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Review

Vestibular evoked myogenic potentials (VEMPs) in central neurological disorders

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HIGHLIGHTS

- Overview concerning VEMP abnormalities in central neurological disorders.
- VEMPs can give important clues to the localization of neurovestibular problems.
- VEMPs can give insight into the pathophysiological hallmark of the disorder.

ABSTRACT

Several types of acoustic stimulation (i.e. tone bursts or clicks), bone-conducted vibration, forehead taps, and galvanic stimulation elicit myogenic potentials. These can be recorded in cervical and ocular muscles, the so called vestibular evoked myogenic potentials (VEMPs). The cervical VEMP (cVEMP) resembles the vestibulo-collic reflex and the responses can be recorded from the ipsilateral sternocleidomastoid muscle. The ocular VEMP resembles the vestibulo-ocular reflex and can be recorded from extra-ocular muscles by a surface electrode beneath the contralateral infraorbital margin. Initially, the literature concerning VEMPs was limited to peripheral vestibular disorders, however, the field of VEMP testing is rapidly expanding, with an increasing focus on central neurological disorders. The current literature concerning VEMP abnormalities in central neurological disorders is critically reviewed, especially regarding the methodological aspects in relation to quality as well as the clinical interpretation of the VEMP results. Suggestions for further research are proposed as well as some clinically useful indications.

Contents

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1. Introduction

In the last two decades vestibular evoked myogenic potentials (VEMPs) came into use as a test suitable for detailed physiological assessment of the vestibular system. VEMPs can be evoked by short intense auditory stimuli (i.e. tone bursts or clicks), bone-conducted vibration, forehead taps, and galvanic stimulation (Curthoys, 2010a; Papathanasiou et al., 2014; Rosengren et al., 2010; Rosengren and Kingma, 2013; Welgampola and Colebatch, 2005). In daily practice, air-conducted acoustic stimuli are used most often, followed by bone-conducted vibration and forehead taps. The responses can be divided into a cervical response and an ocular response.

The cervical vestibular evoked myogenic potential (cVEMPs) can be recorded by placing an active surface electrode over the upper middle part of the sternocleidomastoid muscles with a reference electrode on the sternal manubrium. The sternocleidomastoid muscles, however, both have to be activated by flexing the neck, or they have to be ipsilaterally activated by rotating the head contralaterally away from the stimulated ear (when cVEMPs are acoustically elicited by air-conducted clicks or tone bursts, AC-cVEMPs). cVEMPs measure the integrity of the vestibulo-collic reflex from the saccular afferents to the brainstem vestibular nuclei (through the inferior vestibular nerve), evoking an inhibitory motor response in the ipsilateral sternocleidomastoid muscle (through the medial vestibulospinal tract, upper cervical motor neurons and the accessory nerve) (Curthoys, 2010a; Eleftheriadou and Koudounarakis, 2011; Rosengren et al., 2010; Rosengren and Kingma, 2013) (Fig. 1).

The ocular vestibular evoked myogenic potential (oVEMP) measures the function of the vestibulo-ocular reflex arc from the otolith end-organ(s) to the brainstem vestibular nuclei through the superior vestibular nerve and medial longitudinal fasciculus, evoking an excitatory oculomotor response in the inferior oblique muscle mainly in the contralateral eye. The precise localization of the end-organ involved in the origin of the oVEMP is controversial and has been debated extensively in the literature (i.e. whether the end-organ is predominantly the sacculus, the utriculus, or a combination of both), however there is consensus that the relevant afferents travel through the superior division of the vestibular nerve (Colebatch, 2010; Curthoys, 2010a,b; Eleftheriadou and Koudounarakis, 2011; Papathanasiou, 2012, 2013; Rosengren et al., 2010; Rosengren and Kingma, 2013; Todd, 2014) (Fig. 1). By maintaining an upward gaze during the stimulation oVEMPs can be recorded by an active electrode just below the middle of the infraorbital margin with the reference electrodes 1–2 cm below the active electrode (Curthoys, 2010a; Walter et al., 2011).

