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ORIGINAL ARTICLE

Post Auricular Muscle Response in Auditory Neuropathy

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Background and Objective: Auditory neuropathy (AN) is a term used to describe specific hearing disorder with abnormal auditory neural responses in the presence of normal cochlear function. Post Auricular Muscles Response (PAMR) is a sound evoked myogenic potential could be useful for hearing evaluation. Though the exact pathway of the PAMR is not known in human, however it is a brainstem reflex. Theoretically, the absent acoustic reflex in AN may be indicative for abnormal PAMR as well .The aim of this study is to investigate the PAMR in patients with AN.

Materials and Methods: The study group consisted of 20 adult patients with AN while the control group consisted of 10 normal subjects of matched age and gender distribution.

Results: PAMR response was recorded in the entire control group. The PAMR threshold was within 20 dB SL of the pure tone average of frequencies 1, 2 and 4 kHz in the control group. In contrast all AN patients showed abnormal PAMR response. PAMR was absent in 90% (18/20) of AN patients, and in the remaining 10% (2/20) the response was elicited only on 90 dB nHL stimulus level with delayed peak latency and poor wave morphology.

Conclusions: The PAMR is either absent or abnormal in AN, this prevents its use as an objective tool for hearing assessment in AN. However, PAMR could be an addition for the audiological test battery to detect AN. Further studies is recommended to investigate the neurodiagnostic value of PAMR .

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Introduction

Post auricular muscle response (PAMR) is a large sound evoked myogenic compound action potentials could be recorded over the post auricular muscle located behind the pinna. It was first identified by Kiang et al. [1]. The response consists of a simple bipolar compound action potential with a first peak latency of between 12.5 and 15 ms, depending on the stimulus intensity and post auricular muscle tone. It has a frequency spectrum mostly between 25 and 200 Hz. Unlike ABR and OAE, PAMR is a muscular response, it is much larger than a neural response and hence requires less averaging to obtain a robust waveform, and is optimally recorded when subjects are awake [2].

During the 1970s and 80s, prior to ABR becoming a popular clinical tool for hearing threshold estimation, PAMR was recommended as an objective hearing test for young children [3]. However, it has been ignored in last 20 years due to the large variability within and between subjects [4]. Patuzzi and colleagues found that PAMR could be reliably recorded in adult when recording stimuli and parameters are optimal [2, 4-7]

The exact pathway of the PAMR is not known in human, however it is a brainstem reflex most likely including structures such as cochlear nuclei, superior olivary complex, lateral laminscus nucleus and possibly the inferior colliculus. The afferent portion of PAMR is the auditory nerve, while the efferent portion is the facial nerve [8].

Auditory neuropathy (AN) is an auditory nerve disorder characterized by abnormal ABR though presence of normal outer hair cell function as evidenced by the presence of OAEs and/or CM. The possible sites of pathology include auditory nerve, inner hair cells, or their synapses. Recently ,auditory neuropathy is classified according to the site of neural affection into two types; Type I AN is a postsynaptic disorder involving both the number and functions of auditory nerves and Type II AN is a pre-synaptic

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disorder affecting inner hair cells' ability to form and/or release neurotransmitters [9].

In AN patients, the acoustic reflex, which is another brainstem reflex, is usually absent to the ipsilateral and contralateral stimulation at a 110-dB hearing level [9]. Theoretically the PAMR may be an objective method for hearing assessment in AN yet the absent acoustic reflex may be indicative for abnormal PAMR as well. The aim of this study is to investigate the PAMR in patients with AN and its value for hearing detection.(for authors best knowledge PAMR was not investigated before in AN patients).

Materials and Methods

The study group consisted of 20 subjects (12 males and 8 females) with age range 18-42 years. They were selected from our out patient clinic records of auditory neuropathy patients. The control group consisted of 10 normal hearing subjects with equal sex distribution, and age range 20-45 years. The procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 1983. All the patients participated in this study were informed and they gave their consent prior to study.

