
Vestibular evaluation of patients with unilateral subjective idiopathic tinnitus

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Abstract

Introduction: Objectives: To determine the value of vestibular evaluation by Vestibular Evoked Myogenic Potential (VEMP), and Videonystagmography (VNG) tests in patients with unilateral subjective idiopathic tinnitus (SIT).

Method: Fifty patients with unilateral (SIT) (studied group) and 25 normal healthy volunteers (control group) were included in this study. The studied group was classified to tinnitus and non-tinnitus ears. VEMP and VNG tests was done to both groups in Audio-vestibular medicine unit of Assiut University Hospital from 2015 to 2018.

Results: The results of both groups compared to each other and we found that VEMP response was present in 46 (92%) and absent in 4 (8%) in non-tinnitus ears, while response was present in 42 (84%) and absent in 8 (16%) in tinnitus ears among studied group. There is statistically significant difference in P1-N1 amplitude, P1 Latency and N1 Latency between tinnitus and non-tinnitus ears. Also, lower VEMP amplitude in tinnitus ears was recorded in comparison to non-tinnitus ears and control ear.

Conclusion: Vestibular system can be affected in patients with unilateral SIT and this may be a potential detector of asymptomatic endolymphatic hydrops.

Keywords: VEMP, VNG, Subjective Idiopathic Tinnitus

Introduction

Tinnitus is defined as the perception of sound in the absence of acoustic events. This sound perception or noise come from the ears or head ranges from a barely noticeable annoyance to a debilitating chronic condition.¹

Subjective idiopathic tinnitus (SIT), is a neurotologic disorder of the cochleovestibular system, which may be acute or chronic in its clinical course, it may interfere with the lifestyle of the patient. Despite attempts over many years to identify an underlying cause of tinnitus, its site of lesion and pathophysiology, tinnitus remains a disorder that can be categorized as idiopathic.^{2,3}

Tinnitus is one of the three symptoms that characterize Meniere's disease. Shulman A, & Goldstein B suggested that SIT may be the initial symptom of a delayed or Secondary Endolymphatic Hydrops (SEH). They suggested that the SEH in SIT patients may be the mechanism for clinical types of tinnitus, identified as a vestibular and/or cochlear type tinnitus occurring alone or in combination.⁴

VEMP is a neurophysiological assessment technique to evaluate the patient vestibular function.^{5,6} The VEMP response is not mediated by the cochlea. The neurophysiologic and clinical data indicate that VEMP is

mediated by a pathway that includes the saccular macula, inferior vestibular nerve, lateral vestibular nucleus, lateral vestibulospinal tract, and motoneurons of the ipsilateral SCM muscle.⁷

It could be useful in the analysis of saccular and vestibulospinal tract function, detecting pathologies in inferior vestibular nerve and diagnosis of the Meniere's disease. Saccular afferents stimulate VEMP response and this disease in early stages, affects saccular function, so this is clear that the altered saccule has different function and will cause changes in VEMP test result.⁸

VNG is a complete diagnostic system for recording, analyzing, and reporting eye movements using video imaging technology. VNG includes a series of tests used to determine whether a vestibular disease may be causing a balance or dizziness problem; VNG can differentiate between a central and a peripheral vestibular lesion, and, if peripheral, it can distinguish between unilateral and bilateral vestibular loss. VNG therefore could address the functionality of each ear.⁹

Dizziness and vertigo have only been mentioned sometimes by tinnitus patients. So, vestibular function is not often studied. Some authors suggested a hypothetical possibility of the vestibular system impairment in those patients.¹⁰ Many patients with tinnitus display abnormal vestibular test results even in the absence of vertigo or other balance disorders.¹¹ We planned to determine the value of vestibular evaluation by VEMP and VNG tests in patients with unilateral SIT in this study.

Patients and Methods:

Patients:

Our study consisted of two groups of patients attended to the Audio-vestibular

medicine unit of Assiut University Hospital, during the period between June 2015 to February 2018.

