

New perspectives on vestibular evoked myogenic potentials

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New perspectives on vestibular evoked myogenic potentials

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Purpose of review

Although the vestibular evoked myogenic potential (VEMP) measured from the cervical muscles (cVEMP, cervical VEMP) is well described and has documented clinical utility, its analogue recorded from the extraocular muscles (oVEMP, ocular VEMP) has been described only recently and is currently emerging as an additional test of otolith function. This review will, therefore, summarize recent developments in VEMP research with a focus on the oVEMP.

Recent findings

Recent studies suggest that the oVEMP is produced by otolith afferents in the superior vestibular nerve division, whereas the cVEMP evoked by sound is thought to be an inferior vestibular nerve reflex. Correspondingly, the oVEMP correlates better with caloric and subjective visual vertical tests than sound-cVEMPs. cVEMPs are more complicated than often thought, as shown by the presence of crossed responses and conflicting results of recent vibration studies. Altered inner ear mechanics produced by the vestibular diseases superior semicircular canal dehiscence and Ménière's disease lead to changes in the preferred frequency of the oVEMP and cVEMP.

Summary

The oVEMP provides complementary diagnostic information to the cVEMP and is likely to be a useful addition to the diagnostic test battery in neuro-otology.

Keywords

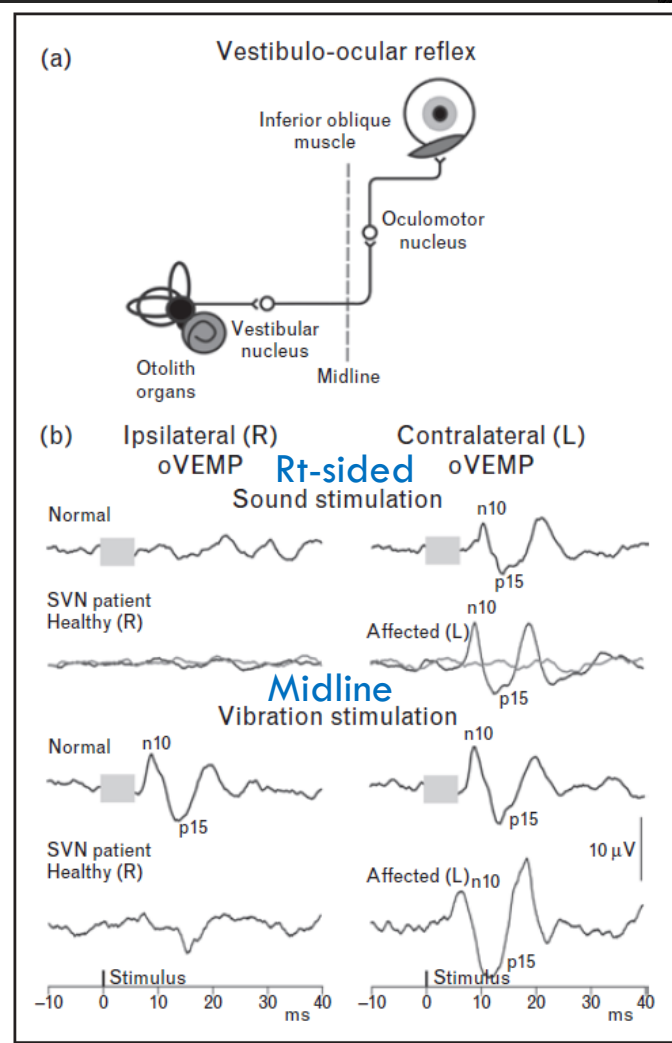
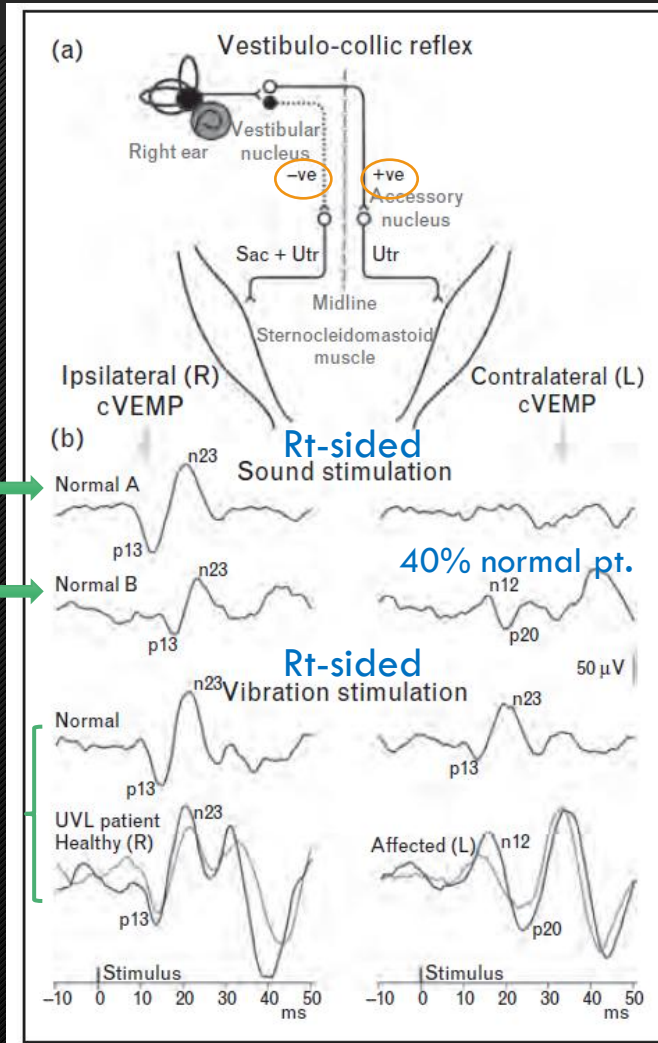
otolith, vestibular evoked myogenic potential, vestibulo-collic reflex, vestibulo-ocular reflex