The inclusion criteria of the study (AN) group were:

(1) Bilateral sensorineural hearing loss

(2) Poor speech discrimination out of proportion to the degree and configuration of hearing loss

(3) Normal middle ear function with abnormal (absent or elevated) acoustic reflex.

(4) Absent ABR waves. (5) Preserved otoacoustic emissions OR present cochlear microphonics (CM)

While the inclusion criteria of the control group were: (1) Normal hearing (2) Excellent speech discrimination. (3) Normal middle ear function with normal acoustic reflex. (4) Normal ABR

All subjects included in this study were subjected to the following:

(1) Pure tone for octave frequencies (250-8,000) Hz and speech audiometry using Madsen, Orbiter 922 audiometr calibrated according to ANSI (1969)

(2) Immittancemetry including tympanometry and acoustic reflex threshold measurement using AZ 7 immittancemeter

(3) ABR using Vivosonic Integrity System

(4) PAMR using Vivosonic Integrity System

The patients with AN group were subjected to CM testing as well, using Vivosonic Integrity System in order to confirm the cochlear status during time of evaluation.

ABR and CM recording criteria

Clicks were ipsilaterally presented through ER-3A insert earphones to record ABR and CM at 27 pulses per second, for ABR testing rarefaction clicks were delivered starting at 90 dB nHL. The stimulus level was expected to decrease in 10 dB steps if repeatable and identifiable ABR waves were obtained till reaching the threshold. For CM testing clicks intensity were 85 dBnHL to avoid excessive stimulus artifact, and "Alternating split" mode was applied whereas alternating polarity clicks are delivered.

The high pass filter was 30 Hz with 12 dB/ octave rejection rate, low pass filter was 1500 Hz with 24 dB/ octave rejection rate. Active (non inverted) electrode was placed on high forehead (Fz), the reference (inverted) electrode was placed on ipsilateral mastoid according to the tested ear. The ground electrode was applied to the contra lateral mastoid. The response was recorded in 10 m sec. window.

PAMR recording parameters

During PAMR recording the tested subject was asked to turn his eyes toward the tested ear. These maneuvers were found to markedly increase the amplitude of the PAMR response. Clicks were ipsilaterally presented through ER-3A insert earphones to record PAMR at 27 pulses per second, rarefaction clicks were delivered starting at 90 dB nHL. The stimulus level was expected to decrease in 10 dB steps if repeatable and identifiable PAMR waves were obtained till reaching the threshold.

The high pass filter was 30 Hz with 12 dB/ octave rejection rate, low pass filter was 1,000 Hz with 24 dB/ octave rejection rate. Active (non inverted) electrode was placed on ipsilateral mastoid (M1 left mastoid, and M2 right mastoid), the reference (inverted) electrode was placed on dorsum of the ear pinna of the tested ear. The ground electrode was applied to the high forehead (Fz). The response was recorded in 30 m sec-window.

Results

The study group consisted of 20 subjects (12 males and 8 females) with age range 18-42 years (mean age 29 years, SD 6.8). The control group consisted of 10

subjects with equal sex distribution, and age range 20-45 years (mean age 31 years, SD 7.4).Both groups were matched as regards age and gender distribution. (p>0.05)

I-The control group:

According to the selection criteria , all subjects had normal hearing with excellent speech discrimination (Table 1). All subjects had type (A) tympanogram with normal acoustic reflex threshold (Table 2).

Table 1. Mean and SD of pure tone audiometry and speech audiometry of the control group (20 ears).

	Mean	SD	Range
250 Hz	16.5	5.2	10-25
500 Hz	16.5	5.6	10-25
1 kHz	14	6	5-25
2 kHz	15	6	5-25
4 kHz	13	7.3	5-25
8 kHz	15	6.5	5-25
SRT	18	4.7	10-25
WDS	95.6	3.4	92-100

SRT: speech reception threshold, WDS: word discrimination scores.

Table 2. Mean and SD of the contralateral acoustic reflex threshold of the control group.

