VEMP: Vestibular Evoked Myogenic Potential

VEMP is a neurophysiological assessment technique used to determine the function of the otolithic organs (utricle and saccule) of the inner ear. It complements the information provided by other forms of vestibular apparatus testing (caloric testing, ENG/VNG, etc).

History

Bickford et al. (1964) and subsequently Townsend and Cody (1971), provided evidence for a short latency response in posterior neck muscles in response to loud clicks that appeared to be mediated by activation of the vestibular apparatus. Subsequent work led to the suggestion that the saccule was the end organ excited.

In 1992 Colebatch and Halmagyi found the same response using a modified recording site (the sternocleidomastoid muscles: SCM).

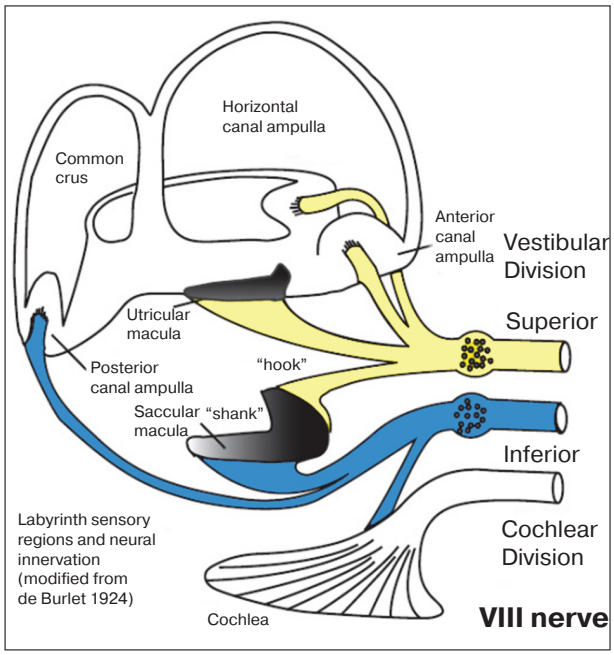

Fig.1. Human Vestibular System

Diagnostic Applications:

- Pathologically lowered thresholds:
  - superior canal dehiscence (SCD)
  - benign proxysmal positional vertigo (BPPV)
  - vestibular hypersensitivity disorders
- Absent or decreased potentials:
  - Ménière's disease
  - vestibular schwannoma (acoustic neuroma)
  - vestibular neuritis (neuronitis, neuropathy)
  - multiple sclerosis
  - otosclerosis
- Increased latencies:
  - vestibular schwannoma (acoustic neuroma)
  - benign proxysmal positional vertigo (BPPV)
  - multiple sclerosis
  - Guillain–Barré syndrome (GBS)

VEMP concept:

- Loud sound stimulates vestibular otolith organs
- Results in a change in muscle field potential (EMG)
- Generated by a brief period of inhibition of motor unit discharge (vestibulo-cervical reflex)
- Occurs ipsilateral to the stimulated ear
- Scales in direct proportion to the level of tonic neck contraction
- Does not depend upon hearing (cochlear function) per se
- Is small (although larger than many evoked potentials) and requires averaging

Types of VEMP tests:

- cVEMP (Cervical VEMP): electrodes are on the SCM muscle of the neck
- oVEMP (Ocular VEMP): electrodes are beneath the eyes.

Types of stimulation:

- AC (Air Conduction) – stimulates mostly saccule
- BC (Bone Conduction) – stimulates both saccule and utricle

Manzari et al, Otolaryngology – Head and Neck Surgery (2010) 143, 274-280: "*oVEMPs to BC vibration in superior vestibular neuritis show utricular function.*"

VEMP: Vestibular Evoked Myogenic Potential

Common Parameters:

A loud click or 500 Hz tone burst can be used.

Usually, 500 Hz tone burst produces largest response amplitude and more stable latencies.

Recording parameters

Analysis time window	50 ms
Sampling rate	5000 Hz

Stimulus parameters

Type	Tone burst
Rise/Fall	2 ms
Plateau	0 ms
Envelope	Blackman
Intensity	95-100 dB nHL
Stimulation rate	5 Hz

These are recommended parameter values for your information. You don't have to set them manually. **Neuro-Audio** software already contains test templates with these parameters.

