Vestibular-evoked myogenic potential (VEMP) triggered by galvanic vestibular stimulation recorded in the lower limbs

Ludimila Labanca,Júlia Fonseca de Morais Caporali,Maurício Campelo Tavares,Denise Utsch Gonçalves

Abstract

Galvanic vestibular stimulation (GVS) is a method that stimulates the vestibular afferents with a small current, triggering a motor reflex response in the posture-controlling muscles. This response can be captured by electromyography (EMG) and is called vestibular evoked myogenic potential (VEMP). The VEMP triggered by GVS (galvanic-VEMP) assesses the central pathways of the vestibular system. When the EMG responses are recorded in the lower limbs, galvanic-VEMP provides information about the function of the vestibulospinal tract extending from the cervical to the lumbar spine. Galvanic-VEMP is a safe, low-cost, and easily performed test which has been used to investigate spinal cord function in cases of trauma, tumor, ischemia, and infection. Our research group has been using galvanic-VEMP to follow patients with diseases that cause postural disabilities, such as Human T-cell lymphotropic virus type 1-associated myelopathy (HAM), Schistosomal myeloradiculopathy, and Parkinson's disease. This protocol aims at showing how to perform VEMP triggered by galvanic vestibular stimulation with the EMG responses being recorded in the lower limbs.

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Protocol

Equipment / Software

Step 1.

This protocol uses the EvP4/ATCPlus model (Contronic Ltd., Pelotas, Brazil) connected to a laptop. During the exam the laptop cannot be connected to the mains power (figures 1 and 2).

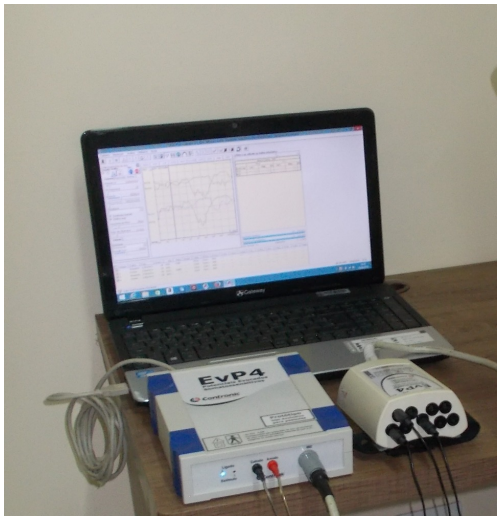

Figure 1. The laptop connected to EvP4 equipment (Contronic Ltd., Pelotas, Brazil).

