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Original Research Article

Acoustic Vestibular Evoked Ocular Myogenic Potentials (Ac oVEMP) an Important Diagnostic Tool for Vestibular Neuronitis

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Abstract

Introduction: Standard vestibular evoked myogenic potentials (VEMP) are widely used in the assessment of vestibular disorders in clinical practice. But studies have shown that role of VEMP alone in the diagnosis of vestibular dysfunction is not entirely satisfactory. In the recent years' ocular myogenic potentials, produced by the synchronous activity in the extra ocular muscles in response to vestibular stimulation, is being studied extensively for identifying vestibular diseases

Aims & Objective: In this study we evaluate the usefulness of acoustic vestibular evoked ocular myogenic potentials (Ac oVEMP) along with traditional cVEMP (Cervical vestibular evoked myogenic potentials) and BAER (Brain stem auditory evoked Response) for diagnosing vestibular neuronitis.

Materials and Methods: 100 subjects were included in this study (Group A 50 -normal subjects; Group B – 50 patients with vestibular neuronitis). Ac oVEMP was performed on both the groups and the results were analyzed for difference and statistical significance. Patients in Group B were additionally subjected to cVEMP and BAER.

Results: Ac oVEMP in Group A subjects produced n and p response that was consistent and reproducible. There was no inter-aural difference. Ac oVEMP in Group B showed prolongation of n and p latencies when compared with normal subjects ($p \leq 0.01$). 23 patients in group B demonstrated abnormal Ac oVEMP (46%) whereas 10 patients in group B had abnormal cVEMP (20%). This was attributed to the more common involvement of superior division of vestibular nerve in vestibular neuronits, which is best tested by Ac oVEMP.

Conclusion: Acoustic vestibular evoked ocular myogenic potential (Ac oVEMP) plays an important role as an electrophysiological tool in the diagnosis of vestibular neuronitis.

Keywords: Acoustic Vestibular Evoked Ocular Myogenic Potentials (Ac oVEMP); Vestibular neuronitis; Vestibular nerve divisions; Evoked potentials.

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Introduction

Among the various causes of peripheral vertigo, vestibular neuronitis is a notable disease entity. This is the second most common cause of vertigo after Benign Paroxysmal Positional Vertigo [1]. Despite being extensively described in various review articles, its diagnosis has always been elusive. Patients present with dramatic symptoms including severe nausea, vomiting and reeling sensation. As this process only affects the vestibular

system, there is absence of cochlear symptoms such as hearing loss or tinnitus. Physical examination in this condition is limited and electrodiagnostic tests contribute to the diagnosis.

Dizziness is usually an alarming symptom for a patient. Various studies have revealed that vertigo is one of the commonest complaints in medicine, which affects 20-30% of the general population [2]. These patients often visit doctors of multiple specialties including family physicians, ENT doctors, neurologists, internists and orthopaedicians. They are also subjected to a wide array of investigations including blood tests, imaging of the brain, imaging of the cervical spine, angiograms and electrophysiological testing before a correct diagnosis is made and appropriate treatment is started. When it comes to quantitative electrophysiological testing of vestibular functions, the list is exhaustive. The list includes electronystagmogram, caloric testing, rotational chair testing, posturography, vestibular evoked myogenic potentials (VEMPS), brainstem auditory evoked response (BAER) etc. Despite such many tests that are available, a popular medical reference website says that these tests do not help the clinician with diagnostic information [3].

Standard vestibular evoked myogenic potentials (VEMP) are widely used in the assessment of vestibular disorders in clinical practice [4]. But recent studies have shown that the role of VEMP alone in the diagnosis of vestibular dysfunction is not entirely satisfactory [5]. In the recent years' ocular myogenic potentials, produced by the synchronous activity in the extra ocular muscles in response to vestibular stimulation, is being studied extensively for identifying vestibular diseases.

In this study we evaluate the usefulness of acoustic vestibular evoked ocular myogenic potentials (Ac oVEMP) along with traditional VEMP and BAER for diagnosing vestibular neuronitis.

Materials and Methods

Study Methodology

This study was conducted in a tertiary care hospital. It was a prospective study and the study period was from May 2015 to April 2016. A total of 100 subjects were included in this study. The procedures followed in this study were ethically approved by the Department Board. All subjects who participated in this study were informed and they gave their consent prior to study.

