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Vestibular evoked myogenic potentials: which modality should we use?

M GERALDINE ZUNIGA MD

Disclosure Information

This presentation will include discussion of

Off-label use of an evoked potential system to perform VEMP testing
Learning Objectives

After this course, participants will be able to:

1. Describe the different modalities currently available to perform VEMP testing including different types of stimuli, different measurement sites and outcome parameters.

2. Identify which is the 'go to' VEMP modality that may be used routinely when testing any type of patient.

3. Determine if a patient needs a different type of information than what the routine VEMP testing provides and will be able to select the particular modality that will be of greater use.

Overview

VEMP fundamentals
VEMP findings and suggested techniques per condition
◦ Control data
◦ Age effects
◦ Meniere’s disease
◦ Vestibular migraine
◦ Third window: SCDS, LVA
◦ Vestibular schwanoma
◦ Vestibular neuritis
◦ Central neurological disorders

Summary

References/suggested readings
VESTIBULAR EVOKED MYOGENIC POTENTIAL (VEMP)

EMG: modulated by stimulating vestibular afferents

The suggested pathway for the sound-evoked cVEMP, consisting of the primary vestibular afferent, medial vestibulo-spinal tract (MVST) and spinal accessory nerve (ACC).

OVEMP pathway, consisting of the primary vestibular afferent, possibly the medial longitudinal fasciculus and the oculomotor nuclei and nerves.

What do we measure?
CVEMP

1. Latency
2. Peak-to-peak amplitude
3. Corrected peak-to-peak amplitude
4. Frequency tuning
5. Thresholds
6. Asymmetry ratios

What do we measure?

**OVEMP**

1. Latency
2. Peak-to-peak amplitude
3. N1 or n10 peak amplitude
4. Frequency tuning
5. Thresholds
6. Asymmetry ratios

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**Sudden Bilateral Hearing Loss After Cervical and Ocular Vestibular Evoked Myogenic Potentials**

*Jameson K. Mattingly, †Cory D. F. Portnuff, ‡Brian M. Hondorp, and *Stephen P. Cass*

**Objective:** Cervical and ocular vestibular evoked myogenic potentials (cVEMP's and oVEMP's) are commonly used in evaluation of neurologic disorders. We present a case of sudden bilateral hearing loss immediately after oVEMP and cVEMP testing. The hearing loss did not recover. To our knowledge, no previous case reports discuss sudden hearing loss, especially bilateral, associated with VEMP testing.

**Patient:** A single patient with sudden bilateral hearing loss that has persisted after cVEMP and oVEMP.

**Intervention:** The patient had a history of chronic daily dizziness. She underwent vestibular function testing that included oVEMP and cVEMP testing. A significant bilateral sensorineural hearing loss was noted immediately after cVEMP and oVEMP testing and confirmed with audiometric testing. Despite the use of oral steroids, her hearing loss did not recover.

**Main Outcome Measures:** Serial audiograms, calculated maximum total sound energies to each ear.

**Results:** Pre-VEMP versus post-VEMP audiograms show increased thresholds and decreased word recognition scores; total sound energy delivered to each ear shows significant sound exposure.

**Conclusion:** Although VEMP testing is thought to be safe and well tolerated, a significant amount of sound can be delivered to the cochlea, and certain individuals may be susceptible to acoustic trauma at these levels. We recommend limits for VEMP stimuli levels and attention to total sound exposure when multiple trials are used. **Key Words:** Noise-induced hearing loss—Sudden hearing loss—Vestibular evoked myogenic potential.