But VEMPs to clicks should still be included in the test batteries for the diagnosis of vestibular schwannoma (*T. Murofushi – Vestibular schwannoma with absent VEMPs to clicks but normal ABR, caloric responses and VEMPs to 500 Hz tone bursts. Acta Oto-laryngologica, 2010)*.

cVEMP

Electrode Placement

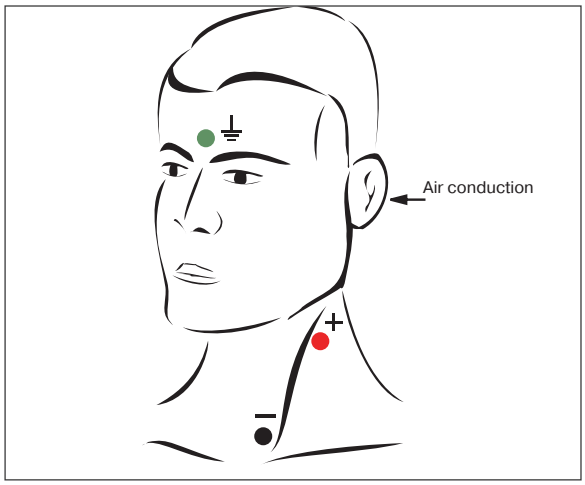

Fig. 2. Electrode placement for cVEMP

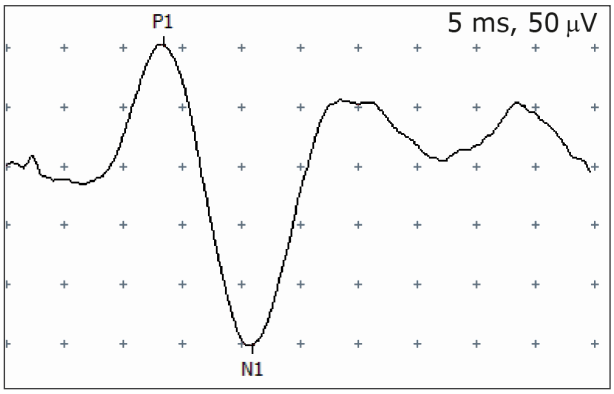

Fig. 3. The cVEMP trace recorded with shown electrode placement

Inverting (–): sternoclavicular junction

Non-Inverting (+): midpoint or upper ½ of SCM muscle of the side being stimulated

Ground: forehead or high forehead (Fpz)

Some doctors swap places of inverting and non-inverting electrodes. In this case the resulting VEMP trace will be inverted (mirrored horizontally).

Recording parameters

No. of channels	1-2
Filters	30–2000 Hz
No. of sweeps	60-250
Artifact rejection	Off

Stimulus parameters

Polarity	Rarefaction
Intensity	95 dB nHL
Stimulation rate	3-5 Hz

Pre-stimulus interval: 20 ms.

Normal latencies

P1	13-20 ms
N1	20-30 ms

Threshold normal values:

- 80 dB nHL +/- 10 dB
- <15 dB asymmetry between ears

VEMP Ratio: An amplitude asymmetry > 30-47% is considered clinically significant.

VEMP Ratio or IADR = 100(%)×(Amp[left]-Amp[right])/(Amp[left]+Amp[right])

Current Protocol

- >90 dB nHL
  - Amplitude asymmetry (VEMP Ratio, %)
  - Latency measurements
- 80 dB nHL for threshold estimation

VEMP: Vestibular Evoked Myogenic Potential

Problem: Amplitude Asymmetry Calculation

There is a direct correlation – the more tonic muscle tension, the larger the VEMP amplitude. Therefore, even normal subjects, whose saccular functions would be equal between right and left side, reveal right/left amplitude difference as well as wide ipsilateral test-retest variations. It means that there are limits for direct application of VEMP Ratio on clinical decisions because it shows a great deal of variations among even normal subjects. It's a problem. And there are solutions.

Solutions: Approaches to maintain the same EMG level on both sides

- **Biofeedback** (Min/Max RMS EMG limits; all traces outside limits are rejected)

  Test Procedure: RMS (or MRV) is calculated for EMG before each stimulus (pre-stimulus area) and displayed on a dial on a computer screen for patient to see. The subjects are instructed to keep the EMG level constant and at a predefined target level.

