Preservation of tap vestibular evoked myogenic potentials despite resection of the inferior vestibular nerve

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Received 2 July 2003
Accepted 27 January 2004

Abstract. Sound and skull-tap induced vestibular evoked myogenic potentials (VEMP) were studied in a 43-year-old man following inferior vestibular neurectomy. Surgery was performed because of a small acoustic neuroma. Postoperative caloric testing suggested sparing of superior vestibular nerve function on the operated side. In response to sound stimulation there were no VEMP on the operated side, irrespective of whether sounds were presented by air- or bone-conduction. This suggests sound-induced VEMP to be critically dependent on inferior vestibular nerve function and this is in agreement with present knowledge. However, VEMP were obtained in response to forehead skull taps, i.e. positive-negative VEMP not only on the healthy side but also on the operated side. This suggests remnant vestibular function on the operated side of importance for forehead skull tap VEMP, because with complete unilateral vestibular loss there are no (positive-negative) VEMP on the lesioned side. Thus, forehead skull-tap VEMP depend, at least partly, on the superior vestibular nerve function.

Keywords: VEMP, vestibulocollic, skull tap, vestibular nerve, acoustic neuroma

1. Introduction

During the last few years, there have been many reports on vestibular evoked myogenic potentials (VEMP). Loud sounds evoke short-latency ipsilateral positive-negative EMG responses of a tonically contracting sternocleidomastoid muscle [1–3]. These sound-induced vestibular responses are related to the functional integrity of the sacculus [4–6] and the inferior vestibular nerve [7,8] (which innervates the major part of the sacculus).

The idea of a vestibular origin is supported by observations of similar VEMP in response to a more direct route for stimulating the vestibular apparatus, i.e. tapping the head lightly with a tendon reflex hammer [9–12]. The VEMP in response to skull taps delivered on the upper forehead are very similar to those which are sound-induced. However, while sounds cause VEMP mainly on the side of stimulation, skull tapping can cause bilateral responses (i.e. normal VEMP on one side with an inverted response on the other side) also in patients with complete unilateral loss of vestibular function [13]. This might suggest that sounds and skull taps to some extent stimulate different parts of the vestibular organ. Moreover, although patients with vestibular neuritis usually have normal sound-induced VEMP (because the inferior nerve is usually spared in this disease [7,14–16]) they often show abnormal skull-tap VEMP [17]. Consequently, skull-tap VEMP could, to some degree, also be related to superior vestibular nerve function.
The aim of the present study was to test sound- and skull tap-induced VEMP in a patient with a selective resection of the inferior vestibular nerve, in order to determine whether skull taps can evoke VEMP despite loss of inferior vestibular nerve function.

2. Methods

All VEMP testing was done using a Medelec Sapphire II signal averager. Air-conducted sound stimuli were 500 Hz tone bursts (rise/fall time 2 ms, plateau 2 ms) with a C-weighted max peak value of 129 dB SPL (which is the routine stimulus for VEMP testing used at our clinic). Sounds were presented monaurally via TDH-49P headphones. The stimulus rate was 4/s. Three stimulation sequences were given, each consisting of 64 tone bursts.

When VEMP in response to bone-conducted sounds were tested, the Medelec Sapphire II signal averager supplied a trigger to a waveform generator (HP33120A, Hewlett Packard). The output of the waveform generator was coupled to the CD/Tape input of an audiometer (Madsen Itera). The input level of the audiometer was adjusted to give maximal output without distortion. This setting is equal in amplitude to a 250 Hz tone with a setting of 65 dB HL. The sound stimuli were tone bursts (2 ms rise/fall time, 8 ms plateau time) delivered monaurally on the mastoid using standard bone-conductors (Radioear B-72). The stimulus rate was 4/s. Three stimulation sequences were given, each consisting of 128 tone bursts.

VEMP in response to gentle skull taps were obtained using a reflex hammer with an inertial trigger switch (Patella Hammer, Medelec, Surrey, UK). This stimulus was delivered manually through a pad on the upper forehead. The stimulation was given in three sequences, each consisting of 8 skull taps. The stimulus rate used was approximately 0.5/s.

Two-channel recordings of surface electromyographic activity were obtained using disc electrodes (Red Dot, 3 M Health Care, Borken, Germany). The active electrodes were placed symmetrically over the most prominent part of each sternocleidomastoid muscle (above the midpoint between the mastoid process and the sternum), the reference electrodes were placed near the mid-portion of each clavicle and the ground electrode was placed on the uppermost part of the sternum. Recordings were made in the supine position and the subjects were instructed to raise their heads in order to activate the sternocleidomastoid muscles. A (numeric) mean value for the rectified EMG for the right and the left sternocleidomastoid muscle during the 50 ms post-stimulus period was also recorded. This was done to correct for differences in tonic muscle contraction, which has been shown to be linearly correlated to the amplitude of the VEMP [2].