The study population was further divided into 2 groups. Group A consisted of 50 normal people. The subjects aged 20-65 years (28 F 22 M). They had no history of dizziness, ear disorders or sense of imbalance. They served as control for Ac oVEMP testing. Group B consisted of 50 patients (27 F 23 M) aged 20 to 80 years. All patients included in this group had been clinically evaluated by two independent neurologists and were diagnosed to have vestibular neuronitis. These patients presented with symptoms of severe vertigo, unsteadiness, nausea and vomiting. On examination they had nystagmus, that was evident on Hallpike maneuver, with fast phase oscillations towards the healthy ear. They had a normal MR imaging of the brain and MRI middle ear showed normal structural integrity.

Patients in Group B were then subjected to Ac oVEMP, cVEMP and BAER studies. All subjects included in this study were informed and they gave their consent prior to the study.

The collected data were analysed with IBM. SPSS statistics software 23.0 Version. To describe about the data descriptive statistics frequency analysis, mean & S.D were used. To compare the Group A (Normal subjects) & Group B (Patients with vestibular neuronitis) the Unpaired sample t-test was used. In the above statistical tool the probability value .05 is considered as significant level.

Ac oVEMP Protocol

Ocular VEMPs are myogenic responses representing the vestibuloocular reflex (VOR). Here the ocular muscles, contralateral to the ear that is stimulated, are used to record the potential.

The subject was seated on a chair. The active electrode was placed on the face 1 cm inferior and at centre of the lower eyelid. The reference electrode was positioned at the chin and one ground electrode was placed on the forehead (Fig. 1).

The evoked potentials were measured using Neuropack-four pack mini (Nihon Kohden). The electrode impedance was kept under 5kΩ. During the recording the subject was instructed to look upward at a small fixed target (>2m from the eyes). The vertical eye positions were at an angle of approximately 30-350 above horizontal. The EMG signals were amplified and band pass filtered between 10 and 1000 Hz. Acoustic stimuli were delivered at 95 dBnHL using headphones. One ear was stimulated while the other was masked with a white noise. Short tone bursts (500 Hz, rise/fall time = 1ms, plateau time = 2ms) with refraction polarity was delivered through the head phones. Monaural

stimulation with contralateral eye recording was employed for recording Ac oVEMPs. The stimulation rate was 5 Hz. Analysis time for each run was 50ms and 50 responses were averaged for each run [6]. The initial negative biphasic waveform was identified and the latencies for the two peaks (n and p) were calculated (Fig. 2). The amplitude for these waveforms (n peak to p peak) was also calculated.

CVEMP Protocol

The subject was seated on a chair. An active electrode was placed on mid points of the sternocleidomastoid. Reference electrode was placed on the suprasternal notch and a ground electrode was placed on the forehead. EMG signals were amplified and filtered between 10 and 1000Hz [6]. The acoustic stimuli were similar to the Ac oVEMP protocol. . Analysis time for each run was 50 ms and 50 responses were averaged for each run. The initial negative biphasic waveform was identified and the latencies for the two peaks (n and p) were calculated. They were classified as normal or abnormal according to our lab normative data.

BAER Protocol

The subject was lying supine with a pillow below his head. An active electrode was placed at the vertex (Cz). Reference electrode was placed on the ipsilateral ear lobule. Ground electrode was placed on the contralateral ear lobule. Acoustic stimuli were delivered at 80 dBnHL using headphones. Short tone bursts (500 Hz) with refraction polarity was delivered through the head phones. Filters of 30- 3000Hz were used with an electrode impedance of 5KΩ. Latencies of waveforms I, III and V were observed for this study. They were classified and normal or abnormal according to our lab normative data.

Results

Group A

Ac oVEMP was obtained in all the normal (Group A) subjects. Both the ears on stimulation showed similar waveforms. As shown in the table 1, the 'n' and 'p' response between right and left were comparable (nRt- 8.32±0.7, nLt-8.11±0.75; pRt-11.96 ±0.9, pLt 11.70±0.86). Based on this descriptive statistical data, we fixed the 'n' and 'p' response cut off at 10 ms and 14 ms respectively. Latencies beyond this were considered abnormal.

Table 1: Descriptive statistics of Ac oVEMP response in normal subjects (Group A)

	N	Range	Min	Max	Mean	SD
n (rt)	50	2.60	7.20	9.80	8.320	0.7
p (rt)	50	4.75	9.10	13.85	11.965	0.9
AMP (rt)	50	39.10	3.95	43.05	14.537	8.7
n (lt)	50	4.0	6.65	10.65	8.11	0.75
p (lt)	50	4.30	9.40	13.70	11.70	0.86
AMP (lt)	50	26.37	2.93	29.30	13.07	6.0

The 'n' and 'p' responses between the two groups (rt and lt) were similar and comparable. The amplitudes (AMP) between the two groups were comparable too, but the deviation from mean was large

Group B

A total of 50 patients with a diagnosis of vestibular neuronitis were included in this study. They were subjected to Ac oVEMP along with cVEMP and BAER studies. Of these, 23 patients had abnormal Ac oVEMP response. When the 'n' and 'p' response were compared between Group A (Normal subjects) and Group B, the difference was very evident and with respect to 'n' latency it was also statistically significant. (see tables 2 below).

