

## Evaluation of Dizzy Patients Using Videonystagmography and Vestibular Evoked Myogenic Potentials

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**Abstract: Background:** Patients complain of sense of rotation may have otolith dysfunction and this may be the cause of dizziness in undiagnosed patients. **Objectives:** This study aimed to evaluate the otolith function in patients with dizziness. **Subjects and Method:** Control group consisted of 20 normal adults who had no vestibular complaint with bilateral normal peripheral hearing. Study group consisted of 42 adults which divided into two subgroups, subgroup IIa (patients with normal VNG results) and subgroup IIb (patients with abnormal VNG results). All patients underwent basic audiological evaluation, office test, videonystagmography (VNG) and both cervical and ocular vestibular- evoked myogenic potential (VEMPs) tests. **Results:** c-VEMPs was abnormal in 52.27% in patients of subgroup IIa and in 45% in patients of subgroup IIb. o-VEMPs was abnormal in 40.9% in patients of subgroup IIa and in 37.5% in patients of subgroup IIb. These abnormalities were in the form of absent waves or delayed absolute latencies. **Discussion:** Dizziness ranks among the most common complaints in medicine. However, the term dizziness encompasses a variety of different sensations, rotational vertigo or other illusory sensations of motion might indicate a vestibular origin. **Conclusion:** Patients complaining of dizziness and VNG results normal or even show abnormalities should be evaluated by VEMPs to exclude presence of otolith affection contribute to dizziness.

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### 1. Introduction

Vertigo is classified into vestibular or systemic causes. Vestibular causes may be peripheral or central depending on the location of the dysfunction along the vestibular pathway (Wippold and Turski, 2009).

Vestibular Evoked Myogenic Potentials (VEMPs) is a non-invasive test to assess the functioning of the otolith organs of the inner ear. It is a short latency muscle potential which is elicited by the presentation of a loud sound. One variant of VEMP is cervical VEMP (cVEMPs) which has been found to originate from the saccule and inferior vestibular nerve (Todd et al., 2000). cVEMPs consist of a biphasic peak with positive peak at approximately 13 ms and a negative peak at approximately 23 ms (Haque and Dickman, 2008).

Another variant of VEMP is the ocular VEMP (oVEMPs), which has been found to originate from the utricle and superior vestibular nerve (Welgampola and Carey, 2010). oVEMPs consist of a biphasic peak with negative peak, N10, a positive peak, P15 (Manzari, 2010).

The complexity of this system makes it difficult for one single test to assess the function of all systems. Meanwhile, VNG which is the basic and most widely used test, may yield normal results despite the patient's complaint of dizziness.

Patients with dizziness with normal VNG may have otolith dysfunction (Nada and El Dessouky, 2014).

Because some cases of vertigo may have normal VNG but have affection in the otolith which is assessed by VEMPs, so in this study we will assess the dizzy patients using VNG and VEMPs.

### 2. Subjects and Method

#### Subjects

This study included 62 adults. Their age ranged from 18 to 50 years. The subject area was sanctioned by The Research Ethics Committee on May 2016 (approval code 30968/05/16). Subjects were divided into two groups: control group (GI), which consisted of 20 healthy adults with normal peripheral hearing in the frequency range of 250-8000Hz (hearing threshold level  $\leq$  25 dBHL) and with bilateral normal middle ear function with no vestibular complaints. **Study group (GII)** consisted of 42 adults of the same age as control group with vestibular complaint, They were classified into two subgroups: Subgroup II a: It included patients with dizziness but with normal VNG findings and Subgroup IIb: It included patients with dizziness but with abnormal VNG findings.

All subjects in this work subjected to full audiological history, Otological examination, Basic audiological evaluation and Speech audiometry (SRT

& SD) using GSI 61 clinical audiometer, Acoustic immittance measurements (tympanometry/stapedial reflex) were also done using dinteracoustics AT235H impedance low frequency 226Hz probe tone (Middelfart, Denmark).

### Bed side tests were done

**Videonystagmography (VNG):** infrared glasses of VNG was done using GN Otometric ICS-CHARTR (version 5.3, USA).

The following tests were performed:

1) Tests of oculomotor function (with fixation): includes saccade, tracking, and optokinetic test.

2) Tests of gaze stabilization (with or without fixation, alertness level): includes gaze/spontaneous nystagmus, static position tests.

3) Caloric test.

4) Tests for specific etiologies: includes Dix-Hallpike maneuver (dynamic positioning).