The studied group: consisted of 50 patients with unilateral SIT. The control group: consisted of 25 normal healthy volunteers. Age of all subjects in both groups ranged from 20 years old up to 50 years old.

We included in our study patients with unilateral SIT, normal hearing sensitivity not exceeding 25 dB in the frequencies from 250 Hz to 8000Hz, normal middle ear function, normal ABR neuro-otologic and normal MRI to exclude any possibility of lower brainstem or retro-cochlear lesions.

Subjects with any of the following were excluded from the study group: History of hearing loss, middle ear disease, trauma, intake of ototoxic drugs, exposure to risky noise. Also, we excluded subjects with neurological disorders, pulsatile tinnitus, bilateral tinnitus, abnormal ABR neuro-otologic and abnormal MRI findings.

This study was approved by the Institutional Ethics and Research Committee of the Faculty of Medicine, Assiut University, Assiut, Egypt. The whole study was explained to the patients and a written consent was taken. They were completely free to be included in the study or not.

Equipment:

A-Dual channel clinical audiometer (Madsen model Orbiter 922, GN Otometrics, Copenhagen, Denmark). B-Immitancemeter (Impedance audiometer, Interacoustics AZ 26, Denmark). C-Otometrics VNG (GN Otometrics Demo Facility). D-Intelligent Hearing System for VEMP and Auditory Brainstem Response (ABR).

Method:

All subjects in the current work were subjected to the following: Full history

taking, ENT examination, neurological examination, audiological evaluation in the form of: Pure tone and speech audiometry, Immittance, ABR, Vestibular evaluation by using VEMP and VNG tests.

Regarding VEMP test, EMG activity of sternocleidomastoid muscle (SCM) was recorded from the upper half of each SCM muscle using surface electrodes (active electrode), with a reference electrode on the upper edge of the sternum and a ground electrode on the forehead.

Supra-aural headphone was conducting the stimulus. During recording, the subjects remained in the sitting position. They were instructed to keep their heads held up and rotated to the opposite side (head-rotation technique). The EMG signals were amplified, bandpass filtered between 30 and 3000 Hz. Acoustic stimuli using 95 dB, short tone bursts (500 Hz) Binaural acoustic stimulation with bilateral recordings was used. The stimulation rate was 5/sec, analysis time for each response was 60 msec, and 200 responses were averaged for each run.¹²

Measurements made on VEMP response were the latency of the first positive peak (P1), latency of the next negative peak (N1), and the amplitude difference between the P1 and N1 amplitude. Thus, VEMP responses were termed 'present' if biphasic P1-N1 waveform was present and reproducible and termed 'absent' when the biphasic waveform is lacking. The analyzed VEMP parameters were: P1-N1 corrected amplitude (A), P1-N1 asymmetric ratio (AR), P1 Latency, N1 latency. AR was calculated using the following formula: $AR\% = 100 \times (\text{large corrected amplitude} - \text{small corrected amplitude}) / (\text{sum of corrected amplitude})$, corrected amplitudes obtained from stimulating each ear.¹³

An AR of more than the 95% confidence interval of the mean of the

AR in the control group between the two sides was considered pathological. VNG test battery as the following was done: (1) Spontaneous nystagmus test (with and without fixation). (2) Oculomotor function: gaze, fixation, saccade, tracking (pursuit), and optokinetics. (3) Positioning / positional testing tests. (4) Monothermal caloric Test: the subject was placed on supine position with head elevated 30 degrees, in order to make the horizontal canal vertical, and stimulation was done with ice water 10°C, 2 cm of water are drawn into syringe and infused into ear canal, the patient maintain his head position for 20 seconds with the water in place.

Proper mental tasks were given, and nystagmus was recorded. The abnormalities of horizontal canal function, asymmetry of reaction and unilateral weakness were calculated according to the formula of $(\text{larger ear response} - \text{smaller ear response}) / \text{total} \times 100$ and canal weakness if asymmetry more than 20%.¹⁴ Fixation suppression was calculated or observed.¹⁵

Statistical analysis:

We analyzed the data using statistical package for the social science for Windows 19.0 (SPSS Inc., Chicago, Illinois, USA). Data expressed as mean, standard deviation, number, and percentage. Mann Whitney test, sample T-test and Anova T-test were used to determine significance for numeric variables. Chi Square was used to determine significance for categorical variables.