Introduction

- cVEMP v.s. oVEMP

cVEMP	oVEMP
Saccular	Utricular
SCM	Inferior oblique muscle
Vestibulo-collic reflex	Vestibulo-ocular reflex

The physiological basis of VEMPs



0.1 ms clicks →

500Hz tone bursts →

500Hz on the Rt mastoid

Left-sided unilateral vestibular loss (UVL)

500Hz 4ms

Superior vestibular neuritis (SVN)

The physiological basis of VEMPs

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- The cVEMP is an **inhibitory reflex** measured from the **ipsilateral SCM** neck muscle.
- The oVEMP is a **crossed excitatory reflex** of the **inferior oblique eye muscle**.

The physiological basis of VEMPs

- VEMPs are commonly evoked by **loud sound or vibration**, stimuli that are thought to activate irregular otolith afferents.
- New evidence raises the possibility of contributions from the **semicircular canals**.

The physiological basis of VEMPs

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- VEMPs and vestibular neuritis:
 - Vestibular neuritis can affect the two portions of the vestibular nerve independently.
 - **Utricular afferents** (and some saccular afferents) course through the **superior nerve division**.
 - **Most saccular afferents** travel through the **inferior division**.

oVEMP origins

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- Abnormal horizontal canal responses on **caloric** or **head impulse testing (HIT)** but **present sound-cVEMPs**:
 - Partial dysfunction of superior vestibular nerve, and the inferior nerve was preservation.
 - Iwasaki et al., Manzari et al.: oVEMP evoked by **vibration** of the forehead are typically **asymmetric** or **absent in SVN**.
 - Curthoys et al., Govender et al., Shin et al., Lin et al.: Same result in **sound-oVEMP**.

oVEMP origins

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- Shin et al.:
 - Most of the patients with superior vestibular neuritis(SVN) had abnormal sound-oVEMPs.
 - The patient with inferior vestibular neuritis(IVN) had normal sound-oVEMPs but impaired sound-cVEMPs.
- Manzari et al.:
 - Most patient with IVN showed abnormal sound-cVEMP and symmetric vibration-oVEMP.

oVEMP origins

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- IVN is more difficult to definitively diagnosed than SVN, and preferably includes **a positive head impulse testing (HIT) for the posterior canal**.
 - Sound-cVEMP can sometimes be absent in normal individuals, particularly with **advanced age**.

oVEMP origins

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- Isolated cVEMP abnormality should be interpreted with caution when the **background muscle contraction** is not known, as it could be the result of underactivation of the SCM muscle.