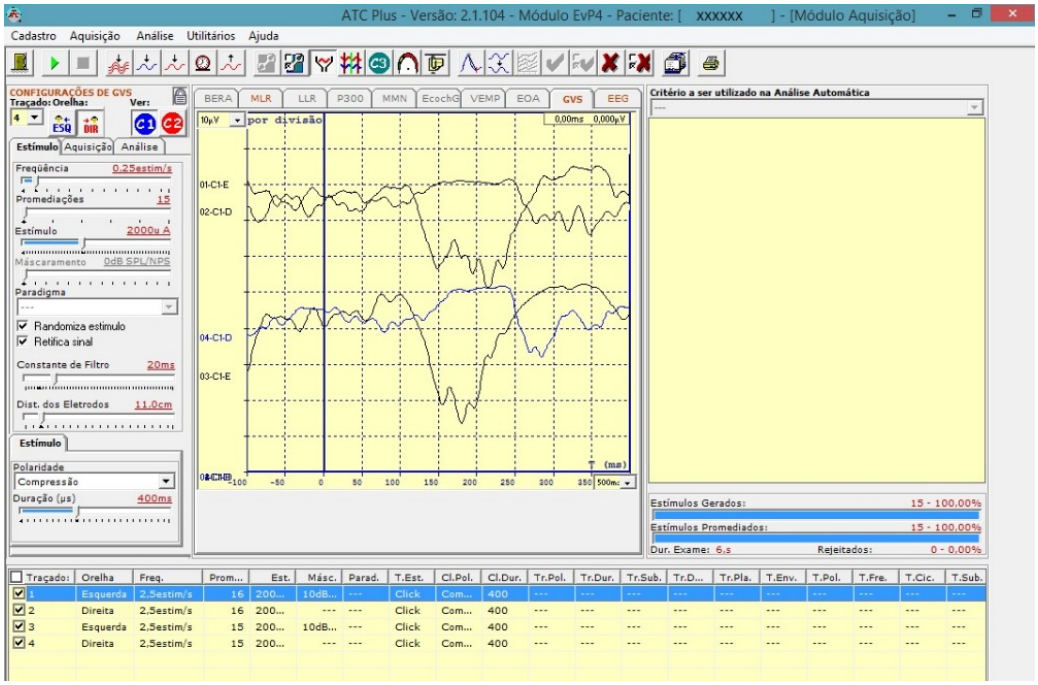

Figure 2. Electromyography traces of galvanic-VEMP using ATC Plus software (Contronic Ltd., Pelotas, Brazil).

Position of stimulation electrodes

Step 2.

The electrodes of stimulation must be set on the right and left mastoid processes by using self-adhesive surface electrodes (Figure 3). Underneath the electrodes the skin must be clean, dry and

with few or no hair.

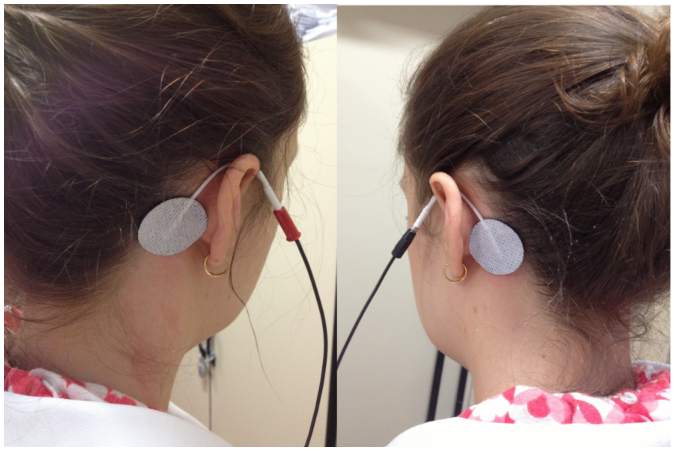

Figure 3. Self-adhesive surface electrodes of stimulation set on the right and left mastoid processes.

Position of recording electrodes

Step 3.

A pair of recording electrodes is vertically placed 5 cm below the popliteal fossa, on the medial head of the gastrocnemius muscle, with approximately 5 cm between their centers. A reference electrode is placed on the back of the thigh, approximately 10 cm above the superior recording electrode (Figure 4). Underneath the electrodes the skin must be clean, dry, and with few or no hair. The acceptable impedance range for the skin-electrode connection is from 0 to 5 KOhm.