Table 2: Group statistics comparing 'n' and 'p' latenecies between Group A(Normal) and Group B (Abnormal) Group Statistics

Groups		N	Mean	Std. Deviation	Std. Error Mean
Age	Abnormal	50	47.88	14.976	2.118
	Normal	50	43.14	15.257	2.158
N (rt)	Abnormal	50	9.0754	1.48855	.21051
	Normal	50	8.3202	.70041	.09905
P (rt)	Abnormal	50	12.1366	1.91155	.27033
	Normal	50	11.9650	.90214	.12758
N (lt)	Abnormal	50	8.7088	1.48730	.21034
	Normal	50	8.1136	.75535	.10682
P (lt)	Abnormal	50	11.6084	1.92092	.27166
	Normal	50	11.7074	.86631	.12251

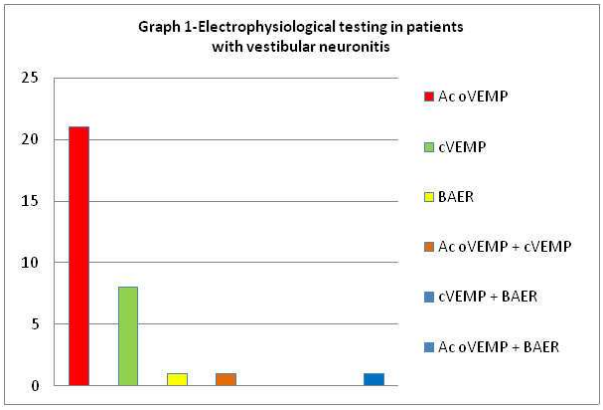
Table 3: Unpaired sample t test- To compare Group A and Group B samples*

	Levene's Test for Equality of Variances		t-test for Equality of Means					P value
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	
N (rt)	29.166	.000	3.246	98	.002	.75520	.23265	

			3.246	69.683	.002	.75520	.23265	≤0.01*
P (rt)	27.664	.000	.574	98	.567	.17160	.29893	≥0.05
			.574	69.796	.568	.17160	.29893	
N (lt)	9.623	.003	2.523	98	.013	.59520	.23591	≤0.01*
			2.523	72.700	.014	.59520	.23591	
P (lt)	19.396	.000	-.332	98	.740	-.09900	.29801	≥0.05
			-.332	68.140	.741	-.09900	.29801	

*The collected data were analysed with IBM.SPSS statistics software 23.0. To compare the Group A & Group B the unpaired sample t-test was used. In the above statistical tool the probability value 0.05 is considered as significant level.

When compared to cVEMP and BAER, Ac oVEMP was more likely to identify patients with vestibular neuronitis. Of the 50 patients who had vestibular neuronitis, 23 patients had abnormal Ac oVEMP response, 10 had abnormal c VEMP response and 2 had abnormal BAER study (See Graph 1 Below)



Graph 1:

Acoustic evoked ocular myogenic potentials were more likely to pick up patients with vestibular neuronitis

Discussion

Vestibular evoked myogenic potentials are short latency electromyograms (EMG) that are evoked by high level acoustic stimuli and are recorded from surface electrodes. The first sound evoked vestibular responses were described by Von Bekesy in 1935. He used high intensity sound stimuli (about 135 dB) in order to generate head movements towards the side of stimulus [7]. Townsend GL, Cody DT in 1971 noticed surface EMG potentials from the sternocleidomastoid following saccular stimulation [8]. Vestibular evoked cervical myogenic potentials (cVEMP) was first described by Colebatch JG and Halmagyi MS (1992, 1994) who measured electromyographic (EMG) activity from the sternocleidomastoid (SCM) muscles following vestibular stimulation with brief pulses of sound [9,10]. Over years this electrophysiological test gained a lot of momentum and in the year 2005-2006 alone more than 60 papers were published in various journals around the world. Soon cVEMP was inducted into the battery of tests that were done for patients with vertigo, in order to establish peripheral vestibular disease.

While a lot of work has been done on cVEMP, vestibular evoked ocular myogenic potentials (oVEMP) are relatively new. In 2005 and 2007, Resengren SM and Todd NPM (2005, 2007) recorded short latency potentials from around the eyes by bone conducted sounds [11]. A recent study has also shown that oVEMPs predominantly reflect utricular functions while cVEMPs reflect saccular functions [12].