Results:

According to demographic data and history we found that there was no statistically significant difference in age and gender between studied and control group this shown in Table (1).

Table (1): Shows comparison between studied group and control regarding demographic data.

| Parameters | Studied group N=50 | Control N=25 | P-value |
|--------------------------|-----------------------|-----------------|-------------|
| Age (years): Mean +SD | 40.6±6.42 | 42±5.3 | 0.074 NS |
| Gender: | | | |
| Male | 19 (38.0%) | 9 (36.0%) | 0.86 NS |
| Female | 31 (62.0%) | 16 (64.0%) | |

NS: No statistically significant difference, $P > 0.05$.

We found that the right ear 28 (56%) more commonly affected with tinnitus than the left ear 22 (44%) in our studied group. When compared VEMP parameters between groups we found that there is no statistically significant difference in P1-N1 amplitude, P1 Latency and N1 latency between control and non-tinnitus ears, while there was statistically significant difference between control and tinnitus ears in P1-N1 amplitude and N1 latency. Table (2)

Table (2): Shows comparison between control and tinnitus ears.

| Parameters | Control Mean±SD | Tinnitus ears Mean±SD | P Value |
|--|--------------------|--------------------------|----------|
| P1-N1 amplitude (μv) | 72.15±14.75 | 45.87±37.73 | <0.001** |
| P1 Latency milliseconds | 14.14±1.84 | 13.27±6.26 | 0.345 |
| N1 Latency milliseconds | 23.59±1.45 | 19.66±9.05 | 0.003** |

Sample T-test

* Statistically significant difference ($p < 0.05$),

**Highly statistically significant difference ($p < 0.01$).

There was statistically significant difference between non-tinnitus and tinnitus ears in VEMP parameters (P1-N1 amplitude, N1 and P1 latency) Table (3).

When we compared between the three groups, we found that there was

statistically significant difference in P1-N1 amplitude and N1 latency and there was no statistically significant difference in P1 Latency as shown in Table (4)

There is significant difference in asymmetry ratio between the studied and control group. Table (5)

The difference in amplitude between tinnitus and non-tinnitus ears is demonstrated in Figure (1).

Regarding the VNG tests in the studied group, we demonstrate that there was neither spontaneous nor gaze nystagmus. There was nystagmus in positioning and positional tests in about 30 to 34% of patients. There was unilateral caloric weakness in 3 patients that represent (6%). Also, there was abnormality in oculomotor tests that represent 12% in saccade and pursuit tests. Table (6)

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Sample T-test

* Statistically significant difference (p<0.05),

** Highly statistically significant difference (p<0.01).

Table (4): Shows difference between control, tinnitus and non-tinnitus ears:

| | Control | Non-tinnitus ear | Tinnitus ear | P .value |
|------------------------|-------------------|-------------------|-------------------|----------|
| P1-N1 Amplitude | 72.15 \pm 14.75 | 63.36 \pm 48.13 | 45.87 \pm 37.73 | 0.002** |
| P1 Latency | 13.27 \pm 6.26 | 15 \pm 5.13 | 14.14 \pm 1.84 | 0.198 |
| N1 Latency | 19.66 \pm 9.05 | 22.28 \pm 7.44 | 23.59 \pm 1.45 | 0.015* |

Anova T-test

* Statistically significant difference (p<0.05).

** Highly statistically significant difference (p<0.01).

Table (5): Comparison between the Asymmetry ratio for both groups.

| Asymmetry ratio: | Study(n=50) | Control(n=25) | P-value |
|------------------|----------------|-----------------|-----------|
| Mean \pm SD | 22.62 \pm 30 | 3.85 \pm 3.15 | <0.001 S* |
| Range | 11.1 – 94.7 | 22 – 67 | |

Mann Whitney test

* Highly statistically significant difference (p<0.01).