### Vestibular Evoked Myogenic Potentials (VEMPs)

Cervical and ocular VEMPs were recorded

For recording cVEMPs:

- Two active electrodes were placed on the middle third of the contracted sternocleidomastoid muscle of the neck (SCM) on each side.

- Two reference electrodes were placed on the middle third of both clavicles.

-One ground electrode was placed over the forehead.

The subject was asked to rotate his head to the opposite side of recording with flexing the head approximately 30 degrees forward to contract the SCM.

For recording of oVEMPs:

- Two active electrodes were placed just inferior to each eye, about 1cm below the centre of the lower eyelid.

- Two reference electrodes were placed about 1-2cm below the corresponding active electrodes below each eye.

-One ground electrode was placed over the forehead.

The subject was instructed to look upward at a distant target in the midline from the eyes. The eye position was measured as a vertical visual angle of approximately 30°- 35° above horizontal. Stimulation of ipsilateral ear for recording of cervical VEMPs and contralateral ear for recording oVEMPs.

### Statistical analysis

Using the mean, standard deviation, student t-test, Chi-square and Analysis of variance [ANOVA] tests by SPSS V17.

### 3. Results

Sixty two adults were enrolled in this work. Their age ranged from 18 to 50 years and they were divided into two groups: **Control group ( GI):**

It consisted of 20 subjects {5 males (25%) and 15 females (75%)}. Their age ranged from 18-48 years with a mean of  $33.75 \pm 8.26$  years. All subjects had bilateral normal peripheral hearing in the frequency range of 250-8000Hz and had no vestibular complaint. The mean of PTA was  $12.5 \pm 2.9$  dBHL and  $12.7 \pm 3.45$  dBHL in right and left ears respectively. Speech Recognition Threshold (SRT) was  $8.75 \pm 2.75$  dBHL and  $8.5 \pm 2.85$  dBHL in right and left ears respectively. Word discrimination score was 100% in both ears. All subjects had bilateral type A tympanograms and acoustic reflex thresholds were within the expected values for normal.

#### Study group (Group II):

It included 42 subjects with vestibular complaint. Their age ranged from 18 to 50 years with a mean of  $37.33 \pm 9.48$  years. This group was further subdivided into two subgroups:

**Subgroup IIa** It included 22 subjects with vestibular complaint with normal results. They were 5 males (22.7%) and 17 females (77.3%). Their age ranged from 18 to 50 years with a mean of  $36.59 \pm 9.88$  years. The mean of PTA was  $17.6 \pm 5.9$  dBHL and  $19.3 \pm 6.9$  dBHL in right and left ears respectively. The mean of SRT was  $13.40 \pm 5.64$  dBHL and  $14.31 \pm 6.41$  dBHL in right and left ears respectively. Word discrimination score was  $99.09 \pm 2.11\%$  and  $99.27 \pm 2.35\%$  in right and left ears respectively.

**Subgroup IIb:** It included 20 subjects with history of vestibular complaint and VNG results were abnormal. They were 5 males (25%) and 15 females (75%). Their age ranged from 24 to 50 years with a mean of  $38.15 \pm 9.2$  years. The mean of PTA was  $20.4 \pm 7.7$  dBHL and  $21.9 \pm 14.0$  dBHL in right and left ears respectively. The mean of SRT was  $15.0 \pm 6.8$  dBHL  $15.29 \pm 10.52$  dBHL in right and left ears respectively. Word discrimination score was  $99.05 \pm 2.24\%$  and  $99.29 \pm 2.11\%$  in right and left ears respectively. Results of clinical manifestations of both groups were illustrated in table 1.

**Table (1): Clinical manifestations of both groups:**

Complaint	GIIa		GIIb	
	N of patients N=22	%	N of patients N=20	%
Sense of rotation of surroundings	18	81.8%	16	80%
Sense of self rotation	3	13.6%	3	15%
Sense of imbalance	1	4.5%	1	5%

**Bedside test results:**

Visual alignment, spontaneous nystagmus and gaze nystagmus showed no abnormalities in all studied groups, rest of tests are shown in the table (2).

**Table (2): Bedside test results in studied subgroups**

Test	subgroup IIa (N=22)		subgroup IIb (N=20)	
	No	%	No	%
Smooth pursuit	0	0	6	30%
Saccades	0	0	2	10%
Head thrust	0	0	5	25%
head shake	0	0	8	40%
Sharpened Romberg test	4	18.1%	3	15%
Romberg test and fukuda tests	4	18.1%	5	25%

As regard results of VNG, no Spontaneous nystagmus were recorded, results of Oculomotor evaluation, no abnormalities were recorded in Gaze test, Optokinetic testing except in one patient (5%) of subgroup IIb:

**Saccade:** Three parameters were used for evaluation: velocity, accuracy and latency. Comparison between right and left sides revealed no statistically significant difference in control group and study subgroups.