  Calibration: Prior to the VEMP test, the maximum contraction level is determined for each individual. Then the target level for all subsequent VEMP tests is set at approximately 70-80% of the maximum contraction level. The target level for normal adults (MRV): 50 µV (±20 µV).

  Article: R.Vanspauwen – VEMP test-retest reliability and normative values with a feedback method for SCM muscle contraction (Journal of Vestibular Research) [2009]

- **VEMP rectification/EMG scaling** (Rectified waveforms calculation, based on avaraged EMG MRV)

  Test Procedure: The averaged EMG level (in the pre-stimulus area) is calculated after each trial.

  Then the whole response waveform is scaled according to this average EMG level.

  Alternatively, just the corrected amplitude value is displayed: P-N amplitude / averaged EMG level.

  Article: Lee, Kim et al – The Usefulness of Rectified VEMP (Clinical and Experimental Otorhinolaryngology) [2008]

- **VEMP for children** (EMG histogram)

  Test Procedure: Record all epochs and EMG, later manually choose the EMG limits (target level) and epochs that will go to the final average.

  Article: E.Jacot, S.Wiener-Vacher – Potential value of VEMP in paediatric neuropathies (Journal of Vestibular Research) [2008]

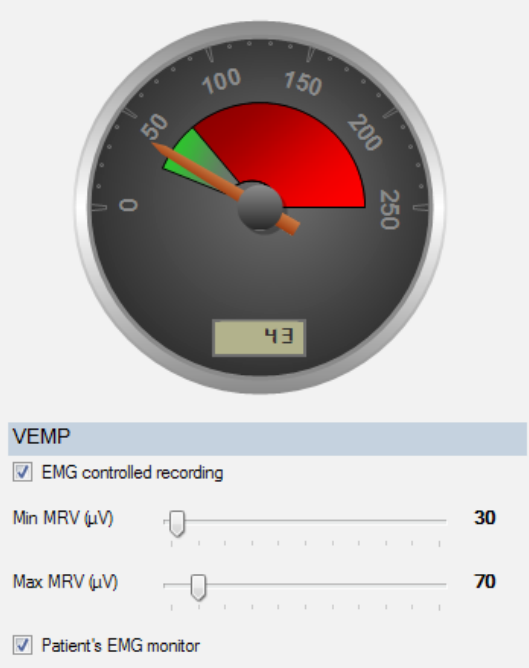

Fig.4. Biofeedback

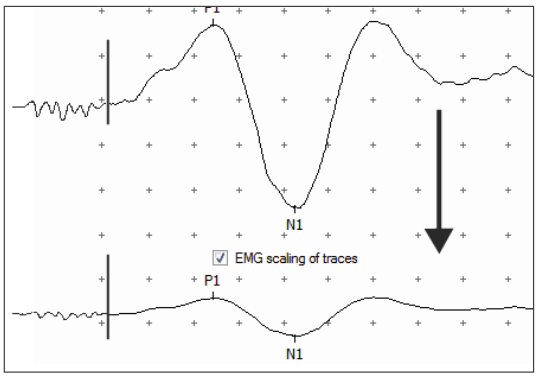

Fig. 5. VEMP rectification process

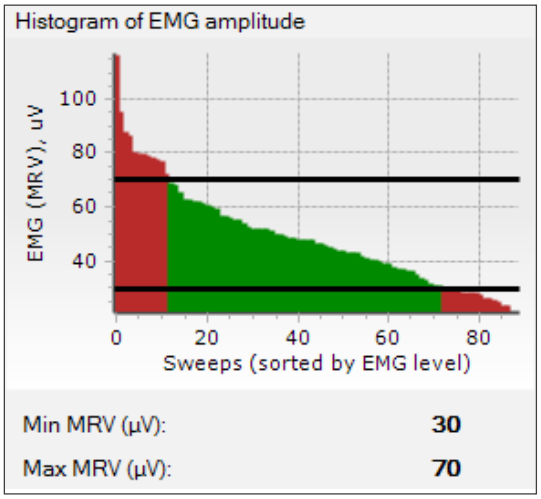

Fig.6. VEMP for children