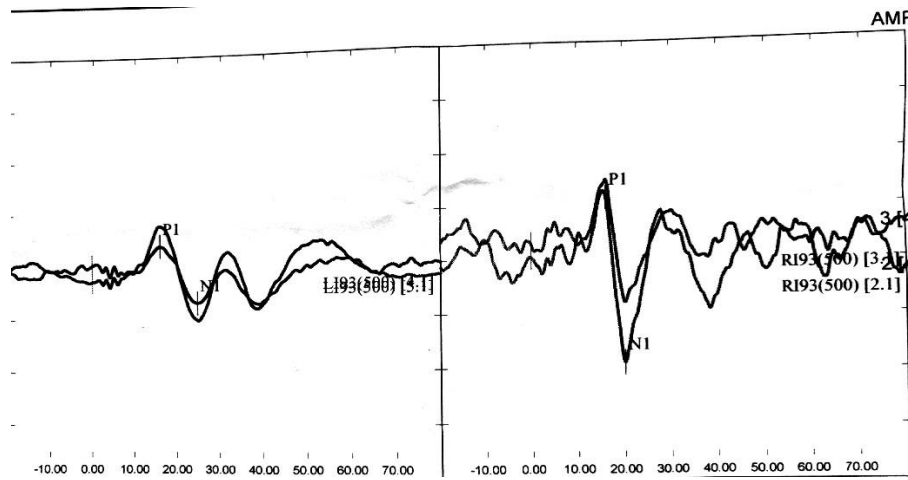


Figure (1): Shows the difference in P1-N1 amplitude between the right and the left ear with lower amplitude in the left ear of a studied patient.

Table (6): VNG tests finding in the studied group

| VNG tests | Abnormal | (%) |
|--------------------------------|----------|-----|
| Spontaneous nystagmus test | 0 | 0 |
| Gaze nystagmus test | 0 | 0 |
| Post head shaking test | 17 | 34% |
| positional head tests | 15 | 30% |
| Nystagmus in Dix-hallpike test | 17 | 34% |
| Unilateral caloric weakness | 3 | 6% |
| Saccade test | 6 | 12% |
| Pursuit test | 6 | 12% |
| Optokinetic test | 0 | 0 |

Discussion :

Tinnitus is one of three otoneurological manifestation together with sensorineural hearing loss and dizziness being in many cases the main patient complaint. Audiological evaluation is usually performed as a routine investigation in tinnitus patient. However, vestibular assessment is not routinely done.

Tinnitus occurrence in individuals with normal hearing can be explained by diffuse damage of outer ciliated cells in all spirals of cochlear duct, without affection of the hearing thresholds, the same theory could be proposed in vestibular end organ also. This fact

signals the indication for a complete evaluation of audiological and vestibular systems in patients with tinnitus.

Many investigators recommended the use of vestibular examination in: Screening for retro cochlear lesion and acoustic tumor, Patients receiving ototoxic drugs, Patients with tinnitus related to metabolic diseases.¹⁶⁻¹⁹

But few investigators have recommended the use of vestibular evaluation in the battery of assessment of patients with SIT and emphasize the importance of audiologist and otologist working as a team to establish the correct diagnosis at early stage and consequently plan for proper management. In the diagnosis of Meniere's disease (MD), otoneurological

evaluation is used to help in staging the disease.²⁰

Tinnitus with normal hearing ear and has abnormal VEMP is considered pre-symptomatic and ear with normal VEMP may be considered asymptomatic ear. VEMP is sensitive to structural change in saccule indicative of asymptomatic or pre-symptomatic endolymphatic hydrops, a possible harbinger of evolving bilateral MD. Literatures about MD suggest that progression from unilateral to bilateral disease is seen in approximately one third of cases.^{21,22}

Bilateral involvement was seen in approximately 1/3 of Meniere's patients.²³ Saccular hydrops appeared to precede symptoms in bilateral MD. Change in VEMP appears to be sensitive to these structural changes in the saccule, then VEMP may be useful as a detector of a symptomatic saccular hydrops and as a predictor of evolving bilateral MD. Results of the current study showed that P1-N1 VEMP amplitude was substantially affected in patients with SIT, compared to control ears, some of SIT patient demonstrated either absent VEMP response, reduced P1-N1 amplitude, or abnormally AR. Furthermore, tinnitus ears with intact VEMP response had smaller mean P1-N1 amplitude compared to the control ears and compared to non-tinnitus ears. SIT patient ears had statistically significant difference in AR compared to control ears.

