# **Original Research Article**

DOI: https://dx.doi.org/10.18203/issn.2454-5929.ijohns20214220

# Usefulness of vestibular evoked myogenic potentials in diagnosis of peripheral vestibular disorders

Sreelatha Sirige, S. Rajesh Kumar\*, V. Krishna Chaitanya, Vasu Kumar Reddy

Department of ENT, Narayana Medical College and Hospital, Nellore, Andhra Pradesh, India

Received: 04 October 2021 Revised: 19 October 2021 Accepted: 20 October 2021

# \*Correspondence:

Dr. S. Rajesh Kumar,

E-mail: entdrrajesh@gmail.com

**Copyright:** © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

#### **ABSTRACT**

**Background:** Vestibular evoked myogenic potentials (VEMP) are electromyographic responses to high-intensity acoustic stimuli to test vestibular system, otolith function and integrity of inferior vestibular nerve. These are easy to perform and non-invasive. In this study, we aimed at clinical application of VEMP to evaluate common peripheral vestibular disorders.

**Methods:** Prospective observational study carried in ENT department during January 2015-November 2016 over 40 patients in age group between 30-70 years with history of vertigo who underwent regular neuro-otological examination and VEMP.

**Results:** Of these, 25 diagnosed with BPPV, 11 with Meniere's disease, and four with vestibular neuritis. Eight patients showed delayed VEMP responses. 28 (70%) patients had normal VEMP, 12 (30%) had abnormal VEMP responses. Out of 25 patients suffering from benign paroxysmal positional vertigo (BPPV) posterior semi-circular canal was involved in 20 (80%) patients and lateral semi-circular canal in 5 (20%) patients. Abnormal VEMP was found in 5 (20%) patients involving posterior semi-circular canal and in 1 (20%) patient involving lateral semi-circular canal. In patients with Meniere's disease stage I, Meniere's disease was observed in 7 (63.6%), stage II in 2 (18.1%), and stage IV disease in 1 (9.09%) patient. In these patients, abnormal VEMP was found in 3 (42.8%) of 7 stage I, 1 (50%) of 2 stage II and 1 (100%) of stage IV patients. One (20%) patient had abnormal VEMP responses during study.

**Conclusions:** VEMP are short-latency EMG that evaluates saccule and inferior vestibular nerve in peripheral vestibular nervous system. VEMP should be considered as complementary test along with conventional vestibular function tests in patients with peripheral vertigo.

Keywords: VEMP, Vestibular disorders, Vertigo, Meniere's disease, Vestibular neuritis

# INTRODUCTION

Vestibular evoked myogenic potentials (VEMP) are electromyographic responses to high-intensity acoustic stimuli that are used as a test for the vestibular system by providing information on otolith function and the functional integrity of the inferior vestibular nerve. VEMP are a test that evaluates the saccule and inferior vestibular nerve in the peripheral vestibular nervous system. These are easy to perform, non-invasive, and cause minimal patient discomfort.

BPPV, Meniere's disease, and Vestibular Neuritis are the most common diseases that cause peripheral vertigo.<sup>3</sup> The development of peripheral vertigo can be associated with the saccule or inferior vestibular nerve, which are pathways for VEMP. Also, in Meniere's disease, as the process may be associated with a pathologic change in the saccule, VEMP testing could provide information about the involvement of the saccule in peripheral vertigo. Patients with vestibular neuritis show unilateral peripheral vestibular dysfunction mainly in the superior vestibular nerve.<sup>4</sup>

The application of VEMP to study the function of otolith organ and integrity of inferior vestibular nerve in peripheral vestibular disorders is not eloquently reported earlier. In this study, we aimed at the clinical application of VEMP as a tool to evaluate the common peripheral vestibular disorders BPPV, Meniere's disease, and vestibular neuritis.

### **Objectives**

The objectives of the present study were the assessment of the involvement of semi-circular canal in BPPV, evaluation of saccular hydrops in Meniere's disease and assessment of cases of vestibular neuritis by VEMP.

