INTER- AND INTRASUBJECT VARIABILITY OF MIDDLE LATENCY RESPONSE (MLR) AND EFFECTS OF REFERENCE ELECTRODE PLACEMENT

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In

AUDIOLOGY

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INTRODUCTION

INTRODUCTION AND RATIONALE

Auditory evoked potentials (AEPs) were first recognized in the human electroencephalogram (EEG) in 1939. It was, however, not until the introduction of averaging technique to the neurophysiology and the advent of computer in 1961 that the use of AEPs measurements in clinical audiology became feasible. Since that time, there has been a tremendous accumulation of data concerning the AEPs and their clinical applications.

AEPs are a series of far-field, volume-conducted reflections of the stimulus related changes that take place in raw EEG with the presentation of an acoustic stimulus to the listener's ear (Squires and Hecox, 1983). Initially, they were classified according to the site of active electrode placement into vertex potentials (the active electrode placed on the vertex) and electrocochleography (the active electrode placed in the ear) (Davis and Zerlin, 1966). Further subdivision was made by Davis (1976) based on the latency and anatomical site of the potential generators. The various potentials were designated as "first" (0-2msec), "fast" (2-10msec), "middle" (10-50msec), "slow" (50-300msec) and "late" (300+msec). This classification was widely accepted among workers in the field of AEPs and is still valid to date.

During the period of about 10 years from 1963, the slow components of AEPs were extensively investigated for the objective assessment of hearing. However, these responses were reported to be dramatically affected by maturational change, state of arousal and anaesthesia (Zerlin and Davis, 1967 & Picton et al., 1977). Consequently, the enthusiasm for their clinical use has waned.

On the other hand, the fast components of AEPs (auditory brainstem response or ABR), first described by Jewett and Williston (1971), are now the most widely used potentials in the field of clinical audiology. This is mainly due to the fact that they are not altered by subjective changes in arousal (Amadeo and Shagass, 1973), attention (Picton and Hillyard, 1974) or sedation (Goff et al., 1974 & Stockard et al., 1980). This stability made the ABR an available objective and reliable technique in hearing threshold determination as well as in neuro-otologic diagnosis (Selters and Brackman, 1977 & Stockard et al., 1980). Unfortunately, no ABR technique is yet available to define the audiogram into discrete frequencies. Indeed, it was found to correlate well with the high frequency threshold only (Jerger and Mauldin, 1978). Furthermore, the ABR, which has origins from the eighth nerve to the rostral brainstem, samples only an anatomically and functionally restricted portion of the auditory pathway (Lev and Sohmer, 1972 & Hashimoto et al., 1981). The evaluation of the rostral portion of the auditory pathway necessitates the use of other AEPs generated at levels higher than the brainstem.

The middle latency response (MLR), in the 10-50 msec range, was reported to involve neural activities from multiple central auditory structures. These included the primary auditory area, the thalamo-cortical pathways as well as the reticular formation (Cohen, 1982 & Kileny et al., 1987). Many investigators demonstrated that, at least, the early components of the MLR were stable during natural and drug-induced sleep (Mendel and Goldstein, 1971; Picton et al., 1974; Brown 1982 & Ozdamar et al., 1982). Therefore, MLR has become an increasingly popular diagnostic tool in neuro-otologic diagnosis. In addition, MLR, being identifiable near behavioral threshold, may be useful in hearing evaluation especially in the low frequency range (Musiek and Geurkink, 1981 & Hood and Berlin, 1986).