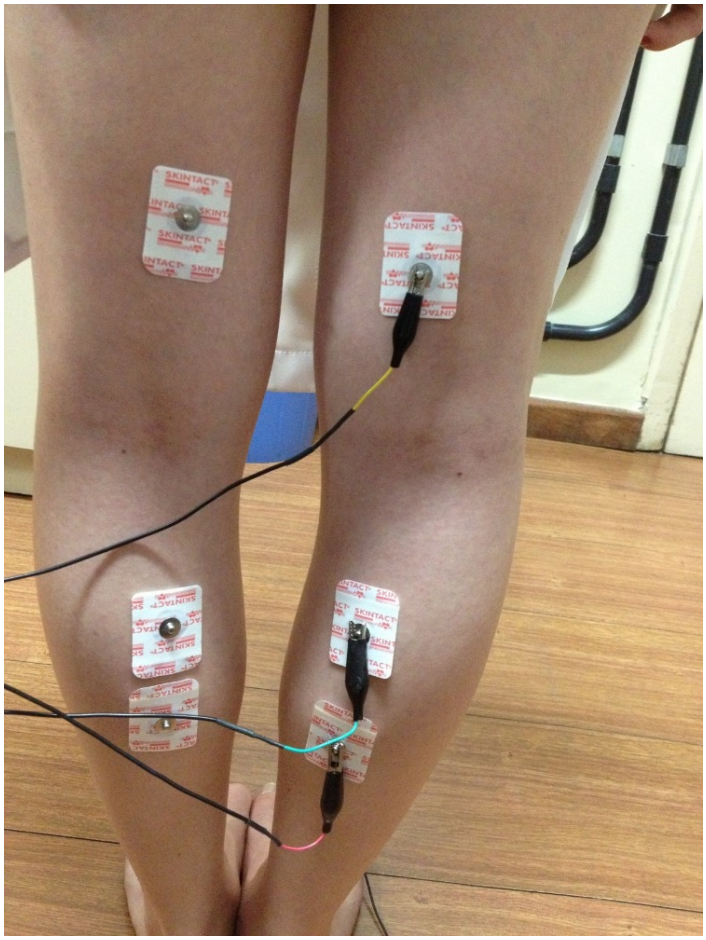

Figure 4. Pair of recording electrodes placed on the medial head of the gastrocnemius muscle. A reference electrode is placed on the back of the thigh.

Position for the exam:

Step 4.

During the procedure, the examined person must stand barefoot on a flat and hard surface with his/her eyes closed, feet close together and body leaning forward in order to get the gastrocnemius muscle contraction. For a stronger response, the person must be instructed to turn his/her head approximately 90° to the contralateral side of the leg undergoing electromyography recording (Figure 5).

Figure 5. Vestibular-evoked myogenic potential triggered by galvanic vestibular stimulation procedure. The picture shows: the standing position of the examined person (barefoot on a flat and hard surface with eyes closed, feet close together and body leaning forward in order to cause the gastrocnemius muscle contraction); the equipment used for stimulus generation (a); the electrode positions for GVS (b); the electrode position for electromyography on the gastrocnemius muscle (c); the equipment for signal processing (d); and the laptop (e) connected to (a) and (d).

The environment during the performance

Step 5.

Galvanic-VEMP must be performed in a quiet indoor space, free from unexpected noise or visual disturbance. During the procedure, there should be no talk to the examined person. The room must be free from electronic devices or machines switched on or plugged in, such as freezers, other computers, mobiles, etc., in order to avoid electromagnetic interference with the galvanic-VEMP device.

The stimulus

Step 6.

GVS is achieved by passing a direct, monophasic and rectangular current with an intensity of 2 mA, pulse of 400 ms of duration , and the stimuli are delivered at random intervals of 4-5 s between the mastoid processes.

Performance

Step 7.

For transmastoid binaural bipolar stimulation, two current sets are used: cathode on left and anode on right (CLAR) and cathode on right and anode on left (CRAL). The stimulation polarity is controlled via computer. For each test, four trials of 15 stimuli (Table 1) are applied and distributed, resulting in 30 responses recorded on the left lower limb (15 CLAR and 15 CRAL stimuli) and 30 responses recorded

on the right lower limb (15 CLAR and 15 CRAL stimuli). The galvanic-VEMP is firstly measured on the left leg and after on the right leg (Table 1). This procedure must be repeated for each leg to ensure data replication. It is necessary a 2-min resting interval (approximately), between the examination of each leg, to avoid muscle fatigue.

Table 1. Polarity configuration of the stimuli and corresponding leg for capturing responses during vestibular-evoked myogenic potential (VEMP) triggered by galvanic vestibular stimulation (GVS).

Polarity configuration of the stimuli	Local Response
cathode left and anode right (CLAR)	Left leg
cathode right and anode left(CRAL)	Left leg
cathode left and anode right (CLAR)	Right leg
cathode right and anode left(CRAL)	Right leg

Data of acquisition

Step 8.

The amplifier input impedance is 10 MOhm, differential. The EMG signals are measured, corrected, filtered between 10 Hz (second order high pass filter) and 1000 Hz (second order low pass filter). The sampling rate is 1 kHz. Data are collected for 500 ms, starting at 100 ms before GVS. The full scale is 400 uV and the plotted with the resolution of 10 uV/division. The final traces are promediated EMG responses of 15 consecutive stimuli associated with each polarity configuration (i.e., CLAR and CRAL). At the end of 15 consecutive stimuli in one polarity set, the software provides an averaged trace for that trial (Figure 6), which will be later superimposed with the trace obtained by the opposite polarity and then analyzed by the examiner (Figure 7). The whole procedure is then repeated, for replication of the traces.