#### **METHODS**

This study is a prospective observational study carried at otorhinolaryngology department of Narayana medical college, and hospital, Chinthareddypalem, Nellore during the period of January 2015-November 2016 after institutional ethics committee clearance. The sample size of the study was 40 patients with age group between 30-70 years who presented to the outpatient department with a history of vertigo. Patients in age between 30-70 years having vertigo were included in the study. Patients having central nervous system diseases, with limitation of neck movements, history of any head and neck injury, with history of usage of drugs like anti-epileptics, muscle relaxants, vestibular toxic drugs and with history of head and neck surgery were excluded from the study.

All the study population suffering with clinical features of vertigo underwent a regular neuro-otological examination. After the complete neuro-otological examination and clinical tests performed, patients were accordingly categorized into three groups group 1-BPPV, group 2- Meniere's disease and group 3-vestibular neuritis.

The diagnosis of BPPV is based on medical history and findings of characteristic nystagmus in the Dix-Hallpike and head roll tests. Meniere's disease was diagnosed using criteria established by the 1995 American academy of otolaryngology-head and neck surgery balance and hearing committee. Those patients who had experienced vertigo attack lasting for at least several hours, absence of auditory and neurological symptoms was included in this group.

The battery of clinical tests performed included otoscopy, pure tone audiometry, fistula test, Dix Hallpike test, head roll test, cerebellar function tests, Unterberger's stepping test, and electronystagmography (ENG). All these patients underwent a vestibular assessment by using VEMP.

In the study population suffering from vertigo, VEMP responses were recorded from the sternocleidomastoid EMG to reflect the repetitive summative relaxation of the

sternocleidomastoid in response to synchronized acoustic stimulation of the ipsilateral ear/saccule. The electrode montages were placed to perceive positive on upper 1/3<sup>rd</sup> sternocleidomastoid, negative on the sternum at the sternal notch, and ground or reference electrode on the forehead.<sup>7</sup> VEMP was performed in an audiological sound-treated room with electrical isolation using GSI AUDERA equipment and software having ER-3A insert earphones as output transducers.<sup>8</sup>

Initially, the patient is placed on a couch in the supine position. The test is conducted in a lying position with the head flexed opposite to gravity. Precautions are taken to maintain absolute silence and switching off all the electronic devices which can interfere with the responses. The test measures relaxation impulses on a contracted sternocleidomastoid muscle in response to acoustic stimulation of the saccule. Individual small amplitude relaxation impulses are summated on a background of electromyogram (EMG) activity.

Patients were given stimulus type of short duration tone pip (2-1-2 cycles) with stimulus frequency of 500 Hz, stimulus intensity of 105 dB NHL with alternating stimulus polarity at a stimulus rate of 5.1/sec with filter settings of 10-750 Hz. The test was repeated twice at each intensity level on both sides for the confirmation of the obtained response based on wave morphology and repeatability. The latencies of P1, N1 are measured. The amplitude of the waveform from P1 to N1 is also measured. Interaural amplitude difference (IAD) was calculated based on the formula amplitude of the affected ear-amplitude of the contralateral ear/amplitude of the affected ear with amplitude of the contralateral ear × 100. Values above 30% were considered abnormal.

Based on the clinical features and clinical normative, the following criteria were set for peripheral vestibular disorders. Criteria for vestibular dysfunction include absent VEMP responses with prolonged p1 and n1 latencies (msec), decreased P1-N1 amplitude ( $\mu V$ ) and IAD ratio >30%. The normative data we observed in otherwise normal patients are mentioned in the table mentioned below.

Table 1: Normative data of VEMP.

VEMP parameters	Range	Mean ± SD
P1 latency (msec)	11.2-15.4	13.2±1.27
N1 latency (msec)	19.5-24.2	22.1±1.54
P1-N1 amplitude(μv)	40.3-227.5	81.7±30.9

The normative values for latency and VEMP asymmetry ratio were calculated as mean  $\pm$  two standard deviations. Independent sample T test using SPSS software version 22.0 was used to analyse the data.

