Editorial

Infant Hearing Screening

No disability affects an infant's ability to communicate as severely as hearing impairment Hearing is a vital part of a newborn's contact with his environment and is crucial for the development of speech and language in a naturalistic fashion(l) The most important period for language and speech development is the first three years of life(2)

While the actual incidence of hearing impairment is unknown, prevalence rates in the USA are estimated at 2 1000 for-severe to profound hearing loss and 5 1000 for all types of hearing loss(3,4) Unfortunately, the average age of detection of hearing loss, even in the USA is about 2V£ years(l) No statistics regarding the incidence of hearing loss in infants or average age of detection are available for India This delay in identification is primarily due to the fact that hearing loss is a "silent" disorder and hence there appears to be an underestimation of the role of hearing in learning to communicate, until hearing is impaired or lost(l,2)

Effects of Hearing Impairment

Hearing impairment (which is an invisible condition), not only restricts speech-language development but also adversely affects educational, social, intellectual, emotional and cognitive development(2,3) A child who is identified late may never be at par with his hearing peers m terms of academic performance, intellectual development, or later in the work place The severity of these learning disabilities is generally related to the length of time the hearing loss is left untreated(2) Hence, with hearing impairment we cannot adopt the "wait and watch" attitude, hoping the child "will grow out of it" To reduce the negative effects of hearing loss, it is important to identify hearing impairment and begin amplification and habilitation as early as possible(2)

Benefits of Early Screening

The rationale for screening is based on the premise that early diagnosis, followed by intervention will either prevent or diminish the severity of the disability(3) There is general agreement that early identification and intervention ensures better parent-child bonding, and has a greater potential for normal/near normal speech-language and social development(l-3, 5) Thus intervention enhances the potential of most hearing impaired children to become adults who are fully independent, participating and contributing members of society

Screening Strategies

Screening programs for hearing impairment may be either "universal" or "high-risk" population based A universal screening approach was first reported m 1961 m the UK, where "health visitors" screened hearing in the home, using a behavioral observation technique(3)

In 1969, the Joint Committee on Infant Hearing (JCIH) was established comprising of representatives from Otolaryngology, Pediatrics, Nursing and Audiology and was responsible for making recommendations concerning newborn hearing programs The JCIH, recognizmg the problems associated with universal screening

endorsed the concept of a High Risk Register (HRR) for selecting infants who required hearing assessment Initially, five factors were identified, as placing an infant at increased risk for hearing loss The JCIH revised and expanded the high risk criteria in 1982, 1990 and more recently in 1994 to include 10 risk "factors for neonates(3,4,6)

(1) *Behavioral Observation Techniques*

These were first used to screen hearing of infants in USA in the mid-late 1960s using the auropalpebral response, startle response and limb and head movements to judge a response to high frequency narrow band noise at about 90-100 dBSPL (Sound Pressure Level) This method was time consuming, subjective and identified only infants with bilateral severe to profound high frequency hearing loss It did not provide ear and frequency specific information and had a high false negative rate(3)

(2) *Crib-O-Gram*

A more objective method for screening, is the Crib-O-Gram, which uses a motion sensitive transducer placed under the crib mattress or between the crib and frame The current Crib-O-Gram is an automated microprocessor based unit which presents a narrow band noise of high intensity and measures and interprets an infant's motor response, stronger than an eyeblink or facial grimace(3,7)

(3) *Auditory Response Cradle*

This was developed in the UK as a fully automatic, microprocessor controlled newborn screening device which measured trunk and limb movements, startle responses of the head, infant respiratory pattern with a combination of pressure sensitive mattress and transducers using a high pass noise of 85 dBSPL as the test stimulus (3,7) Both, the Crib-O-Gram and Auditory Response Cradle had limited sensitivity and specificity(3,8).

(4) *Auditory Brainstem Response (ABR)*

This has been recommended for newborn hearing assessment because it is objective, correlates well with hearing, can detect mild and moderate hearing losses as well as severe to profound losses, permits ear specific information, has good performance statistics (sensitivity and specificity), is stable over time, is unaltered by sleep/ sedation as the response is physiological, and can be done at any age (4,5,9,10).

