IPSILATERAL ACOUSTIC REFLEX VALIDITY IN NORMALS AND SENSORY-NEURAL HEARING LOSS PATIENTS

THESIS

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BY

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بسم الله الرحمن الرحيم

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INTRODUCTION & RATIONALE

INTRODUCTION AND RATIONALE

The HOLY KORAN almost always mentioned Audition before Vision in its verses. This is accepted as a no chance occurrance. It emphasizes the importance of hearing in the development of a vital human function, that is speech and language. While the eyes are protected by the eyelid and by being embedded in the bony orbit, the ear is physically protected by being burried in the stony petrous bone and with the tortious and relatively long, hairy and waxy external acoustic canal.

Much as the eye is protected from its own stimulus, the light, by the involuntary consensual pupillary reflex, the ear is protected from its own stimulus, the sound, by a similar reflex, the acoustic reflex or stapedial reflex.

The acoustic reflex was first described by Metz (1951). It is an involuntary muscular contraction occurring bilaterally in normal-hearing persons even though the stimulating signal is delivered to one ear only. This muscular contraction creates a stiffening effect on the tympanic membrane, thus altering the impedance of the middle ear. Such impedance changes have traditionally been performed in the contralateral ear (crossed reflex). In recent years, available instrumentation permitted impedance changes to take place and be monitored in the stimulated ear. This is referred to as the ipsilateral (uncrossed) reflex.

The value of the ipsilaterally-elicited acoustic reflex is that it yields more sensitive threshold levels than the contralateral one. The difference, however, do not exceed 5 dB, and are not consistently observed for all subjects (Moller, 1962; Fria et al., 1975 and Jerger et al., 1978b).

Indeed, Laukli and Mair (1980), with a commercially available impedancemeter, have shown no significant differences between threshold levels for ipsilaterally versus contralaterally-elicited reflex.

Moreover, Alberti's (1978) findings suggested that, in normal ears at least, excessive decay was less common with ipsilateral stimulation. Borg and Odman (1979), however, reported no ipsilateral versus contralateral differences in decay for normal hearers.

This study was designed to further explore this controversy of ipsi- Vs contralaterally elicited reflex in normals and sensory-neural hearing loss patients.

REVIEW OF LITERATURE

CONCEPT OF IMMITTANCEMETRY

Transfer of acoustical energy from a gaseous medium, to a liquid medium is poor when no matching device is used. This is due to the reflection of acoustic energy back into the first medium. This opposition to the acoustic energy flow is known as the acoustic impedance.

The major function of the middle ear is to overcome the impedance mismatch generated by environmental signals traveling from an air medium to the fluid medium of the cochlea.

When a sound wave enters the external acoustic meatus and touches the tympanic membrane it undergoes the following:

1. Some of the acoustic energy is used to set the tympanic membrane into vibration which is then transmitted to the inner ear through the middle ear.

2. Some of the acoustic energy is absorbed by the surface of the tympanic membrane.

3. The remaining acoustic energy is propagated back towards the source as a reflected wave.

This reflected part of the sound wave is the part which is measured in impedancemetry.

The measurement of acoustic impedance at the eardrum is quite different from any other types of audiometry.

The middle ear mechanical system possesses a certain amount of stiffness, mass and resistance (Onchi, 1949) and the impedance of middle ear is a combination of these variables. The amount of reflected energy from the tympanic membrane depends on the stiffness, mass and resistance of the middle ear mechanical system. The mass and stiffness forces of the impedance complex constitute the reactive components of the total acoustic impedance which is expressed in acoustic ohms.

In current practice, the measurements of acoustic impedance is often inferential (Newman and Fanger, 1973) which means that it is a measurement of the reciprocal of impedance. This ease with which energy flows into or through a system is called acoustic admittance which is expressed in acoustic millimhos. The reciprocal of the reactive and resistance components of the impedance are the susceptance and conductance components of the admittance respectively. Recently, the term 'Immittance' is used either to express the impedance or the admittance (Berlin and Cullen, 1975).

In normal ears, the relative contribution of the mass increases as the frequency of the stimulus increases while, the opposite is true with stiffness.

Mathematically speaking, the complex interaction between the impedance components is expressed by the following equation:

$$Z = \sqrt{R^2 + \left(2\pi fM - \frac{K}{2\pi f}\right)^2}$$

where Z = Total impedance.

R = Resistance.

M = Mass.

F = Frequency.

K = Stiffness.

The percentage of impeded sound increases if the middle ear transformer mechanism becomes stiffer as in:

a) Varying the ear canal pressure, which is the basis of tympanometry.

b) Stimulating the stapedius muscle to contract using high intensity sounds, which is the basis of acoustic reflex elicitation.

c) The presence of some pathological changes in the tympanic membrane or middle ear cavity which interfere with the conduction and propagation of sound waves to the inner ear.

The concept of impedance measurements can be illustrated into two types of measurements:

1. Static Measurements:

These are done with ambient air pressure in the external ear canal while the middle ear muscles are in a state of normal tonus. Such measurements reflect the transmission character of the middle ear and is, therefore, of primary value in the differential diagnosis of conductive pathologies.

2. Dynamic Measurements:

These refer to measurements of acoustic impedance in the presence of dynamic changes within and around the middle ear cavity such as contraction of the intratympanic muscles and changes of pressure in the external ear canal. This measurements include the tympanometry and acoustic reflex testing of the immittancemetry.

HISTORICAL BACKGROUND

To measure the impedance of the tympanic membrane as a mean of assessing the middle ear function objectively have been constantly attempted over the years. Metz (1946) stated that the first paper which directly treated the impedance of the tympanic membrane was written by Lucae in

1867. Lucae (1867) developed an instrument which he called The Interference Otoscope(Fig. 1) and used it to study the sound reflection characteristics of human tympanic membrane in both cadavers and living persons. With the use of this instrument one could make a qualitative Judgement regarding the sound absorption differences between the two ears or changes of absorption resulting from intentional events. These events included maniplulations of the tensor tympani tendon in cadavers and voluntary middle ear muscle contractions and the effects of pressure changes within the middle ear on the living subjects.

Schuster (1934) developed a mechanical acoustic impedance bridge that could be used to determine the acoustic impedance of various materials. This instrument was the basis of another mechanical bridge introduced by Metz in 1946 for use as a clinical tool for the measurements of acoustic impedance. In the Metz mechanical bridge, the impulse on the side of the bridge coupled to the ear could be matched by a variable resistance and volume. These served as the resistance and stiffness components on the variable side of the bridge (Fig. 2).

In the United States, Zwislocki (1957) developed the basis for the first commercially-produced mechanical impedance instrument, later to be manufactured by the Grason Stadler company (Zwislocki, 1963), (Fig. 3).