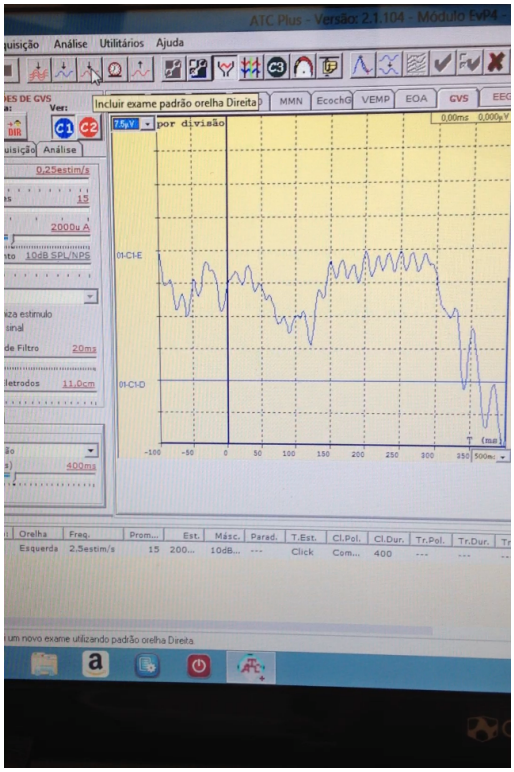

Figure 6. Averaged trace of EMG responses to 15 consecutive stimuli in one polarity set.

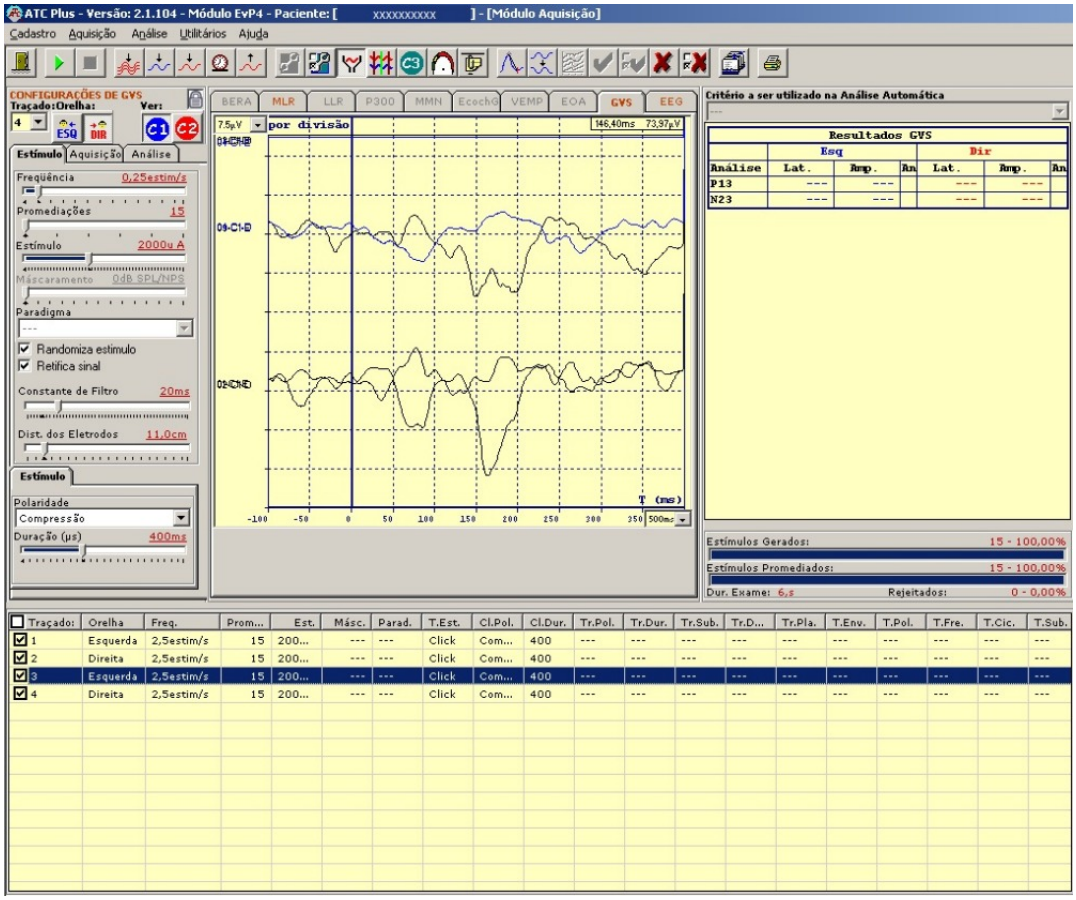

Figure 7: Traces at the end of the galvanic-VEMP procedures, ready to be analyzed by the examiner:

averaged EMG responses in opposite polarities (CLAR and CRAL) superimposed at the top and the replication traces below.