	Mean	SD	Range
500 Hz	88.5	4.6	80-95
1 kHz	88	5.2	80-95
2 kHz	88	4.1	80-95
4 kHz	89	3.7	85-95

All the subjects in the control group gave repeatable well identifiable ABR waves on ipsilateral stimulation of both ears using 90 dB nHL with normal absolute and interpeak latencies and absent interaural latency differences. Wave V was traced down to 30 dB nHL in the entire control group.

PAMR in the control group:

In this study gave mostly biphasic PAMR with the first negative (Ni) trough at. with mean (13.6 m sec SD1.79) and the positive peak (Pii) at (18.57 m sec SD2.07) at 90 dBnHL.

The range of PAMR threshold in this study was 30-50 dB nHL (mean= 38.5 and SD 4.9) this is about 24.5 dB above the behavioral threshold. (Figure 1) shows the PAMR in the right ear of one subject of the control group.

Table 3. Mean and SD of pure tone audiometry and speech audiometry of the study group (20 ears).

	Mean	SD	Range
250 Hz	42	14.1	20-65
500 Hz	40.9	12.2	25-65
1 kHz	36.1	13.8	20-60
2 kHz	38	11.9	20-60
4 kHz	39	13	20-65
8 kHz	41.5	13	20-65
SDT	33.3	11.8	20-55
WDS	22.3	11.2	0-56

II- The study group

According to the selection criteria, AN group had sensorineural hearing with very poor speech discrimination (Table 3). All subjects had type (A) tympanogram with Abnormal acoustic reflex threshold (Table 4).

The entire study group gave no ABR waves with presence of CM.

Only one patient in the study group gave acoustic reflex in his ears on contralateral stimulation at levels higher than 105 dB nHL. The rest of the study group (19 patients, 38 ears) gave no ipsilateral or contralateral acoustic reflex.

Table 4. Different audiological findings in the study group

	ABR	CM	PTA	AR	PAMR
Patient (A)	absent	present	23.3	absent	abnormal
Patient (B)	absent	present	51.7	absent	abnormal
Patient (C)	absent	present	35	abnormal	absent
Seventeen patients	absent	present	37.9	absent	absent

PAMR in the study group:

The PAMR was absent in the entire study group, but 2 patients. In these 2 patients the PAMR was present only at 90 dB nHL with reduced amplitude. (Table 1, Figure 2)

Discussion

Control group:

Tables 1 and 2 shows that control group had normal hearing sensitivity, excellent speech discrimination, and normal acoustic reflex threshold. The detection of normal ABR response confirms the normal hearing and normal auditory pathway in the control group

PAMR in the control group:

The PAMR response may be biphasic (Ni and Pii) or triphasic (Pi, Ni and Pii) according to the recording filter pass band [2]. In this study the responses were mainly biphasic. (13.6 msec±1.79) and the positive peak (Pii) at (18.57 msec ± 2.07) at 90 dBnHL. The PAMR threshold mean in this study was 38.5 this is about 24.5 dB above the behavioral threshold average of the 1-4 kHz which is 4 dB higher than the finding of Yoshie and Okudaira [3].

Purdy et al. [7] reported many conditions that increase the PAMR, looking toward the tested ear proved to be effective methods in this study. Asking the subjects to slightly open the mouth resulted in marked increase in the PAMR.The detection of PAMR in all of the control group supports the assumption reported by Patuzzi and Thomson [4] that PAMR can be reliably recorded in most adults when recording and stimulus parameters are optimal.

II- The study group

Table 3 shows the pure tone and speech audiometry results of the study group. SRT was not applicable in this group because of their poor speech discrimination abilities, so it was replaced by SDT. Table 4 shows the results of ABR, CM, acoustic reflex testing and PAMR in the study group. The findings in tables [3] and [4] agrees with diagnostic criteria of AN as reported by Colm et al. [9]

PAMR in the study group:

Among twenty AN patients only two patients had PAMR on using 90 dB nHL stimulus level and no response could be elicited on using lower stimulus level, though the hearing thresholds average in those patients were only 23 and 51 dBHL ,which assumed not abolish to the detection of PAMR at levels lower than 90 dB nHL. i.e. the PAMR was absent in (18/20) 90% of the study group and abnormal in (2/20) 10%. Not only the PAMR of the 2 patients were of lower amplitude compared to responses of the control group, but also it had broader, slightly delayed peaks. No statistical analysis could be done to validate these observations due to the very small number of positive results in the study group.