The reduced VEMP amplitude in the non-tinnitus ears suggests occult or subclinical hydrops in the assumingly normal or un-affected ears. We found low P1-N1 amplitude of non-tinnitus ears compared to control however there were no statistically significant difference between both groups. A significant minority of patients with MD eventually develop involvement of the second ear a situation with a profound impact on patients' symptoms, quality of

life, and management options.

In dysfunctions of saccule or inferior vestibular nerve, the affection described as asymmetry of amplitude or absence of response in the affected side, showing reflex blockage. The affection usually starts with vestibular affection as noticed from alteration in VEMP response whether prolongation of latencies, absent or reduced amplitude of P13-N23 waves. Prolongation of latency suggests retro-labyrinthine damage, especially of the vestibular-spinal tract.

These results may explain the fact that the vestibular system being more robust than cochlear part, which is more rapidly affected.^{22,24-26} Our study support Shulman's concept (4) and some of literature that tinnitus might be the initial symptoms of SEH. Our finding is the Lower VEMP amplitude in the affected ear with tinnitus in comparison to unaffected ear may support this fact. If this is proved to be true, we should expect those patients progressively to develop other symptoms of endolymphatic hydrops such as SNHL and clinical vestibular dysfunction.^{17,27-29}

Clinically the prospect of a test for pre-symptomatic hydrops is exciting. It is conceivable that VEMP could be used to differentiate pre-Meniere's patients at high risk of developing full blown MD from non-Meniere's patient such as patients with vestibular migraine.³⁰⁻³¹

Initiation of Meniere's treatment such as dietary restriction or diuretics in pre-symptomatic patients may be more effective at preventing progression to overt symptoms than at relieving symptoms in an ear of a patient with full blown disease. Similarly, Meniere's like VEMP changes in the asymptomatic ear of a patients with unilateral MD would indicate occult bilateral disease.²⁹

Some patients with tinnitus have altered vestibular test results, even in the absence of vestibular symptoms.³²⁻³³ Also, Seabra et al.³⁴ observed normal

ENG recordings in only one-third of patients in a tinnitus group. Elfouly et al.,²⁹ found also, that VNG abnormalities in Meniere patients and 21.36% of them had unilateral canal weakness. They suggest the possibility of abnormal central vestibular system function without neuroradiographically apparent structural changes in tinnitus patients. It may be due to some psychometric features, such as inattention and lack of concentration, which are common in tinnitus patients.³⁵⁻³⁶ We emphasize the fact that we found abnormal vestibular tests in tinnitus patients even with no vestibular complaints. This highlights the need for complete neurotological evaluation of these patients.

To, establish a strategy for treatment or control of tinnitus, we must make a precise diagnosis in term of its significance, the site of the lesion and its possible etiology. The cochlear and vestibular systems acting in concert, so to evaluate the state of the inner ear, we must study both cochlear and vestibular function.

Conclusion:

In conclusion we supposed that SIT may be not really idiopathic it may be due to hidden cause that does not manifest yet. VEMP appear sensitive to the hydropic structural changes in the saccule and this may be a potential detector of asymptomatic endolymphatic hydrops. We should evaluate all patients with tinnitus, whether they have any vestibular symptoms or not, they must be evaluated completely in terms of auditory and vestibular functions and this will help in future treatment and prevention.

Conflicts of interest

The authors declared no potential conflicts of interest with respect to the

research, authorship and/or publication of this article.

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