Latencies longer than the calculated upper limit were interpreted as abnormal. Any VEMP asymmetry ratio above the calculated upper limit (mean + two standard

deviations) was considered to reflect depressed response on the side with lower amplitude findings and was interpreted as abnormal. Absence of a meaningful waveform with P13 and N23 (no response) was also considered an abnormal finding.

### **RESULTS**

A total number of 40 patients were selected for the study. Out of 40 patients with vertigo 25 were categorized into BPPV group, 11 of these patients were grouped to be suffering from Meniere's disease, and four patients were grouped to be suffering from vestibular neuritis. The 20 (50%) of these patients were in the age group of 40-50 years. In the following 40 patients, vertigo was a most common complaint in 40 (100%) of patients followed by hard of hearing in 30 (75%), tinnitus was seen in 15 (37.5%), and aural fullness was seen in 10 (25%) of patients.

Among 40 patients having peripheral vestibular disorders, eight patients showed delayed VEMP responses. VEMP responses (latencies) in these eight patients, when compared to the normative data established from the normal population are delayed (P1>13.2±1.27, N1>22.19±1.54).

Also, in the study group of 40 patients with peripheral vestibular disorders, it was observed that 28 (70%) patients had normal VEMP responses, 12 (30%) patients had abnormal VEMP responses. These patients were further classified based on the disease process as a cause for vertigo, and the details were mentioned in the Table mentioned below.

Table 2: VEMP responses in patients with peripheral vestibular disorders.

VEMP responses	BPPV (%)	Meniere (%)	Vestibular neuritis (%)	%
Abnormal response	6 (24)	5 (45.4)	1 (25)	30
Normal response	19 (76)	69 (55.6)	3 (75)	70

Out of 25 patients suffering from BPPV, after performing VEMP, it was observed that the posterior semi-circular canal was involved in 20 patients and lateral semi-circular canal in 5 patients. In this group of BPPV patients, abnormal VEMP were found in 5 out of 25 (20%) patients involving posterior semi-circular canal and in 1 out of 5 (20%) patient involving lateral semi-circular canal.

Similarly, among the group of patients suffering with Meniere's disease after performing VEMP disease of the patient was staged and among these 11 Meniere's disease patients it was observed that stage I Meniere's disease was observed in 7 (63.6%), stage II in 2 (18.1%), and stage IV disease in 1 (9.09%) patient. None of these

patients in our study were diagnosed to be suffering from stage III Meniere's disease. Also, it was observed from VEMP findings that abnormal VEMP were found in 3 (42.8%) of 7 stage I, 1 (50%) of 2 stage II and 1 (100%) of stage IV Meniere's disease patients.

Patients having vestibular neuritis recording of VEMP findings showed inferior vestibular neuritis diagnosed in 1 (25%) out of 4 patients with vestibular neuritis. Also, it was observed that this 1 (20%) patient out of these five patients of vestibular neuropathy had abnormal VEMP responses during the study.

#### DISCUSSION

Our normative clinical results indicated 100% VEMP responses could be obtained in individuals with normal hearing sensitivity and no episodes of vestibular dysfunction. As normative data for VEMP cannot be standardized globally, clinical normative was established for the present study purpose.

In the present study, tone pips were used at a frequency of 500 Hz for eliciting VEMP responses and found that the responses obtained were more reliable. Wang et al compared the VEMP responses evoked by click stimuli with those evoked by tone pips in healthy young individuals and observed that the response rates of VEMP were 93 % for click and 100 % for tone pips.<sup>9</sup>

In the present study, the initial response at around 13 ms latency was positive wave followed by a negative wave at around 23 ms. This initial response was because of the placement of the electrodes. In the present study, the positive electrode was placed on the upper third of sternocleidomastoid, whereas the negative electrode was placed at the sternal notch. The early component of the VEMP depends on the integrity of vestibular afferents, mainly saccule, and inferior vestibular nerve. <sup>10</sup>