VEMP: Vestibular Evoked Myogenic Potential

oVEMP

AC oVEMP

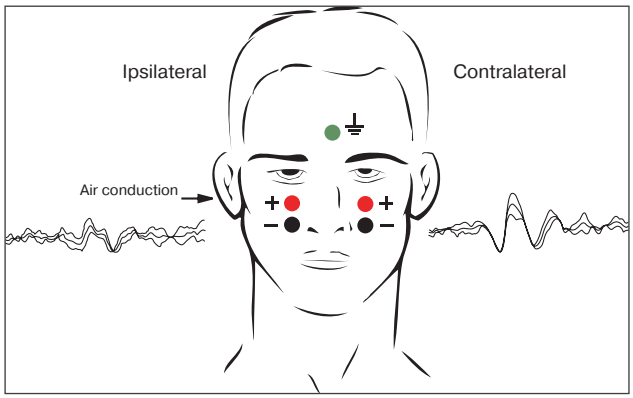

Fig. 7. AC oVEMP: electrodes and responses

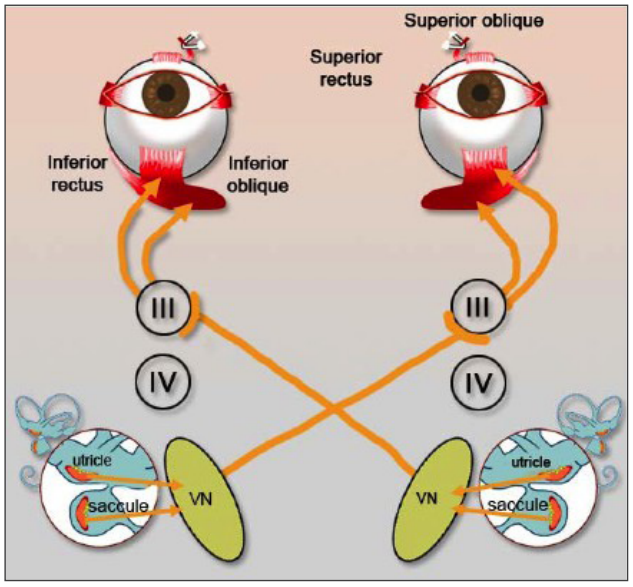

Fig. 8. oVEMP Pathway

Recording parameters

No. of channels	2
Filters	1 – 1000 Hz
No. of sweeps	200-500
Artifact rejection	36 µV
Vertical gaze angle	30 ° (midline)

Stimulus parameters

Polarity	Alternating
Intensity	100 dB nHL
Stim. rate	5 Hz

Recorded from electrodes beneath the eyes with patient looking up.

Predominantly a crossed excitatory response (stronger on the contralateral side).

Normal latencies: Initial negativity (10-12 ms) and a subsequent positivity (15-20 ms).

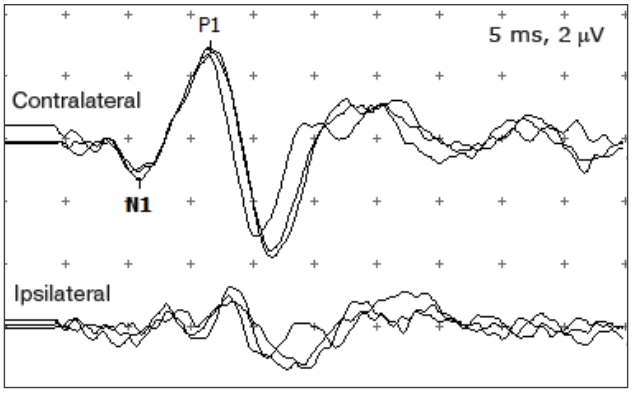

Fig. 9. AC oVEMP Response

BC oVEMP

Recording parameters

No. of sweeps	75
Artifact rejection	Off

Stimulus parameters

Polarity	Rarefaction
Intensity	155 dB FL

Types of transducers:

- Radioear B-71 at mastoid (relatively small response amplitude)
- Tendon hammer taps at Fz (relatively large response amplitude; stimulus calibration?)
- Bruel & Kjaer 4810 Minishaker at Fz (relatively large response amplitude)

oVEMPs: Diagnostic Utility

- BC oVEMPs require less averaging time than AC oVEMPs
- BC oVEMPs have higher response prevalence rate in normals than AC oVEMPs
- BC and AC oVEMPs: no correction for underlying muscle activity (in contrast to cVEMPs)

BC stimulus location at Fz ensures equal and simultaneous stimulation of both labyrinths.