The ABR occurs as a result of synchronous neural activity originating in the auditory nerve and brainstem pathways, arising in the first 10 milliseconds after an auditory stimulus. It is facilitated by a rapid click stimulus presented through headphones and recorded via surface electrodes applied to locations on the skull (vertex and mastoid)(11). The responses are summed up and recorded as a graphic display with vertex positive peaks noted and designated as waves-IV. The waves are described by their amplitude and latency characteristics. The units for latency and amplitude are usually milliseconds and microvolts, respectively(12). Wave V has proven to be the most prominent and robust component of the response pattern(10). The five waveform peaks reflect neurotransmission in the Auditory Response Pathway and give information regarding hearing sensitivity for each ear More recently, an automated ABR technique has become available(3,9). The ALGO 2™ utilizes the automated ABR technique. The ALGO transmits thousands of clicks to the newborn's ears through earphones. Each click generates a specific and identifiable response from the Auditory Brainstem Electrodes on the baby's skin pick up these responses and transmit them to the ALGO. These responses are matched

against a preset pattern /template following which a "PASS" or "REFER" result is generated. The template is biased for the occurrence of Wave V and its trailing negativity, considered the most robust portion of the ABR at the 35 dBnHL stimulus level.

We can obtain a statistically significant number of brainstem responses (result) which match the template in as few as 1000 sweeps/presentations, or it may be necessary to continue averaging to the maximum of 15000 sweeps in order to reach a specified level of confidence. In order for the infant to "PASS", he/she must have a Likelihood Ratio (LR), which is a figure of merit of 160 or greater. If a baby passes the screening one can feel confident that the infant's peripheral auditory system is functioning at a level required for normal speech and language development. If a LR of atleast 160 cannot be obtained in 15000 sweeps, the baby is referred for further testing.

(5) *Transient Evoked Otoacoustic Emissions (TEOAE)*

Transient Evoked Otoacoustic emissions have been introduced for risk register and assessment of newborn hearing. Studies suggest that Otoacoustic Emissions (OAE) can identify infants with hearing loss of approximately >30 dBnHL. This technique measures sounds in the ear canal that are generated and emitted by the outer hair cells of the cochlea in healthy ears in response to acoustic stimuli(3,13,14). A small probe is placed in the ear canal, a seal is obtained and a click stimulus with a 40dB spectrum level is provided. The response is frequency specific and a pass has been defined as the presence of emitted energy having alteast a 3 db signal /noise ratio between 1.6 kHz and 4 kHz(3).

The ABR test is threshold specific while the TEOAE test is frequency specific and is an objective measure of cochlear integrity(3,ll,15).

Currently, the JCIH endorses the goal of universal screening using physiological indicators such as ABR and OAEs, but maintains the role of screening of high risk infants(4).

Hearing Screening Program at the Bai Jerbai Wadia Hospital for Children (BJWHC)

The program at BJWHC is currently committed to screening high risk neonates/ infants for hearing loss using the ALGO 2™ Automated Newborn ABR Screener intended for babies between the age of 37 weeks of gestation and upto 6 months post natal age. Infants screened include those with any of the following risk factors, *i.e.,* family history of hereditary or unexplained deafness since childhood, hyperbilirubinemia, congenital infections (TORCH), craniofacial anomalies, birth weight <1500 grams, bacterial meningitis, birth asphyxia, ototoxic medication, mechanical ventilation, syndromes that include hearing loss. Other risk factors include admission into neonatal ICU (with medical complications including prematurity, seizures, intraventricular hemhorrage, septicemia, apnea), consanguinity, parental concern regarding hearing loss, delayed speech/language development and delayed motor development(4,16,17).

The ALGO screening procedure based on the ABR is simple, convenient, rapid, objective, universal, has a high sensitivity and specificity but has only a binary outcome, *i.e.,* "PASS" or "REFER".

We first screen the baby at 35dBnHL and if the baby "REFERS" we rescreen at 70 dBnHL and 40 dBnHL to determine if the condition causing the original REFER

has cleared. If the baby continues to REFER at this time, we refer them for a complete otologic/audiologic evaluation and initiate parent counselling.