In patients with BPPV, the posterior semi-circular canal is the most commonly affected, followed by the lateral semi-circular canal, with the anterior semi-circular canal rarely involved. Available literature suggests that VEMP evaluates the pathway from the saccule, through the inferior vestibular nerve and vestibular nucleus, to the lower brainstem. It can be drawn that only patients with posterior BPPV innervated by the inferior vestibular nerve would show abnormal findings in modifying values of VEMP. Though ENG is considered as the gold standard to evaluate the function of the vestibular system, it stimulates the horizontal semicircular canal, thus evaluating the integrity of only superior vestibular nerve.

Also, it was observed that the rates of abnormal VEMP were similar in patients with involvement of the posterior and lateral canal is 25.0% in each category. Results, therefore, suggest that abnormal VEMP findings are not related to the location of the lesion. The reason for

abnormal VEMP in lateral canal BPPV was not explained in any previous pieces of literature.

Abnormal VEMP rates were significantly higher in Meniere's disease than in the other disorders. <sup>14</sup> The saccule is the second most frequent location for endolymphatic hydrops, and fifty percent of Meniere's disease involves saccular hydrops. The severe form of endolymphatic hydrops is most frequently found in the saccule. Thus, in these patients who have minimal hearing loss at present but who display sustained saccular hydrops, harbor sensory cells that are not dead but which are on course for functional loss with time. <sup>15</sup>

In the present study, three out of 7 patients with stage I Meniere's disease showed abnormal VEMP indicating saccular hydrops or dysfunction that will be at risk for more hearing aggravation than patients with normal saccular function. A relationship has been demonstrated between increasing inter-aural vestibular evoked myogenic potential amplitude difference (i.e., right earleft ear/right ear with left ear) and Meniere's disease stage progression.

One (25%), out of four patients was identified with vestibular neuritis, involving inferior vestibular nerve. The unique feature of inferior vestibular neuritis patient was normal caloric test results but abnormal vestibular evoked myogenic potential test results thus establishing a firm diagnosis of inferior vestibular neuritis. <sup>16</sup> Findings of the present study provide objective evidence that inferior vestibular neuritis does indeed exist, as a novel subtype of vestibular neuritis. Previously it had been believed that vestibular neuritis mainly affects the superior vestibular nerve; however, cervical vestibular evoked myogenic potential testing revealed that vestibular neuritis could involve not only superior vestibular nerve but also inferior nerve too.<sup>17</sup>

# Limitations

Our study was performed in limited number of 40 patients only which is not very much adequate to observe the normative data and pathological data. However, owing to the cost of the tests and population availability we could confine to the above population in the study group. If larger population was available during the study, data could have helped us to affirm our findings.

## **CONCLUSION**

Vestibular testing is an important tool in the evaluation and management of the patient with dizziness. The bedside evaluation of the dizzy patient, with a careful history and a thorough neurological examination is crucial in establishing the clinical diagnosis. Although ENG provides information about the status of the vestibular system, major limitations are the inability to evaluate the function of the saccule and inferior vestibular nerve.

VEMPs are short-latency EMGs recorded from the tonically contracted sternocleidomastoid muscle in response to acoustic stimuli at relatively high intensities that evaluates the saccule and inferior vestibular nerve in the peripheral vestibular nervous system. Therefore, VEMP should be considered as a complementary test along with the conventional vestibular function tests in patients with peripheral vertigo.

#### **ACKNOWLEDGEMENTS**

Author would like to thanks to chair person, Dr. P. Narayana, dean Dr, Surya Prakash Rao, director, Dr. Narsimha Reddy, medical superintendent, Dr. Seshamma and to the management and staff Narayana medical college for their timely guidance and approvals and also their immense support in making this study a success.