Standard bone oscillator B-71 is ineffective:

- On Fz: the magnitude of the linear acceleration generated at the mastoids is not enough
- On each mastoid (successively): not clinically practical: small changes in the location, direction or force of B-71 on the mastoid cause substantial changes in the applied linear acceleration. As a result, the measured VEMPs will show artificial amplitude asymmetry.

VEMP: Vestibular Evoked Myogenic Potential

Healthy subject has approximately equal amplitude oVEMPs.

Patient with a complete unilateral vestibular loss has the oVEMP beneath the contralateral eye reduced or absent.

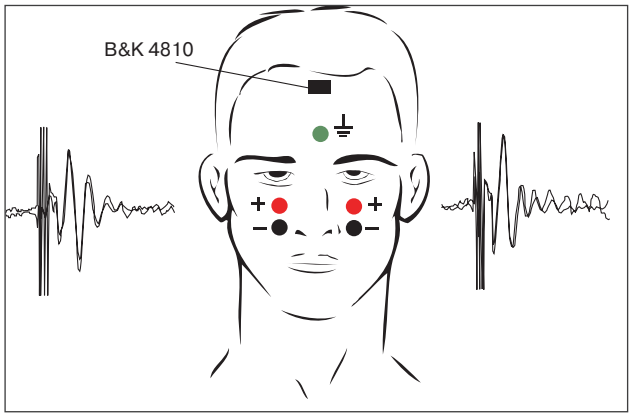

Fig. 10. BC oVEMP: electrodes and responses

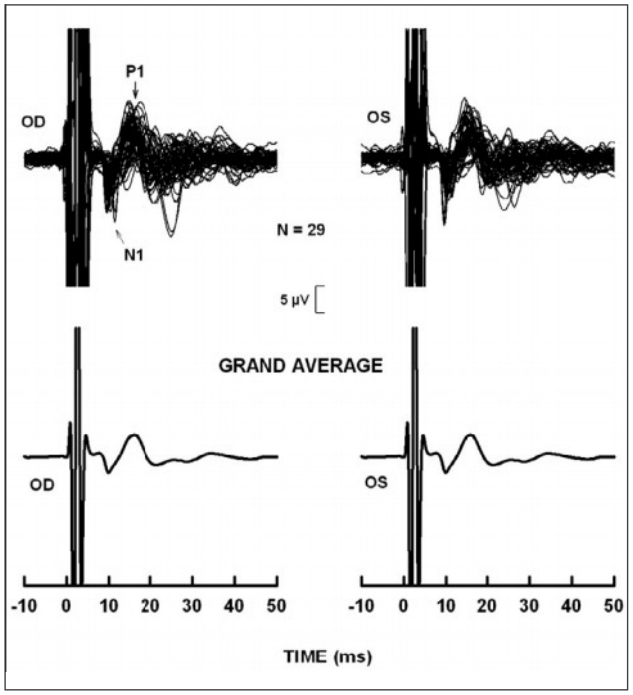

Fig. 11. BC oVEMP: Normal Waveforms

Abbreviations

OD – Oculus Dexter (right eye)

OS – Oculus Sinister (left eye)

OU – Oculus Uterque (both eyes)

RMS – Root-Mean-Square

MRV – Mean Rectified Value

IADR – Interaural Amplitude Difference Ratio

Sources

1. Wikipedia article on VEMP
2. VEMP presentations from Audiology NOW 2011:
   - Murnane et al – Ocular Vestibular Evoked Myogenic Potentials (East Tennessee State University)
   - Zapala – Vestibular Evoked Myogenic Potential Update (Mayo Clinic Florida)
3. Gans – Understanding VEMPs *(Audiology Today) [2005]*
4. R.Vanspauwen – VEMP test-retest reliability and normative values with a feedback method for SCM muscle contraction *(Journal of Vestibular Research) [2009]*
5. Lee, Kim et al – The Usefulness of Rectified VEMP (*Clinical and Experimental Otorhinolaryngology) [2008]*
6. E.Jacot, S.Wiener-Vacher – Potential value of VEMP in paediatric neuropathies *(Journal of Vestibular Research) [2008]*
7. Curthoys et al – oVEMPs to test utricular function: neural and oculomotor evidence *(ACTA OTORHINOLARYNGOLOGICA ITALICA) [2012]*

Neurosoft

www.neurosoft.ru