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Invited Convention Presentations

Editor's Note:

One of the highlights of the first annual convention of the American Academy of Audiology, held at Kiawah Island Resort, in April of 1989, was a special tutorial session on clinical applications of auditory evoked potentials. The session was organized and chaired by Roger Ruth and included formal presentations by John Jacobson, Linda Hood, Nina Kraus, and Therese McGee. Chairperson Ruth introduced the session as follows:

INTRODUCTION

Auditory evoked potentials (AEPs) have become an integral part of the current audiologic test battery. The clinical applications of AEPs range from their use as indicators of auditory sensitivity in patients who either cannot or will not respond in a conventional behavioral test situation, to their use in the diagnosis and monitoring of various otologic and/or neurologic disorders. Given the wide range of clinical applications of this rapidly advancing area of our discipline, the time seems appropriate for a tutorial session on recent trends in AEPs. Of the many topics one might include in such a session, we have elected to cover four fairly circumscribed areas of contemporary interest in the clinical application of AEPs. The following four papers provide a current overview of the following topics:

Issues in Newborn ABR Screening .... John Jacobson
Frequency Specificity of AEP Measures .... Linda Hood
Advances in Auditory Middle Latency Response Testing .... Nina Kraus and Therese McGee
Trends in Clinical Electrocochleography .... Roger Ruth

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Issues in Newborn ABR Screening

John T. Jacobson

Abstract

The introduction of electrophysiologic measures has provided a renewed interest in the early identification of newborns and infants at risk for hearing loss. To date, 14 states have enacted mandatory legislation for newborn hearing screening, whereas other states have incorporated private and hospital-based programs. Although all state and local programs are inherently different, their common goal is to identify hearing loss as early as possible, and to provide appropriate management strategies in the rehabilitative process. While many technical and recording techniques have been established, there remain several unresolved problems associated with newborn screening programs. The purpose of this article is to bring to the forefront several issues of current concern. Major topic areas include screening versus diagnosis, program design, and stimulus variables. A final recommendation regarding the importance of follow-up services is reiterated.

Key Words: Auditory evoked potentials (AEP), auditory brainstem response (ABR), newborn hearing screening, hearing tests, infants, high-risk, hearing disorders

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Although the impetus for infant auditory brainstem response (ABR) investigation had been previously established (Hecox and Galambos, 1974), it was Galambos and colleagues (Galambos, 1978; Schulman-Galambos

and Galambos, 1975; Schulman-Galambos and Galambos, 1979) who first reported newborn ABR screening techniques with high risk infants. Two critical issues evolved that set the stage for the acceptance of ABR as the technique of choice in newborn auditory screening: first, that ABRs provided an objective and reliable means of assessing newborn hearing; and second, that as many as 1 to 50 high risk infants were significantly hearing impaired. This latter revelation has been confirmed and may represent a conservative estimate.

In retrospect, a review of the historic development of ABR screening finds several issues yet to be resolved. Although ABR screening has been subject to critical review (Downs, 1982) much of the criticism is based on: (1) a lack of understanding of the distinction between screening and diagnosis, and (2) a superficial grasp of the principles of screening and test characteristics (Fria, 1985).

SCREEN VERSUS DIAGNOSIS

In the context of test methods, it is necessary to consider precisely what is meant by the term *screening*, versus other terms such as *detailed* or *diagnostic* test. A feature of most so-called screening tests is that they are quick and easy to administer to large populations and they tend to be inexpensive. A screening test is a measure that attempts to sort out apparently healthy persons who probably have a disease from those who probably do not. Positive or suspicious findings dictate referral for diagnosis and treatment. Semantic debates are secondary to the bottom line; that is, a clear distinction can be drawn between the two types of ABR methodology. Clinically, the use of one or two stimulus conditions per ear is a screen; a definitive threshold search and comprehensive neurologic determination of the auditory brainstem pathways is not.

PROGRAM DESIGN

In order to achieve effective and efficient program design, several factors must be taken into account. Some of these basic considerations are who, when, where, and how to test.

Since it is impractical to test all babies, selection rules must be applied to determine who will receive ABR testing. Therefore, each selection process is a test, and it will have its own operating characteristics. For example, even if the ABR screen were totally error-free, a program that includes a prior selection process based on current risk factors will fail to detect most hearing loss of recessive genetic origin. Thus, the determination of risk is the first test in the screening process.