Reading the data

Step 9.

The normal EMG wave pattern is characterized by a baseline EMG activity, and then by a short-latency (SL) wave response that begins at approximately 50 ms after the stimulus, followed by a medium-latency (ML) wave response with opposite polarity that occurs at approximately 100 ms after the stimulus.

To determine the onset (in milliseconds) and the amplitude (in μV) of SL and ML waves, the traces of inverted polarity (i.e., the CRAL trace and the CLAR trace) must be superimposed (Figure 8). The point where the traces diverge from the EMG baseline defines SL and ML onsets and can be visualized and measured by the cursor.

The first divergence, which occurs at approximately 50 ms, defines the onset of the SL response. Following this, the traces return to baseline and then diverge again. The second divergence, which occurs at approximately 100 ms, marks the onset of the ML response (Fig 8). The amplitude of the SL and ML waves are measured by the highest and lowest points from CRAL and CLAR traces of each wave (Figure 8).

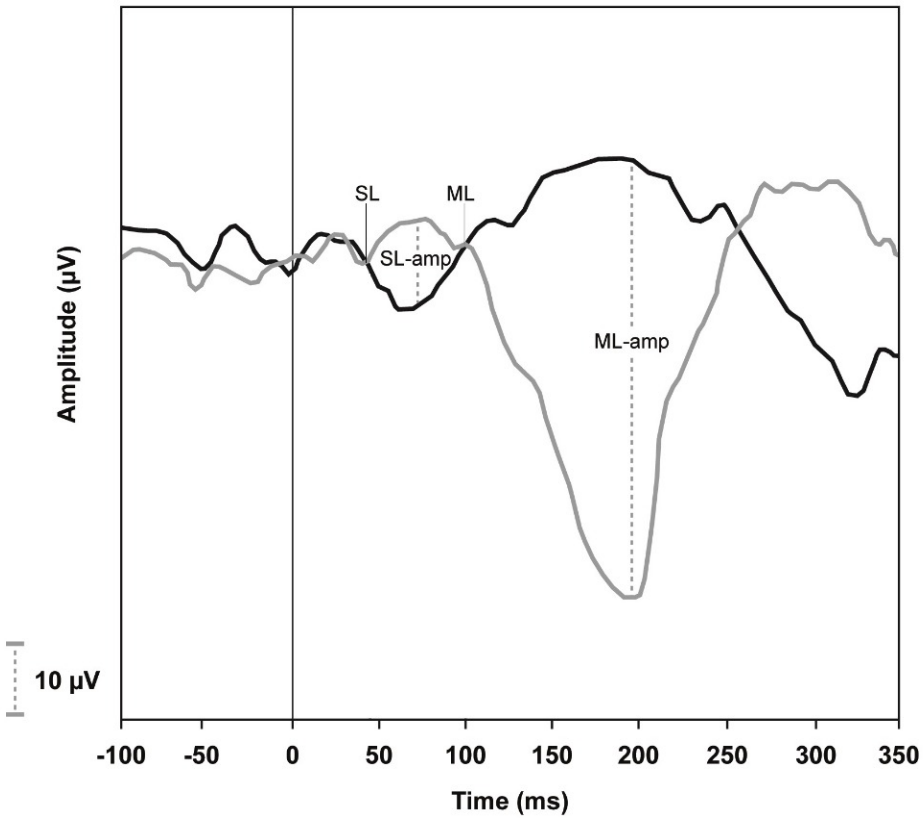

Figure 8. A normal vestibular-evoked myogenic potential triggered by galvanic vestibular stimulation (galvanic-VEMP) trace. These recordings were obtained from a person with his head turned to the left and electromyographic (EMG) response recorded from the right gastrocnemius muscle. The black line indicates the recorded trace with the cathode on the right and the anode on the left (CRAL), whereas the gray line indicates the opposite stimulation polarity (CLAR). SL, short-latency response (47 ms); ML, medium-latency response (100 ms); SL-amp, SL amplitude (12.5 μV); ML-amp, ML amplitude (62.5 μV).