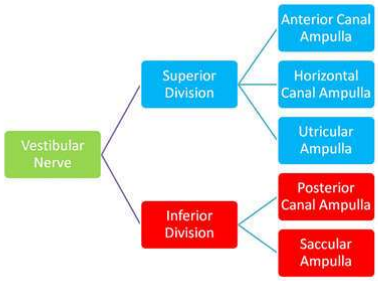
Ac oVEMP when performed on normal subjects (Group A) resulted in an 'n' and 'p' response whose latencies were consistently similar between the two ears and definitely reproducible. The amplitudes however showed large deviations from the mean and hence abnormal values could not be defined. Other studies have had similar difficulties. Murofushi, T, Kaga, K, (2009) defined abnormal amplitude as a asymmetry ratio between the two sides greater than 35% and the side with reduced amplitude was considered to be the affected side [13]. Another study simply used absence of any producible waveform as an abnormal oVEMP [14]. Ian S. Curthoys 2007 demonstrated that the mean of Inter-aural amplitude difference was 8.09%±8.01 [15]. This variation is probably because multiple factors determine the amplitude of oVEMP. For instance, Iwasaki S et al., 2007 showed that the amplitude of the oVEMP waveform increases when patient gazes upwards [16]. The 'n' and 'p' responses in all these above mentioned studies were similar. We therefore decided not to study the amplitudes in patients with vestibular neuronitis.

When we compared the 'n' and 'p' response of Ac oVEMP between the two groups the results were clearly different. The disparity in 'n' response was also statistically significant (p value of ≤ 0.01) as shown in Table 2.

Of the 50 patients who were in Group B, 23

of them had an abnormal Ac oVEMP. This was in contrast to 10 patients who had an abnormal cVEMP. In other words, our study showed that patients with peripheral vestibular neuronitis were more likely to have an Ac oVEMP abnormality rather than a cVEMP abnormality. Surprisingly, the number of patients who had both Ac oVEMP and cVEMP abnormality was very few (n=2).

The fact that patients with vestibular neuronitis were likely to have an abnormal Ac oVEMP has more to do with the physiology of the vestibular apparatus and its connections rather than the superiority of Ac oVEMP over cVEMP. As shown in the figure below, the vestibular nerve has two divisions, the superior division and the inferior division. The superior division consists of fibers from the Utricule, horizontal and anterior semicircular canal. The inferior division has fibers from the saccule and posterior semicircular canal.



In vestibular neuronitis, the superior vestibular nerve is more often involved because of its course through a long and narrower bony canal, making it more susceptible to compressive edema [5]. Ac oVEMP tests the superior division of the vestibular nerve, whereas cVEMP tests the inferior division (See Table 4). Since the superior division of vestibular nerve is more commonly affected in vestibular neuronitis, Ac oVEMP was able to identify more patients with this condition. A combination of Ac oVEMP and cVEMP was able to identify 66% of patients with vestibular neuronitis.

Table 4: Interpretation of clinical tests in patients with vestibular neuronitis 15

Clinical Test	Superior Vestibular neuronitis	Inferior Vestibular neuronitis
Horizontal head turn to ipsilateral horizontal canal	Abnormal	Normal
Pitch Head impulse test in the plane of the ipsilateral anterior canal (Head turn nose down)	Abnormal	Normal
oVEMP Testing	Abnormal	Normal
cVEMP Testing	Normal	Abnormal
Pitch Head impulse test in the plane of the ipsilateral posterior canal (Head turn nose up)	Normal	Abnormal

Limitations

The major limitation of this study is that the sample size is small. It's a single centers experience in diagnosing patients with vestibular neuronitis. A multicentre study with similar electrophysiological equipments and reference parameters would strengthen the findings that we have observed in this study. We have also restricted ourselves to the clinical entity of vestibular neuronitis. But the findings of this study definitely warrant Ac oVEMP use in other vestibular disorders.

Conclusion

Ac oVEMP and cVEMP are two electrophysiological investigations that test the superior and inferior divisions of the vestibular nerve respectively. Our study demonstrates that Ac oVEMP is more useful as a diagnostic tool for vestibular neuronitis as superior division of the vestibular nerve is more commonly affected. Ac oVEMP and cVEMP when combined together can identify more patients with peripheral vestibular disorders. As both these tests require similar equipments for testing, it is definitely an economical and quick method of objectively diagnosing vestibular disorders in an outpatient setting.

Conflict of interest: None

Funding Source: None

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