The cVEMP's morphology can be divided into two parts. The early biphasic positive–negative component (p_{13}–n_{23}) is presumed to be of mainly saccular origin. The second biphasic negative–positive complex (n_{34}–p_{44}) is thought to be auditory in acoustic stimulation and of an unknown origin in forehead tap evoked responses (possibly a stretch reflex) (Fig. 2). The oVEMP's morphology consists of a quadriphasic negative–positive deflection (n_1–p_1 and n_2–p_2 complex) (Fig. 2).

Historically, the clinical research concerning VEMPs focused on peripheral neurovestibular disorders. However the field of VEMP testing is rapidly expanding with an increasing focus on central neurological disorders. For an overview on VEMP abnormalities in mainly peripheral vestibular disorders we refer to Brantberg (2009). Reviews concerning VEMP abnormalities in central neurological conditions are scarce, despite the growing number of clinical studies. In this paper, we present an overview concerning VEMP abnormalities in central neurological disorders, the interpretation of these VEMP results, and their clinical application. In addition, we stress the importance of applying a correct methodological procedure in future clinical VEMP research and clinical VEMP testing in individual patients. We critically assessed the available literature concerning VEMP abnormalities in central neurological disorders in order to get an impression of the applied technical aspects as well as the methodology and the interpretation of the studies aiming to estimate the level of diagnostic evidence.

2. Clinical applications

2.1. Demyelinating disease

Multiple sclerosis (MS) is a chronic, demyelinating disease of the central nervous system. MS is a leading cause of disability in young adults with a prevalence of 1 out of 1000 persons living in northern Europe (Compston and Coles, 2008).

The presence of AC-cVEMPs abnormalities varies from 31% to 70% in the literature; delayed p_{13}, often in combination with increased n_{23} latencies, are the most common abnormalities,

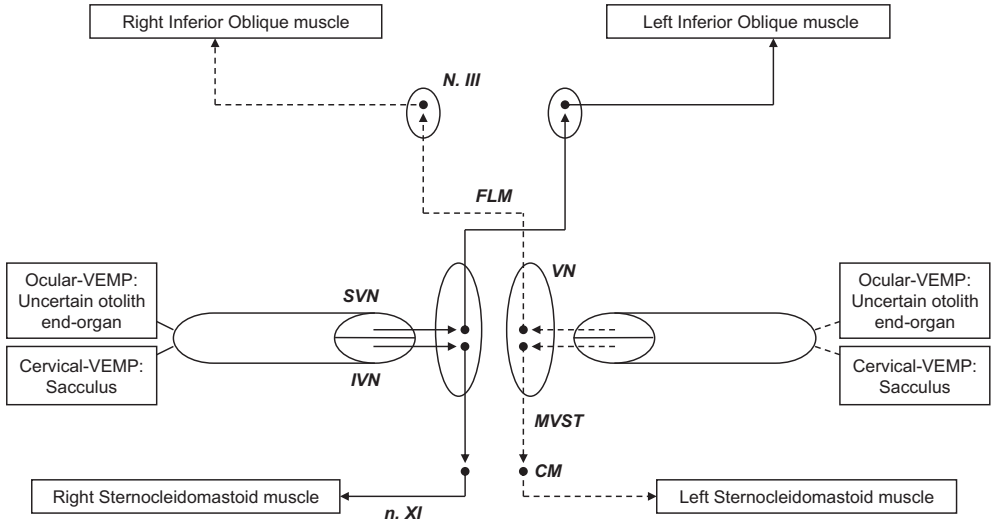

Fig. 1. Neurophysiological pathways concerning the ocular and cervical vestibular evoked myogenic potentials. We refer to the text for further explanation. CM: cervical motor neuron; FLM: medial longitudinal fasciculus; IFN: inferior division of the vestibular nerve; MVST: medial vestibulospinal tract; N. III: oculomotor nucleus; n. XI: accessory nerve; SVN: superior division of the vestibular nerve; VN: vestibular nuclei.