VEMP testing for evaluation of otolith function

In general (or for control data)
Saccular function

- Cervical VEMP in response to ACS
  - 500 Hz tone bursts
  - Robust responses with greater test-retest reliability
    - Nguyen et al 2010; Viciana et al 2012
  - Why?
    - ACS VEMPs show frequency tuning at around 400–1000 Hz (Rosengren et al 2009)
  - Stimulus duration: 500 Hz TB = 4ms vs Clicks = 0.1ms
  - Outcome parameter → corrected peak-to-peak amplitudes
In general (or for control data)

Utricular function

- Ocular VEMP in response to midline taps
  - Reflex hammer
  - Better test-retest reliability vs Mini-shaker
  - Nguyen et al 2010
  - Outcome parameter → amplitudes

Age-matched results

With increasing age there is a decline in c- and oVEMP responses
- Decrease in peak-to-peak amplitudes, elevated thresholds

Consistent observation by different authors

- Li C et al "Epidemiology of vestibular evoked myogenic potentials: Data from the Baltimore Longitudinal Study of Aging." Clin Neurophysiol. 2015 Jan 24 [Epub ahead of print]
**VEMP in the elderly: screening tool for future fallers?**

*Cochlear & Saccular dysfunction*  
\( r = -0.37, p < 0.0001 \)

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**Age-related slowing of gait speed is in part mediated by the decreased magnitude of saccular response associated with age.**

- Layman and colleagues (2015)
  - 314 participants (mean age, 73.1 yr; range, 26-96 yr)
  - Greater cervical VEMP latency was associated with slower usual, rapid, and narrow gait speed in women but faster rapid gait speed in men.

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VEMP in different pathologies

Meniere's disease
Vestibular migraine
Superior canal dehiscence syndrome
Enlarged vestibular aqueduct
Vestibular neuritis
Vestibular schwannoma
Central Neurological disorders

Meniere’s disease

- Hydrops
  - After the cochlea, the sacculus is the second most commonly involved end organ
Meniere’s disease

- Cervical VEMP → ABNORMAL

Rauch and colleagues found in ears with MD – VEMP thresholds increased & frequency tuning impaired
This protocol is time-consuming and exhausting for patients

VEMPs in MD

Take away message...

For MD a simple air conducted sound evoked (ACS) cervical VEMP measure of corrected amplitude is useful for diagnosing MD

Criteria for definite Vestibular Migraine (Radtke/Neuhauser)

A. At least 2 attacks of vestibular vertigo

B. Current or previous history of migraine headaches

C. Concomitant migrainous symptoms during at least 2 vertigo attacks

D. No evidence of other central or otological causes of vertigo
Pathophysiology of VM

Central electrical disturbances
- Excitation/inhibition waves in brain affect central vestibular centers.

Peripheral trigemino-vascular efferent disturbances
- Trigeminal release of vasoactive peptides cause local inflammation in the ear.

by Katie McMeans
web.mac.com/mcmeansk, with permission


Click-evoked cVEMP

500 Hz TB oVEMP

VEMPs in VM

An abnormal VEMP result
- Does not equal MD
- Does not rule out VM

Cervical VEMP (500 Hz TB or Clicks)
- Help demonstrate peripheral hypofunction in VM relative to controls

Ocular VEMP: 500 Hz TB
- A NORMAL response (n10 > 4 μV), especially in patients younger than 40 years old
- Point more to VM vs MD.

No current ROC curves to provide the sensitivity vs specificity

Superior Canal Dehiscence Syndrome

Welgampola et al. VEMP thresholds normalize on plugging of SCD. Neurology (2008)
OVEMP amplitudes have been described superior to CVEMP amplitudes for the diagnosis of SCDS

CVEMP thresholds

OR

oVEMP amplitudes ...?

Click-cVEMP thresholds

Cut-off value: 87.5 dB (85 dB in practice)

Sensitivity: 73%
Specificity: 87%
500 Hz tone-burst oVEMP amplitude

Sensitivity & Specificity: > 90% for all ages

**Cut off:** ≥ 17μV

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SCDS VEMP

- **OVEMP amplitudes**
  in response to 500 Hz TB
Augmented Ocular Vestibular Evoked Myogenic Potentials to Air- Conducted Sound in Large Vestibular Aqueduct Syndrome

Rachael L. Taylor, Andrew P. Bradshaw, John S. Magnussen, William P. R. Gibson, G. Michael Halmagyi, and Miriam S. Welgampola

Objective: To demonstrate the value of recording air-conducted ocular Vestibular Evoked Myogenic Potentials (oVEMP) in a patient with bilaterally enlarged vestibular aqueducts.