Funding: No funding sources Conflict of interest: None declared

Ethical approval: The study was approved by the

Institutional Ethics Committee

#### REFERENCES

- 1. Sheykholeslami K, Kaga K. The otolithic organ as a receptor of vestibular hearing revealed by vestibular-evoked myogenic potentials in patients with inner ear anomalies. Hearing Res. 2002;165(1-2):62-7.
- 2. Ferber-Viart C, Dubreuil C, Duclaux R. Vestibular evoked myogenic potentials in humans: a review. Acta oto-laryngol. 1999;119(1):6-15.
- 3. Hughes CA, Proctor L. Benign paroxysmal positional vertigo. Laryngoscope. 1997;107(5):607-13.
- 4. Ochi K, Ohashi T, Nishino H. Variance of vestibular- evoked myogenic potentials. Laryngoscope. 2001;111(3):522-7.
- Bhattacharyya N, Baugh RF, Orvidas L, Barrs D, Bronston LJ, Cass S et al. Clinical practice guideline: benign paroxysmal positional vertigo. Otolaryngology--head and neck surgery. 2008;139(5):47-81.
- 6. Shepard NT, Telian SA. Programmatic vestibular rehabilitation. Otolaryngol Head Neck Surg. 1995;112(1):173-82.
- Kanumuri S, Chaitanya KV, Nara J, Reddy KV. Role
  of cervical vestibular-evoked myogenic potentials in
  evaluating vestibular dysfunction in patients with
  Type II diabetes mellitus: A prospective institutional
  study. Indian J Otol. 2018;24(2):105.
- 8. Lee SH, Song DG, Kim S, Lee JH, Kang DG. Results of auditory brainstem response monitoring of microvascular decompression: a prospective study of 22 patients with hemifacial spasm. Laryngoscope. 2009;119(10):1887-92.
- 9. Wang BC, Liang Y, Liu XL, Zhao J, Liu YL, Li YF et al. Comparison of chirp versus click and tone pip stimulation for cervical vestibular evoked myogenic

- potentials. Eur Arch Oto-Rhino-Laryngol. 2014;271(12):3139-46.
- Akin FW, Murnane OD, Panus PC, Caruthers SK, Wilkinson AE, Profiitt TM. The influence of voluntary tonic EMG level on the vestibular-evoked myogenic potential. J Rehabilitation Res Develop. 2004;41.
- 11. Parnes LS, Agrawal SK, Atlas J. Diagnosis and management of benign paroxysmal positional vertigo (BPPV). Cmaj. 2003;169(7):681-93.
- 12. Rauch SD. Vestibular evoked myogenic potentials. Curr opinion otolaryngol head neck surg. 2006;14(5):299-304.
- 13. Nandi R, Luxon LM. Development and assessment of the vestibular system. Int J Audiol. 2008;47(9):566-77.
- Egami N, Ushio M, Yamasoba T, Yamaguchi T, Murofushi T, Iwasaki S. The diagnostic value of vestibular evoked myogenic potentials in patients with Meniere's disease. J Vestibular Res. 2013;23(4,5):249-57.

- 15. Paparella MM. The cause (multifactorial inheritance) and pathogenesis (endolymphatic malabsorption) of Meniere's disease and its symptoms (mechanical and chemical). Acta oto-laryngologica. 1985;99(3-4):445-51.
- 16. Zapala DA, Brey RH. Clinical experience with the vestibular evoked myogenic potential. J Am Academy Audiol. 2004;15(3):198-215.
- 17. Fife TD, Colebatch JG, Kerber KA, Brantberg K, Strupp M, Lee H et al. Practice guideline: Cervical and ocular vestibular evoked myogenic potential testing: Report of the Guideline Development, Dissemination, and Implementation Subcommittee of the American Academy of Neurology. Neurology. 2017;89(22):2288-96.

Cite this article as: Sirige S, Kumar SR, Chaitanya VK, Reddy VK. Usefulness of vestibular evoked myogenic potentials in diagnosis of peripheral vestibular disorders. Int J Otorhinolaryngol Head Neck Surg 2021;7:1724-8.