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Invited review

Vestibular evoked myogenic potentials: Past, present and future

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A B S T R A C T

Since the first description of sound-evoked short-latency myogenic reflexes recorded from neck muscles, vestibular evoked myogenic potentials (VEMPs) have become an important part of the neuro-otological test battery. VEMPs provide a means of assessing otolith function: stimulation of the vestibular system with air-conducted sound activates predominantly saccular afferents, while bone-conducted vibration activates a combination of saccular and utricular afferents. The conventional method for recording the VEMP involves measuring electromyographic (EMG) activity from surface electrodes placed over the tonically-activated sternocleidomastoid (SCM) muscles. The "cervical VEMP" (cVEMP) is thus a manifestation of the vestibulo-collic reflex. However, recent research has shown that VEMPs can also be recorded from the extraocular muscles using surface electrodes placed near the eyes. These "ocular VEMPs" (oVEMPs) are a manifestation of the vestibulo-ocular reflex. Here we describe the historical development and neurophysiological properties of the cVEMP and oVEMP and provide recommendations for recording both reflexes. While the cVEMP has documented diagnostic utility in many disorders affecting vestibular function, relatively little is known as yet about the clinical value of the oVEMP. We therefore outline the known cVEMP and oVEMP characteristics in common central and peripheral disorders encountered in neuro-otology clinics.

Contents

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1. Introduction

An important aim of vestibular research is to develop techniques for assessing vestibular function in clinical settings. Methods based upon short-latency reflexes and evoked responses have been applied to the vestibular system only relatively recently, with the development of the VEMP (vestibular evoked myogenic potential). The VEMP is a short-latency myogenic response which is evoked by brief pulses of air-conducted (AC) sound, bone-conducted (BC) vibration or electrical stimulation and recorded using surface electrodes placed over muscles. The VEMP as currently understood was first described by Colebatch and Halmagyi (1992) and Colebatch et al. (1994a), who measured electromyographic (EMG) activity from the sternocleidomastoid (SCM) muscles following vestibular stimulation with brief pulses of sound (clicks). It is a manifestation of the vestibulo-collic reflex, resulting from activation of the vestibular nerve and nucleus, the vestibulospinal tract, the accessory nucleus and nerve and the sternocleidomastoid muscle (Fig. 1). Since the initial report, VEMPs have become a standard clinical test of otolith (predominantly saccular) function, with documented diagnostic utility in varied vestibular and central nervous system disorders.

In more recent years, similar myogenic responses have been evoked in other muscle groups, such as the masseter (Deriu et al., 2005). In particular, recordings made from around the eyes have demonstrated that short latency potentials can also be recorded from the extraocular muscles as part of the vestibulo-ocular reflex (e.g. Rosengren et al., 2005; Todd et al., 2007), i.e. by activation of the vestibular nerve and nucleus, and transmitted possibly via the medial longitudinal fasciculus, the oculomotor nuclei and nerves and the extraocular muscles (Fig. 2). Due to the strength of the vestibulo-ocular reflex arc, the extraocular responses are easily recorded and have promising diagnostic potential. To distinguish them from the conventional VEMP, the extraocular responses are referred to as ocular VEMPs (oVEMPs or OVEMPs), while SCM responses are now sometimes qualified as cervical VEMPs (cVEMPs, CVEMPs or VEMPs). This review describes the historical development of both the cVEMP and oVEMP, provides practical information for recording VEMPs and discusses the clinical applications of the reflexes.

2. Cervical VEMPs

2.1. Historical aspects

The development of the digital averager (e.g. Dawson, 1954) led to the initial reports of click-evoked responses recorded from the scalp (Geisler et al., 1958), which Geisler and Rosenblith (1962) reported were largest over the occiput. Bickford et al. (1963) subsequently recorded widespread responses over the scalp to loud AC tone bursts, with the shortest latencies over the cervical muscles. They also made the crucial observations that these responses were myogenic in origin and that the amplitude of the response was related to the tension in the muscles. Bickford et al. (1964) then reported in detail the effects of loud clicks (0.5 ms, 120 dB) in 30 volunteers. A short latency initial peak was present at ~13 ms, the "inion response", which was modulated by the level of tonic neck extension and abolished by curarisation. Recordings in deaf

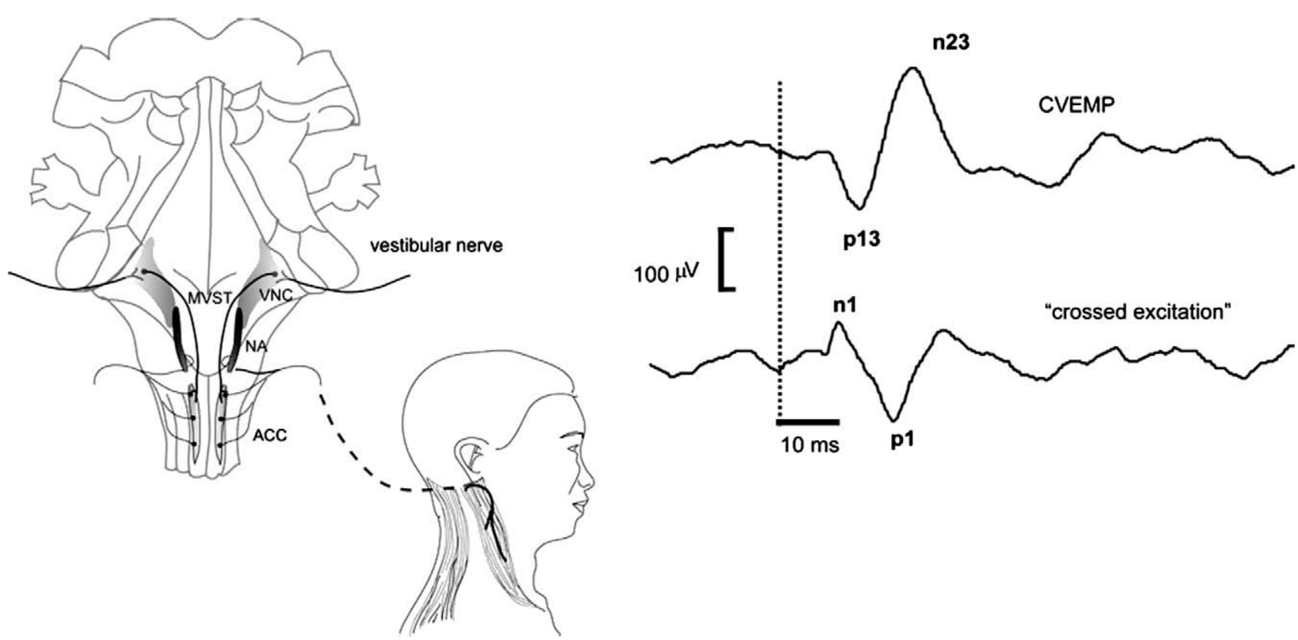

Fig. 1. (Left) The presumed pathway for the sound-evoked cVEMP, consisting of the primary vestibular afferent, medial vestibulo-spinal tract (MVST) and spinal accessory nerve (ACC). VNC, vestibular nuclear complex; NA, nucleus ambiguus. (Right) Averaged sternocleidomastoid EMG traces showing a typical ipsilateral cVEMP to a monaural AC click and a "crossed excitation", which has similar latency but opposite polarity and is sometimes seen in the contralateral SCM (see Section 2.1).