Design: Cervical VEMP and oVEMP were recorded from a patient presenting with bilateral hearing loss and imbalance, attributable to large vestibular aqueduct syndrome. The stimuli were air-conducted tone bursts at octave frequencies from 250 to 2000 Hz. Amplitudes and thresholds were measured and compared with the normal response range of 32 healthy control subjects.

Results: oVEMP reflexes demonstrated pathologically increased amplitudes and reduced thresholds for low-frequency tone bursts. Cervical VEMP amplitudes and thresholds were within normal limits for both ears across all frequencies of stimulation.

Conclusions: This study is the first to describe the augmentation of AC oVEMPs in an adult with large vestibular aqueduct syndrome.

Vestibular neuritis

Iwasaki et al. (2009) ACS cVEMP and BCS oVEMP in patients with superior vestibular neuritis (n=13)

- ACS cVEMPS: Normal
- 12/13 had absent or reduced BC oVEMPS

Vestibular neuritis

Curthoys et al. (2010) looked at ACS 500 Hz TB oVEMP

- ACS oVEMP decreased/absent response
- BCV oVEMP decreased/absent response
- ACS cVEMP
Central neurologic disorders

Demyelinating disease
- Multiple sclerosis

Cerebrovascular disease
- HINTS examination is of greater utility

Neurodegenerative disease

Tumors in the posterior fossa

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Table 1

<table>
<thead>
<tr>
<th>Anatomical localization</th>
<th>Expected abnormalities</th>
<th>oVEMP</th>
<th>cVEMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peripheral labyrinth</td>
<td>Contralaterally absent responses or low amplitudes</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Vestibular nerve</td>
<td>Contralaterally absent responses or low amplitudes</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Brainstem</td>
<td>Contralaterally or bilaterally absent responses, low amplitudes, or latency prolongation are all possible</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Medulla</td>
<td>Bilaterally normal responses are expected. However, with more rostral disease progression absent responses, low amplitudes, or latency prolongation mostly contralateral or bilateral are all possible</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Cerebellar</td>
<td>Normal responses or possibly contralaterally absent responses</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

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### Summary

<table>
<thead>
<tr>
<th>Purpose</th>
<th>VEMP Reflex pathway</th>
<th>Stimulus and measurement</th>
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</thead>
<tbody>
<tr>
<td>Saccular assessment</td>
<td>Cervical</td>
<td>500 Hz TB</td>
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<tr>
<td>Utricular assessment</td>
<td>Ocular</td>
<td>Reflex hammer</td>
</tr>
<tr>
<td>MD</td>
<td>Cervical</td>
<td>500 Hz TB (reduced amps)</td>
</tr>
<tr>
<td>VM</td>
<td>Cervical</td>
<td>Either Clicks or 500 Hz TB to differentiate from normal</td>
</tr>
<tr>
<td>VM</td>
<td>Ocular</td>
<td>500 Hz TB : differentiate from MD in &lt;50 yo</td>
</tr>
<tr>
<td>SCDS</td>
<td>Ocular</td>
<td>500 Hz TB (increased amps)</td>
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</tbody>
</table>

### Summary

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<th>Purpose</th>
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<th>Stimulus and measurement</th>
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<tbody>
<tr>
<td>LVA</td>
<td>Ocular</td>
<td>500 Hz TB (increased amps)-third window effect</td>
</tr>
<tr>
<td>Vestibular schwannoma</td>
<td>O/Cervical</td>
<td>absent</td>
</tr>
<tr>
<td>Vestibular neuritis</td>
<td>Ocular</td>
<td>500 Hz TB or reflex hammer will be decreased</td>
</tr>
<tr>
<td>Central</td>
<td>O/Cervical</td>
<td>Delayed latencies; absent</td>
</tr>
</tbody>
</table>
Acknowledgements

- John P. Carey MD
- Devin McCaslin AuD PhD

Recommended readings