**Sinusoidal Horizontal tracking test:**

In study group, there were abnormal findings in subgroup IIb in the form of four patients showed abnormality in whole tracking (20%).

**Positional and positioning tests:** There was no abnormality in positional tests in all subjects. There was upbeating torsional nystagmus ( $20^{\circ}/s$ ) with latency of 5msec, reversed in direction in upward position. On

repetition, there was fatigability, SPV reduced to ( $10^{\circ}/s$ ) in one patient (1/20) (5%) in subgroup IIb in Dix hallpike test. This case was diagnosed right BPPV.

**Caloric test:**

It was done to patients of subgroup IIa and subgroup IIb. Eight patients of subgroup IIb (8/20) (40%) had unilateral monothermal caloric hypofunction (five in right side and three in left side) and six patients (6/20) (30%) had bilateral monothermal caloric hypofunction.

**iv) Results of combined Vestibular Evoked Myogenic Potentials (combined VEMPs):****1. cVEMPs:****A) Detectability:**

This table show detectability of cVEMPs in two studied subgroups:

**Table (3): Detectability of cVEMPs in two studied subgroups:**

		subgroup IIa		subgroup IIb	
		N=44	%	N=40	%
Absent	Unilateral	4/44	9.1%	1/40	2.5%
	Bilateral	10/44	22.7%	4/40	10%
Delayed latency	P13	6/44	13.7%	8/40	20%
	N23	3/44	6.8%	5/40	12.5%

**B) Latencies:**

ANOVA test was done for comparison of the latency of cVEMPs waves between the control group,

subgroup IIa and subgroup IIb in right and left ears. There was no statistically significant difference between the three studied groups.

**Table (4): Comparison of the cVEMPs wave latencies (in msec) between the studied groups in right and left ears:**

cVEMPs latencies (msec)		Groups									ANOVA	
		I			IIa			IIb			F	P-value
P13 (Rt ears)	Range	9.2	-	14.1	9.2	-	18.7	9.2	-	17.2	2.485	0.094
	Mean ±SD	11.780	±	1.693	13.081	±	2.573	13.282	±	2.460		
N23 (Rt ears)	Range	17	-	24.7	17.2	-	25.6	18.2	-	25.8	0.142	0.868
	Mean ±SD	20.775	±	2.338	21.081	±	2.283	21.141	±	2.116		
P13 (Lt ears)	Range	9.1	-	14.7	9.1	-	18.38	9.1	-	16.5	0.036	0.965
	Mean ±SD	12.130	±	1.863	12.049	±	2.818	11.939	±	2.031		
N23 (Lt ears)	Range	17.4	-	24	17.3	-	27.38	17	-	26	0.026	0.974
	Mean ±SD	20.215	±	1.794	20.056	±	2.526	20.211	±	2.324		

**C) Amplitude:**

ANOVA test was done for comparison of the amplitudes of cVEMPs waves between the control

group, subgroup IIa and subgroup IIb in right and left ears, there was no statistically significant difference (table 5).

**Table (5): Comparison of the cVEMPs wave amplitude (in uv) between the studied groups:**

cVEMPs amplitude (uv)		Groups									ANOVA	
		I			IIa			IIb			F	P-value
P13 (rt ears)	Range	0.4	-	7.5	0.35	-	5.2	0.63	-	7	0.476	0.624
	Mean ±SD	2.241	±	1.958	2.448	±	1.171	2.795	±	1.881		
N23 (rt ears)	Range	0.48	-	7.01	0.6	-	6.76	0.39	-	11.3	0.370	0.692
	Mean ±SD	1.975	±	1.842	2.451	±	1.601	2.485	±	2.532		
P13 (lt ears)	Range	0.64	-	8.02	1.11	-	15	0.63	-	7.8	0.115	0.892
	Mean ±SD	2.848	±	2.261	3.130	±	3.656	2.683	±	1.986		
N23 (lt ears)	Range	0.34	-	14	0.34	-	5.16	0.35	-	7.5	0.193	0.825
	Mean ±SD	2.432	±	3.033	2.514	±	1.191	2.882	±	2.076		

**2. oVEMPs:**

**A) Detectability:** This table show detectability of oVEMPs in two studied subgroups:

**Table (6): Detectability of oVEMPs in two studied subgroups:**

		subgroup IIa		subgroup IIb	
		N=44	%	N=40	%
Absent	Unilateral	7/44	15.9%	6/40	15%
	Bilateral	6/44	13.6%	4/40	10%
Delayed latency	N10	0	0	2/40	5%
	P15	5/44	11.4%	3/40	7.5%

**B) Latencies:**

ANOVA test was done for comparison of the latencies of oVEMPs waves between the control

group, subgroup IIa and subgroup IIb in right and left ears. No statistical significant difference was found (table 7).

