strategy to reduce the high false positive rate needs to be developed.

INTRODUCTION

Significant hearing impairment is common (1 in 1,000 newborns) (McMurray, 2000) and intervention is available and effectively maximizes communication potential if instituted early in infancy. When hearing impairment of any severity is corrected only after 6 months of age, studies have shown significantly lower mean total language quotient scores, a wide difference between cognitive and language quotients and lower mean personal-social quotients (Yoshinaga-Itano, 1998). The impairment is usually not evident in infancy. The American Joint Committee on Infant Hearing in their position statement in the year 2000, endorsed universal newborn hearing screening, evaluation and family centered intervention through integrated, interdisciplinary State and National Systems (Joint Committee on Infant Hearing). The usual method of screening is by the measurement of otoacoustic emissions or by the measurement of auditory brain stem evoked responses (Kempe and Ryan, 1993; Mason and Herrmann, 1998). The objective of the study was to demonstrate that mass newborn hearing screening would in the local context enable early detection and treatment of significant hearing impairment.

MATERIALS AND METHODS

Babies born at the National University Hospital from March 1999 to February 2001 were screened at

birth using the strategy of measuring Transient Evoked Oto Acoustic Emissions (TEOAE) with the ILO 88 Otodynamics Echoport. The screening was conducted within 24 hours of birth in the majority of patients. The assessment was conducted with the baby at rest, sleeping and about an hour after the last feed. The ambient noise was kept at < 40 dB. Initially, fluid and debris were wiped from the opening of the ear canal. A probe housing a transmitter and a microphone was next placed in the outer ear canal. When the test was begun, the instrument would automatically generate stimuli at different frequencies and intensities; it would then measure the emissions and display the results graphically and numerically. A normal response was assigned when the TEOAEs met the predetermined criteria that specified intensity of response, overall and bandwidth correlation of waveforms and bandwidth signal to noise ratio. This included a bandwidth correlation of both averaged waveforms (all > 50% and one >75%) at 1.6 kHz, 2.4 kHz and 3.2 kHz. The bandwidth signal to noise ratio was to be 5 dB or more in all the 3 bandwidths with a signal to noise ratio of 10 or greater in at least two bandwidths. Babies not meeting these criteria were referred for re-screening at about 2 weeks of age and then at 6 weeks if the criteria was not met at 2 weeks. Those who did not meet the criteria at 6 weeks were labeled as testing positive, deemed to be at risk and referred to Otolaryngology for formal hearing evaluation. At this stage middle ear disease was looked out for, otoacoustic emissions were measured again but with a

diagnostic instrument and if abnormal, auditory brain stem responses were measured.

RESULTS

A total screening rate of 97.2% (4,387 out of 4,514 livebirths) was achieved. A normal screening result was obtained in 92.9% (4,075). Of the 312 testing positive (7.1% of those screened) at 6 weeks, 8 were subsequently proven to have significant (at least moderate loss in one ear) hearing impairment. Four of them required binaural amplification, giving a 1 in 1096 incidence of severe hearing impairment. A specificity, positive predictive value and sensitivity of 93%, 26% and 100% respectively were obtained. In all but one, the diagnosis was made by 7 months of age and interventions set in place within 2 months of diagnosis. Except for 3 cases, all the others did not belong to the group that would have been considered to be at risk for hearing impairment. None of the babies had at the time of diagnosis, behavioural changes suggestive of hearing impairment. The interventions that had been instituted were auditory verbal therapy, sound amplification and cochlear implants.

DISCUSSION

The Joint Committee has proposed the following quality indicators and corresponding benchmarks - % of infants screened at birth (screening rate >95% within 1 month of age); % not meeting screening criteria (a referral rate of 4% or less within 1 year of program initiation); and % of failures returning for follow up (return for follow up rates greater than 70%) (Joint Committee on Infant Hearing). Our screening rate of >97%, and a 85% successful referral rate among those testing positive support the efficiency of our program. The false positive rate of 7.1% is however high when compared to the

proposed benchmark. When comparing the criteria for a pass that we use with that of the Texas EDHI Program, we note major differences that could account for the higher false positive rate (Finitzo *et al*, 1998). The criteria for a pass could therefore be made less stringent without affecting the sensitivity. This is being addressed by studying in detail emission characteristics of the false positives from the true positives. The newer generation of instruments is known to have these criteria modified and their use may bring the false positive rates to the benchmark rates.

We conclude that significant hearing impairment is asymptomatic but not uncommon in infancy, in our population. Our screening strategy was found to be reliable and sensitive. We find mass newborn hearing screening to be beneficial, feasible and effective. A strategy to reduce the high false positive rate needs to be developed.

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