Neonatal intensive care unit (NICU) graduates are a convenient and reasonable target population for the development of early screening programs; many of these babies will have at least one of the Joint Committee risk factors, most often low birth weight and/or asphyxia. It is worthy to note that classical risk factors are biased toward severe sensory impairments that are identifiable at an older age when traditional perceptual test formats become acceptably valid. When the spectrum of disease to be detected is extended, that is, to hearing loss of a less severe nature, it will be necessary to reexamine the risk criteria and their performance.

When to test has become a critical aspect in newborn screening. The primary concerns rest with test validity, error rates, relevance, and practicality. Provided that ABR screening uses correct methodology in a stable resting and quiet infant and in an appropriate environment, there is little reason to suspect significant change in the inherent validity of the ABR over time. However, concerns about ABR test validity have been voiced (Murray et al, 1985).

All too often, screening test validity, especially in high risk neonates, is influenced by indirect factors such as transient middle ear pathology, developmental delay, or neuropathy. Two misleading publications (Marshall et al, 1980; Roberts et al, 1982) almost single handedly reversed the progress that had been made to that point. These authors reported initial failure rates of 21 and 59 percent in a group of critically ill infants, raising serious doubt of the effectiveness of ABR screening in the NICU. A closer analysis of these investigations showed that testing was conducted at a point in time when the effects of maturation and neurologic deficits contributed directly to screening failure rates. Further, all infants were in states of significant compromise, violating a fundamental screening edict, medically stable infant status.

Another issue influencing when to test is the problem of emerging hearing loss. It is important to recognize that hearing loss not yet expressed cannot be detected, and hearing loss that is changing over time is difficult to quantify. Patients with risk factors associated with

emerging dysfunction must be followed periodically, even if ABR results are normal (Nield et al, 1986).

The environment where an infant is tested is critical in the determination of pass-fail criteria. An appropriate setting with reduced ambient noise levels is desirable, but not always possible (Richmond et al, 1986). An ideal testing environment (high S/N ratio) should improve failure rates and operating characteristics.

Regardless of what is theoretically optimal, more mundane and practical considerations may determine when to test. The principle advantage of testing prior to hospital discharge is availability and optimal subject state (quiet).

STIMULUS CONSIDERATIONS

For most audiologists, the presence of a replicable wave V peak component elicited by a click stimulus at one or two presentation levels bilaterally constitutes a screening pass. While there is some deviation, usually 60 to 70 dB HL on the high end and 30 to 40 dB HL on the low end is typical. A review of published screening results concludes that failure at lower intensity levels (30 to 40 dB HL) is most likely associated with transient middle ear pathology, whereas failure at higher levels generally indicates actual sensory deficit. Thus, the use of one high stimulus level may be sufficient to rule out permanent sensory hearing loss while remaining with the guidelines of a true screening format.

One point is clear; the selection of pass-fail intensity will directly affect test operating characteristics. As intensity is lowered, more hearing impaired babies will fail and the sensitivity of the test will improve; however, the false positive rate will increase. In contrast, if a higher intensity is chosen, the false negative rate will increase because more abnormal infants will pass the test, with a concurrent decrease in the false positive rate. Clearly, the question of hearing failure due to middle ear effusion could be virtually eliminated if only a high intensity level was selected for pass-fail criteria.

One final comment regarding the high false positive rates reported in the literature, Jacobson and colleagues (Jacobson and Morehouse, 1984; Hecox and Jacobson, 1984; Jacobson and Jacobson, 1987) have argued that ABR test results correctly reflect hearing status but cannot predict change from unforeseen transient auditory or neurologic pathology. To that dilemma we add technical difficulties associated with ear canal collapse. Fortunately, the introduction of insert transducers have circumvented much of this problem. Recently, we and others (Ruth et al, 1985) have noticed a significant decrease in the number of initial failures that can be directly attributed to ear canal collapse as well as improved ambient noise levels with the use of insert phones.

SUMMARY

The general goals of early hearing screening programs are to detect, quantify, and characterize significant hearing loss in order to facilitate prompt and appropriate intervention. These goals and guidelines have been established in several position statements by the Joint Committee on Infant Hearing (American Speech and Hearing Association, American Academy of Ophthalmology and Otolaryngology and American Academy of Pediatrics. Supplementary statement of the Joint Committee on Infant Hearing, 1974; American Academy of Pediatrics Joint Committee on Infant Hearing. Position statement, 1982). In addition to a list of high risk criteria, the Committee recommends that by 6 months of age, the processes of detecting and describing hearing loss in sufficient detail to provide intervention should be well advanced.

It should be noted that despite Joint Committee directives, follow-up protocols remain the weakest element in the screening program. And while it has been said before, it is worth repeating; without an active follow-up, the initiation of a screening program is indefensible.

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