The caloric test was used for quantitative measurements of lateral semicircular canal function [18]. The caloric ratio was calculated from the slow phase eye velocity produced by irrigation according to the formula, (44° R + 30° R) – (44° L + 30° L) / (44° R + 30° R + 44° L + 30° L). In addition, a head-impulse test was used to test the function within each individual semicircular canal [19].

3. A case report

The 43-year-old man had suffered for one year from tinnitus and a slight hearing impairment in his left ear.
He denied, at that point, having any vestibular problem. Audiological testing revealed a small sensorineural loss in the high frequency range on the left side (Pure Tone Average for 0.5, 1 and 2 kHz (PTA) = 21 dB HL, and for 3, 4 and 6 kHz (high frequency PTA) = 36 dB HL). The speech discrimination score (SDS) was normal (100%/60 dB). Auditory brainstem responses showed no reproducible waves on the left side and MRI revealed an intracanalicular acoustic neuroma on the left side with a maximal extracanalicular portion of 4 mm. Different treatment modalities were discussed with the patient; it was decided to follow his condition, but not to give any treatment for the tumor at that stage.

During the following months, hearing deteriorated on the affected side (PTA = 33 dB, high frequency PTA = 60 dB, SDS = 98%/70 dB). He also experienced vestibular symptoms, mainly a weak feeling of being pushed to the left when he was walking, but vestibular tests were not carried out. A new MRI showed an increase in tumor size in all directions; the entire tumor was now 15 × 8 × 9 mm (Fig. 1). He was operated on using a retromastoidal approach. The sigmoid sinus was skeletonized to increase space and the tumor identified following lifting of the cerebellum. The internal acoustic meatus was drilled out to allow tumor removal and the cochlear, facial and vestibular nerves were identified. The tumor originated in the inferior vestibular nerve which was resected; the tumor was decompressed internally and sharply dissected from the remaining three nerves that were left intact. The postoperative period was uneventful and the patient was discharged after five days.

Immediately post-operatively there were no changes regarding the auditory and vestibular symptoms, in particular the patient denied unsteadiness and intolerance for head movements. The results of a postoperative hearing test two months after surgery were not significantly different from the pre-operative results (PTA = 36 dB, high frequency PTA = 63 dB, SDS = 90%/75 dB). In vestibular testing four months after surgery he revealed a fairly normal head-impulse response for the left lateral and left superior semicircular canal, although the response was severely impaired for the left posterior. He had no spontaneous nystagmus. After head-shake there was a weak and decaying right-beating nystagmus (initial slow phase eye veloc-
ity = 3°/s). A caloric test revealed a partially decreased response from the left ear (caloric ratio = 0.31).

There were no VEMP on the left side, neither in response to air-conducted sounds presented to the left ear nor to bone-conducted sounds presented behind the left ear (Fig. 2). However, VEMP in response to forehead skull taps were present bilaterally (Fig. 3). Although the VEMP in response to skull taps look almost symmetrical, there were some differences in tonic muscular contraction during the recording suggesting a somewhat larger response on the healthy right side. In the first recording (“Day 1”) the relative amplitude on the right side was 2.4 (amplitude = 156 µV, tonic muscle contraction = 66 µV) and on the left side 1.6 (amplitude = 131 µV, tonic muscle contraction = 80 µV). In the second recording (“Day 2”) it was 1.9 (155 and 81 µV) on the right side and 1.2 on the left side (118 and 96 µV).

4. Discussion

Innervation divides the labyrinth into two parts. The superior vestibular nerve innervates the lateral semicircular canal, the superior semicircular canal, the utricle and a small part of the saccule. The inferior vestibular nerve innervates the posterior semicircular canal and the majority of the saccule. As expected, the present patient with a resection of the inferior vestibular nerve had no sound-induced VEMP on the operated side. This finding is in agreement with present knowledge, i.e. that sound-induced VEMP are critically dependent on saccular and inferior vestibular nerve function. The fact that VEMP were also absent on the operated side in response to bone-conducted sounds suggests that this was not simply caused by a conductive hearing loss attenuating the sound stimulation [20,21]. In addition, audiograms did not suggest a conductive hearing loss and stapedius reflexes could be elicited on the operated side in response to sounds presented to both the healthy ear and the operated ear.

Earlier studies have demonstrated that forehead skull tap VEMP are dependent on vestibular function. In cases with complete unilateral vestibular loss, in response to forehead taps, there are normal VEMP on the healthy side and inverted VEMP on the lesioned side [9,13]. The present finding of VEMP bilaterally in response to forehead skull taps suggests that this response is not critically dependent on the sound responsive part of the saccule, the posterior semicircular canal or the inferior vestibular nerve. Thus, forehead skull tap VEMP are, at least partly, dependent on su-
perior vestibular nerve function. This conforms with the frequent abnormal forehead skull tap VEMP seen in patients with vestibular neuritis [17].

References