**Table (7): Comparison of the oVEMPs wave latencies (in msec) between the studied groups in right and left ears:**

OVEMP Latency (msec)		Groups									ANOVA	
		Control			Normal-VNG			Abnormal-VNG			F	P-value
N10 (Rt ears)	Range	7.3	-	15.6	7.1	-	12.1	7	-	12.5	1.803	0.176
	Mean $\pm$ SD	10.025	$\pm$	1.786	9.100	$\pm$	1.688	9.086	$\pm$	1.580		
P15 (Rt ears)	Range	11	-	20.1	11.5	-	17.4	11	-	17.5	0.501	0.609
	Mean $\pm$ SD	15.035	$\pm$	1.916	14.675	$\pm$	1.855	14.371	$\pm$	2.012		
N10 (Lt ears)	Range	7.4	-	14.9	7	-	12.1	7	-	16.3	0.514	0.601
	Mean $\pm$ SD	10.003	$\pm$	1.833	9.407	$\pm$	1.712	10.019	$\pm$	2.234		
P15 (Lt ears)	Range	11.2	-	18.7	13	-	20.2	10.1	-	22.5	0.559	0.575
	Mean $\pm$ SD	14.770	$\pm$	1.709	15.379	$\pm$	2.041	14.599	$\pm$	2.714		

**C) Amplitude:**

ANOVA test was done for comparison of the amplitudes of oVEMPs waves between the control

group, study subgroup IIa and subgroup IIb ears in right and left ears, There was no statistically significant difference (table 8).

**Table (8): Comparison of the oVEMPs wave amplitude (in uv) between the studied groups:**

OVEMP Amplitude (uv)		Groups									ANOVA	
		I			IIa			IIb			F	P-value
N10 (rt ears)	Range	0.16	-	1.23	0.05	-	3.3	0.05	-	1.2	2.695	0.078
	Mean $\pm$ SD	0.557	$\pm$	0.276	0.841	$\pm$	0.868	0.384	$\pm$	0.319		
P15 (rt ears)	Range	0.2	-	1.81	0.04	-	3.2	0.02	-	1.5	1.716	0.191
	Mean $\pm$ SD	0.625	$\pm$	0.367	0.909	$\pm$	0.906	0.518	$\pm$	0.433		
N10 (lt ears)	Range	0.2	-	1.62	0.17	-	3.5	0.02	-	2.13	0.985	0.381
	Mean $\pm$ SD	0.589	$\pm$	0.334	0.916	$\pm$	1.016	0.701	$\pm$	0.634		
P15 (lt ears)	Range	0.18	-	6	0.16	-	4.2	0.07	-	1.51	0.417	0.662
	Mean $\pm$ SD	0.799	$\pm$	1.303	1.043	$\pm$	1.176	0.704	$\pm$	0.435		

cVEMPs and oVEMPs was abnormal in subgroup IIa more than subgroup IIb, although VNG finding were normal in subgroup IIa than IIb. So both cVEMPs and oVEMPs should be done to all subjects complaining of vertigo whatever the character of vertigo and even if VNG is completely normal.

**4. Discussion**

In our study, patients in subgroup IIa had normal VNG findings inspite to their complaint of dizziness, This can be attributed to the imprecision of this test as caloric irrigations stimulate the system in a manner equivalent to a frequency between 0.002 and 0.004 Hz. This value is well below the level within which the vestibule-ocular reflex generally functions in daily activities. Moreover, the degree of vestibular imbalance needed to produce a sensation of vertigo may be small relative to the imbalance required to be evident in this test (Nada and El Dessouky, 2014).

In the present study, spinning vertigo was the most frequent vestibular symptom in the two subgroups inspite some of them had affection in

VEMPs results either affection of cervical or ocular. This agreed with with results reported by Nada and El Dessouky, (2014) who found that spinning vertigo was the most frequent vestibular symptom in undiagnosed patients showing abnormal oVEMP and/or cVEMPs in their study.