oVEMP origins

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- Both sound-oVEMPs and vibration-oVEMPs originate in the superior division of the vestibular nerve.
- The greater number of utricular fibres in this division means that a large oVEMP asymmetry is likely to predominantly reflect a **utricular lesion**.

oVEMP origins

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- It is not yet known what role the fibres from the anterior hook region of the **sacculle** may play in this reflex.
- **Isu et al.:**
 - Relatively weak short-latency **sacculo-ocular projections**.

cVEMP origins

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- **Kushiro et al.:**
 - The saccule has only an ipsilateral inhibitory projection to the SCM.
 - The utricle (and probably also the canals) shares this projection and has an additional excitatory projection to the contralateral SCM.

cVEMP origins

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- **Welgampola et al.:**
 - Up to about 40% of normal volunteers, the sound-cVEMP consists of a bilateral response.
 - An inhibition (p13-n23) in the ipsilateral SCM.
 - A small excitation (n12-p20) in the contralateral SCM.
- The sound-cVEMP receives input from other vestibular organs, likely the utricle, especially with increasing stimulus intensity.

cVEMP origins

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- The crossed response is characteristic of patients with **superior canal dehiscence (SCD)**.
- **Watson et al., Brantberg et al.:**
 - It is not known whether it originates in the **utricle or superior canal or both**.
- **Govender et al.:**
 - **Vibration-cVEMP** correlated with **oVEMPs** rather than sound-cVEMPs, suggesting an origin in the **superior nerve and utricle**.

VEMP in vestibular dysfunction

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- Lin et al., Huang et al., Murofushi et al.:
 - The oVEMP appears to be most correlated with **subjective visual vertical (SVV) and caloric responses**, rather than sound-cVEMPs.
- The correlation between SVV and oVEMP is only expected during the **acute stage** of vestibular loss.
 - The performance on SVV improves over time due to vestibular compensation, while the oVEMP remains abnormal.

VEMP in vestibular dysfunction

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- Valko et al.:
 - oVEMPs perform better than SVV during eccentric rotation, a test that can detect SVV abnormalities even in cases of **chronic vestibular loss**.

VEMP in vestibular dysfunction

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- VEMPs have their clearest role in diagnosis of **superior semicircular canal dehiscence (SSCD)** and other ‘third window’ disorders.
- **Welgampola et al., Taylor et al.:**
 - The sound-cVEMP has a **low threshold and normal amplitude.**
 - oVEMP: a **low threshold and a reliably high amplitude.**

VEMP in vestibular dysfunction

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- Manzari et al.:
 - Midline vibration stimulus produces similar results to sound stimulation for both cVEMPs and oVEMPs.
- VEMPs from the dehiscent labyrinth are enhanced partly due to activation of **superior canal afferents**.
- Manzari et al.:
 - VEMPs can be abnormal even with dysfunction of the superior canal.

VEMP in vestibular dysfunction

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- In patients with SSCD have shown broader tuning curves for both reflexes.
 - The sound-cVEMP tend to tune **downwards**.
 - The sound-oVEMP tend to tune **upwards**.
- Zhang et al.:
 - The altered VEMP tuning returns to normal after resurfacing of the superior semicircular canal.

VEMP in vestibular dysfunction

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- Me´nie`re's disease, one that is thought to produce changes in the mechanical properties of the labyrinth.
- **Timmer et al.:**
 - The **sound-cVEMP** in patients with Me´nie`re's disease has **higher frequency tuning** than in controls.
- **Winters et al., Sandhu et al., Taylor et al.:**
 - Same result in the **sound-oVEMP**.

VEMP in vestibular dysfunction

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- Huang et al., Taylor et. al., Winters et al.:
 - The sound-oVEMP shows **lower mean amplitudes** and **higher rates of abnormality** in Me´nie`re's disease compared to control groups
 - Sometimes sound-oVEMP exceed the performance of the sound-cVEMP.
- Taylor et. al., Rosengren et al.:
 - In normal individuals, the sound-oVEMP has a **higher threshold** than the sound-cVEMP.

Conclusion

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- An origin primarily in the **ipsilateral saccule for the sound-cVEMP** and the **contralateral superior nerve (probably mainly the utricle) for sound-oVEMPs and vibration-oVEMPs**, suggesting that the reflexes can provide additional diagnostic information about the function of the otolith organs.

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Thank you for your attention