Neurophysiological studies have shown that the neurons in auditory nerve and auditory brainstem structures such as the cochlear nucleus and superior olive are sensitive to microsecond changes of the acoustic signal. The neural code for such temporal events provide signals for such daily processes as speech comprehension and localizing sound sources.

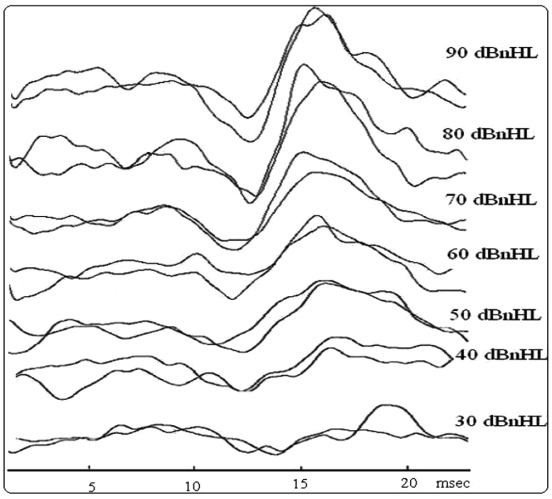

Figure 1. PAMR in the right ear of one subject of the control group

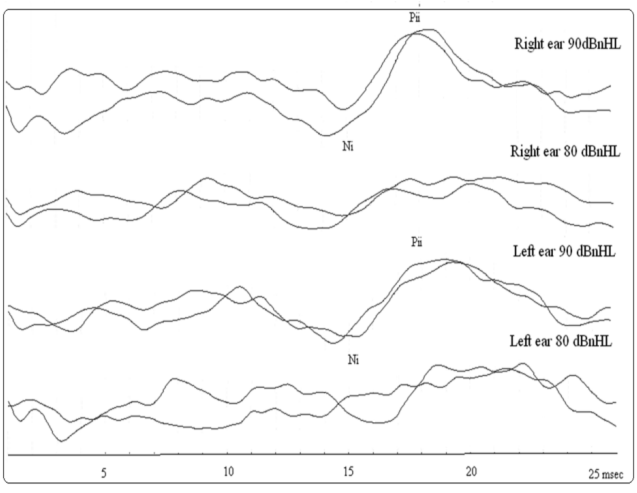

Figure 2. PAMR in AN patient (A)

In AN patients, the altered temporal synchrony of auditory nerve is assumed to be responsible for the failure to detect ABR disproportionately to the degree of hearing loss findings [10]. As the afferent portion of PAMR is the auditory nerve, thus such temporal dys-synchrony could attribute to the absent or abnormal PAMR as well in this study.

Although, PAMR and acoustic reflexes share the afferent portion which is the auditory nerve, and the efferent portion which is the facial nerve, In the current study the two AN patients who had PAMR they did not have acoustic reflex. Another patient who had abnormal AR ,the PAMR was absent. These results reflect the lack of association between the presence or absence of abnormal AR and the abnormal PAMR. But again the very small number of the observations might render such assumption invalid. However, in this study both PAMR and AR were indicative of abnormal pathological process that affects the auditory brainstem pathway. Similarly , previous study showed no relationship between the presence or absence of AR and PAMR in the prognosis of peripheral facial nerve palsy but in large number (83) of patients, although the presence of either one was useful for estimating the prognosis [11].

In conclusion PAMR is either absent or abnormal in AN. This reflect the abnormal pathological process of AN affecting the PAMR reflex pathway. So PAMR could be an addition for the audiological test battery to detect AN but this render it invalid objective diagnostic tool for hearing assessment in those patients. Further studies is recommended to investigate the neurodiagnostic value of PAMR .

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