Interpretations of AEPs collected in a clinical setting are clearly dependent on knowledge of the extent of the normal variability of the response. Many authors have reported data regarding the range of normal variability in the ABR including the amplitudes and the absolute latencies of its components and how they are affected both within a given test session and from one test session to the next. On the other hand, few studies were conducted to assess the normal range of the latencies and amplitudes of MLR components, and they were concerned primarily with the range of between-subjects variability. Kraus et al.(1982) reported that, in normal subjects, the range of amplitude of MLR components is rather large. Ozdamar and Kraus (1983) demonstrated that the latency of MLR components showed greater variability (larger standard deviations) than the ABR components. They added that the variability of amplitude across subjects was greater than that of latency. One of the main elements that might contribute to the large variability in the response amplitude is the myogenic contamination that has been frequently reported with the response especially with the mastoid placement of the reference electrode (Ozdamar and Kraus, 1983; Musiek et al., 1984 & Kileny et al., 1987). Consequently, Wood and Wolpaw (1982), Kadobayashi et al. (1984) and Erwin and Buchwald (1986b) suggested extracephalic electrode as a reference electrode, thus minimizing the myogenic contamination.

These limited reports described only one aspect of the MLR variability that was the intersubject one. To the best of the author's knowledge, studies on intrasubject variability have not been reported in the available literature. Both the inter-and intra-subject variability remains to be explored in terms of range, extent and dependency on various variables.

This research was designed to investigate the range of inter-and intra-subject variability of different MLR components among normal hearing subjects and the effects of reference electrode placement on the response variability.

AIMS OF THE WORK

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The objectives of this study were:

1- To determine the extent of inter-and intra-subject variability of MLR latency and amplitude relative to reference electrode placement.

2- To compare the range of variability for different reference electrode placement.

3- To investigate the relation of such variability to its possible underlying causes.

REVIEW OF LITERATURE

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NEUROANATOMY OF THE CENTRAL AUDITORY NERVOUS SYSTEM

The value of an AEP as a diagnostic test can be severely compromised by a lack of knowledge of the anatomy of the central auditory nervous system (CANS) (Musiek, 1986b).

There is a general agreement that the generators of the MLR lie at and above the inferior colliculus (Musiek, 1990). Therefore, to use MLR as a clinical test, the neuroanatomy of the CANS should be well detailed with special emphasis on the area from the inferior colliculus to the cortex.

A great amount of what is known about CANS is based upon data utilizing anatomical techniques to map out "pathways". This was achieved by cutting the brain into slices, staining the tissues and trying to follow the apparent neural tracts or by creating lesions and following the degeneration of nerve fibers from section to section (Durant and Lovrinic, 1984). Recently, a rather exciting method was developed which made it possible to trace pathway of individual neurons using the horseradish peroxidase enzyme (Graybiel and Devor, 1974 & Calford and Aitkin, 1983). Electrophysiological techniques also have been employed extensively, wherein either discharges from single neurons or a large number of nerve cells are recorded (Philips and Irvine, 1979 & Imig and Morel, 1985). Indeed, given the complexity of most cells in the CANS and the multiplicity of interconnections between them, the mapping of "all" the central auditory pathway remains a formidable task.

The CANS, in humans, is a complex and diffuse system with multiple synapses and decussations. It is morphologically organized into ascending and descending pathways (Keith, 1982). Within these pathways, a succession of levels (nuclei) are encompassed where neural processing occurs (Figure 1).

The neural information from each cochlea is transmitted via the cochlear nerve to the cochlear nuclei (CN), situated on the lateral edge of the hindbrain. All eighth nerve fibers synapse on cells in the CN, thus they are considered as an obligatory synapse (Noback, 1985). The CN are the most caudal structures in the CANS. Neuroanatomical studies have identified numerous nuclei in this complex structure, but only three appear to be of primary importance in audition: the antero and postero - ventral cochlear nuclei and the dorsal cochlear nucleus (Durant and Lovrinic, 1984).

From the CN, the neural signals are conveyed via both the contralateral (crossed) and ipsilateral (uncrossed) ascending pathways, with each pathway having a greater contralateral representation (Lynn and Gilroy, 1976). The fibers decussate in three distinctive striae: a dorsal acoustic stria (stria of Monakov), an intermediate stria (stria of Held) and a ventral acoustic stria known as the trapezoid body which is the largest of the three. They terminate in the superior olivary complex (SOC) mainly the medial olive.