Head Thrust Test (HTT), which is a widely accepted clinical tool to assess asymmetries in semicircular canal – VOR gain, has been reported to have a surpassing accuracy in patients with complete unilateral vestibular loss. Five patients with unilateral caloric weakness show abnormal results but four patients with unilateral caloric weakness also had normal results on HTT, this agreed with results reported by Kamal et al, (2011) who found that ten patients with unilateral caloric weakness also had normal results on HTT. This could be attributed to the fact that the ultra-low frequency response measured by caloric irrigation could be more affected than the high frequency response measured by both HTT and HST (Pérez Vázquez et al., 2005).

Eight patients (8/20) (40%) in subgroup IIb showed nystagmus in head shake test but six patients (6/20) (30%) showed caloric weakness with no head shake nystagmus. This agreed with results reported by Kamal et al, (2011) who found that nine patients showed caloric weakness with no head shake nystagmus and also with results reported by Fujimoto et al., (2009) who found an improved sensitivity of the Head Shake Test of up to 77% with significantly higher degrees of caloric weakness values of 80%. Interestingly, head shake nystagmus was observed in one patient while the caloric response was normal; who proved to have a posterior canal BPPV.

The Fukuda Stepping Test is considered to be a bedside test to evaluate the vestibulo-spinal reflex (VSR). Romberg test and Fukuda tests showed abnormalities in four patients in subgroup IIa (18.1%), but in subgroup IIb, five patients showed abnormalities (25%). The Fukuda Stepping Test did not show a significant correlation to the side of caloric weakness but had a significant correlation to the side of the VEMP abnormality. This may be explained as both tests examine part of the vestibule-spinal pathway (Zhou and Cox, 2004).

Patients in subgroup II b showed abnormal results in VNG test and also we assessed them using VEMPs as patient may have affection in oculomotor test and have affection in VEMP as cerebellum may affect VEMP responses by participating in the modulation of the otolithic signals. Therefore, due to possible damage to the vestibular fascicles, vestibular nuclei and their efferents, and cerebellum that are all involved in relaying and processing of the vestibular signals, central vestibular lesions may impair the VEMP responses along the descending (cVEMPs) and ascending (oVEMPs) tracts in the brainstem. cVEMPs and oVEMPs would provide valuable information in localizing the central lesions when combined (Kim et al. 2013).

Patients may have nystagmus in Dix hallpike test (BPPV) and also have affection in cVEMP and /or in oVEMP due to degenerative process of otolith not only affects the macula of the utricle and causes detachment of the otoliths, but might also affect the macula of the saccule (Xu et al. 2016).

Affection of oVEMPs may occur in patients with reduced or absent caloric response on the affected side. It was found that the oVEMP is reduced or absent in patients suffer from a selective superior vestibular nerve neuritis (Manzari et al, 2010).

In subgroup IIa cVEMPs showed abnormalities in twenty three ears (23/44) (52.27%). This abnormalities were in the form of absent response bilaterally in ten ears (10/44) (22.7%) and unilateral absent response in four ears (4/44) (9.1%) (one in right side and three in left side).

In subgroup IIb cVEMPs showed abnormalities in eighteen ears (18/40) (45%). These abnormalities in form of absent response bilaterally in four ears (4/40) (10%) and unilateral absent response in one ear (1/40) (2.5%) in right side. On the other hand, seven patients had abnormal delayed absolute latency.

OVEMPs was abnormal in (18/44) (40.9%) in patients of subgroup IIa and in (15/40) (37.5%) in patients of subgroup IIb. These abnormalities were in the form of absent waves or delayed absolute latencies.

This result agreed with results reported by Nada and El Dessouky, (2014) that found abnormalities in VEMPs in 19 patients with normal VNG (out of 30 patients) (63.3%) in form of unilateral absent 10 patients (33.3%), bilateral absent 6 patients (20%), shifted latency 3 patients (10%). The results of our study also agreed to with Seo et al., (2008) who reported that 70% of patients with normal VNG with a history of brief episodes of a sense of imbalance and tendency to fall have abnormal VEMP. On the other hand, these results disagreed with Iwasaki et al. (2005) who reported that only 40 of the 811 patients (5%) were found to have abnormal VEMP responses with normal caloric test responses and also disagreed with Iwasaki et al., (2015) who reported of 1521 patients, 227 (15%) had abnormal oVEMPs and/or cVEMP responses with normal caloric responses.

From the results of our study, we can conclude that otolith affection may be the cause of dizziness even if dizziness is sense of rotation not tilting sensation, a sense of moving to and fro and even VNG test give normal results or even abnormal results.

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