Concluding Comments

The dynamic changes in technology and education may soon make infant hearing screening programs viable in our country. Successful hearing screening programs involve commitment and support from Pediatricians, Health Care Administrators, ENT Surgeons, Physicians, Audiologists, families and caregivers and a community educated about the importance of the relationship between hearing and infant development. The ALGO 2™ screener, is much quicker in comparison to screening using the conventional ABR. In addition, as the testing time is very short, sedation is not required. This screener is much more cost effective, since personnel costs can be reduced by using paramedical staff. Since the ALGO 2™ screener reportedly has a negligible false-negative rate and a low false positive rate, referrals for comprehensive ABR testing are reduced. It is anticipated that through infant hearing screening and intervention programs akin to that followed by us, there would be an accompanying increase in prompt referrals of children at earlier ages for hearing evaluation by parents and professionals alike.

The overall cost of operating such identification and intervention programs would result in significant savings over habilitative costs for hearing loss detected in later years.

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REFERENCES

1. Epstein S, Reilly JS. Sensorineural hearing loss. Pediatr Clin North Am 1989; 36: 1501-1519.
2. Ling D. Foundations of spoken language for hearing impaired children. Washington, Alexander Graham Bell Association for the Deaf, 1989; pp 1-58.
3. Vohr BR, Maxn AB. Screening of infants for hearing impairment. J Pediatr 1996; 128: 710-714.
4. American Speech-Language-Hearing Association. Joint Committee on Infant Hearing 1994, Position Statement. Asha 1994; 36: 38-41.
5. Yellin MW. Auditory brainstem response (ABR) audiometry in the neonatal nursery. Seminars Hearing 1993; 14:155-162.
6. Gravel JS, Marttila J, Nerbonne MA. Report on audiologic screening. Am J Audiol 1995; 4: 24-40.
7. Northern JL, Downs MP. Hearing in Children, 3rd edn. Baltimore, Williams and Wilkins, 1984, pp 247-249.
8. Durieux-Smith A, Picton T, Edwards C, Goodman JT, MacMurray B. The Crib-O-Gram in the NICU: An evaluation based on brain stem electric response audiometry. Ear Hearing 1985; 6: 2-24.
9. Kileny PR. ALGO-1 Automated infant hearing screener: Preliminary results. Seminars Hearing 1987; 8: 125-131.
10. Deorari AK, Garg R, Bisht MS, Ahuja GK, Paul VK, Singh M. Auditory brainstem evoked responses in normal neonates and infants. Indian Pediatr 1989; 26: 981-986.
11. Mason S, McCormick B, Wood S. Auditory brainstem response in pediatric audiology. Arch Dis Child 1988; 63: 465-467.
12. Jacobson JT, Hyde ML. An introduction to Auditory Evoked Potentials. *In:* Hand book of Clinical Audiology, 3rd edn. Ed. Katz J. Baltimore, Williams and Wilkins, 1985; pp 496-497.

13. Ravishankar KC. Oto-Acoustic emissions and their application in hearing screening. Hearing Aid Journal 1995; 9:115-120.

14. Glattke TJ, Kujawa SG. Oto-Acoustic Emissions. Am J Audiol 1991; 1: 29-40.

15. Bonfils P, Uziel A, Pujol R. Screening for auditory dysfunction in infants by evoked oto-acoustic emissions. Arch Otolaryngol-Head Neck Surgery 1988; 114: 887-890.

16. Coplan J. Deafness: Ever Heard of It? Delayed recognition of permanent hearing loss. Pediatrics 1987; 79: 206-213.

17. Watkin PM, Baldwin M, McEnergy G. Neonatal at risk screening and the identification of deafness. Arch Dis child 1991; 90:1130-1135.

18. Anand NK, Gupta AK, Raj H. BERA - a Diagnostic tool in neonatology. Indian Pediatr 1990; (27): 1039-1044.

19. Stein L, Ozdamar O, Kraus N, Paton J. Follow-up of infants screened by auditory brainstem response in the neonatal intensive care unit. J Pediatr 1983; 103: 447-453.

20. Misra PK, Katiyar CP, Kapoor RK, Shukla R, Malik GK, Thakur S. Brainstem auditory evoked response in neonates with birth asphyxia. Indian Pediatr 1997; 34: 199-205.