

# Neurophysiological monitoring of brainstem function in a patient with Wallenberg syndrome, using Vestibular Evoked Myogenic Potentials

Deftereos SN<sup>1,2</sup>, Panagopoulos G<sup>1</sup>, Gryllia M<sup>1</sup>, Georganikou D<sup>1</sup>, Polyzoi M<sup>1</sup>,  
Kechagias E<sup>1</sup>, Aessopos A<sup>3</sup>, Karageorgiou CE<sup>1</sup>

<sup>1</sup>Neurology Department, Athens General Hospital, Mesogeion av, 11527, Athens, Greece; <sup>2</sup>Biovista s.a., 1295 Swan Lake Drive, Suite 403, Charlottesville, VA 22902, U.S.A.; <sup>3</sup>First Department of Internal Medicine, “Laikon” Hospital, Mikras Asias 75st, 11527, Athens, Greece

**Corresponding Author:** Dr Spyros N Deftereos, Eirinis 67st, Ag. Paraskevi, 15341, Athens, Greece; e-mail: deftereo@otenet.gr

## ABSTRACT

**PURPOSE:** We evaluated the use of Vestibular Evoked Myogenic Potentials (VEMPs) in the assessment of neural function, following medullary lesions. **METHODS:** A 54-year-old male presented with symptoms and signs typical of right lateral medullary (Wallenberg) syndrome. He underwent brain MRI and three successive neurophysiological investigations, which included VEMPs, Brainstem Auditory Evoked Responses (BAERs) and the blink reflex. **RESULTS:** VEMPs amplitude on the left (unaffected) side was 256.8 $\mu$ v in the first investigation and remained approximately equal to that value in the following two ones. Their amplitude on the right (affected) side was 37.9 $\mu$ v, 154.2 $\mu$ v and 235.2 $\mu$ v correspondingly. At the same time vertigo, diplopia and nystagmus gradually improved. Right blink reflex comprised a normal R1, but delayed R2 ipsilateral and R2 contralateral responses, which remained unaltered during the follow-up period. Brain MRI disclosed a right dorsolateral medullary infarct. **CONCLUSIONS:** VEMPs amplitude progressively increased, parallel to the improvement of vestibular symptoms. The blink reflex evolved differently, while BAERs were not affected. As the three evoked responses are mediated by separate neural circuits, they provide information on different aspects of brainstem function. Thus, VEMPs seem to be a useful method that complements existing ones in the assessment of brainstem lesions.

**Search Terms:** VEMPs, Wallenberg, stroke, neurophysiology

## INTRODUCTION

Neurophysiological assessment of brainstem function mainly comprises the blink reflex, the inhibitory masseter reflex, the jaw jerk and Brainstem Auditory Responses (BAERs), which involve pontine and medullary neural circuits (Cruccu, 2005). Vestibular Evoked Myogenic Potentials (VEMPs), on the other hand, are saccular responses to loud acoustic stimuli and are recordable from the sterno-cleido-mastoid muscle ipsilaterally to the stimulated ear (Ferber-Viart, 1999). Their reflex arc includes the ipsilateral vestibular nuclei, located at the limit of the lower pons and upper medulla. We hypothesized that VEMPs can complement the above-mentioned reflexes in assessing neural function, following medullary lesions. We tested this hypothesis in a patient with lateral medullary (Wallenberg) syndrome.

## CASE REPORT

A 54-year-old Indian male presented at the Neurology emergency department of our hospital (G. Gennimatas General Hospital, Athens, Greece) due to sudden vertigo, nausea, vomiting, diplopia and dysphagia. The findings of the clinical examination were typical of right lateral medullary syndrome: 1) impaired pain and thermal sensation over the right half of the face, 2) ataxia of the right limbs, 3) right Horner syndrome, 4) horizontal nystagmus on right gaze, 5) ipsilateral palatal paralysis, 6) hiccup and 7) impaired pain and thermal sense over the left half of the body. Brain CT upon admission was normal, as were the results of Complete Blood Count and basic laboratory investigations. The patient underwent initial neurophysiological investigations on day 10, when his clinical condition was slightly improved and he was able to cooperate. VEMPs, blink reflex and Brainstem Auditory Evoked Responses (BAERs) were recorded according to standard procedures (Ferber-Viart, 1999; Binnie, 2004).

During VEMPs recording patients were lying supine and were instructed to raise their head off the bed to activate their neck flexor muscles bilaterally and symmetrically. Electromyographic (EMG) activity was recorded from the sterno-cleido-mastoid muscles bilaterally in a belly-tendon montage. Bandpass filter settings were 5Hz to 1.5kHz. The stimuli were rarefaction square wave clicks (duration 0.1ms, intensity 140dB SPL, frequency 5Hz) and were delivered to the left and right ear successively by a calibrated headphone. 250 unrectified EMG traces from 20ms before the stimulus to 50ms afterwards were collected and averaged using a Medelec Synergy T-EP EMG/EP monitoring apparatus (Medelec Synergy, Oxford Instruments Medical, Surrey, UK). Each recording was repeated twice to ensure reproducibility. In the obtained recordings we identified the first positive ( $p_{13}$ ) and negative ( $n_{23}$ ) peaks and we measured their onset latencies and the peak-to-peak amplitude of the  $p_{13}$ - $n_{23}$  wave (Ferber-Viart, 1999). Reported normal values of peak latencies are  $12.0 \pm 1.0$ ms (range 10.0 to 15.9) for  $p_{13}$  and  $20.3 \pm 1.7$ ms for  $n_{23}$  (Welgampola, 2001). The mean amplitude of the  $p_{13}$ - $n_{23}$  wave in healthy individuals has been reported to be  $72.5 \pm 46.8$   $\mu$ V (range 25 to 297, Welgampola, 2001).

The amplitude of the  $p_{13}$ - $n_{23}$  VEMP waves obtained from the right ear was markedly reduced, as compared to those obtained from the left ear (37.9 vs 256.8  $\mu$ V), while the latencies of these waves were similar in both ears (right 12.9, left 12.6 ms). BAERs were normal on both sides. The latency of the R1 blink reflex response was normal on stimulation of either side (right 11.4ms, left 11.2ms). On stimulation of the left (unaffected) side the latencies of the R2 ipsilateral ( $R_{2i}$ ) and contralateral ( $R_{2c}$ ) responses were also normal (36.3ms and 36.4ms correspondingly). However, upon stimulation of the right (affected) side both these responses were delayed;  $R_{2i}$  latency was 45.3ms while that of  $R_{2c}$  was 46ms.

Neurophysiological investigations were repeated on day 29. Right  $p_{13-n_{23}}$  amplitude had increased to  $154.2\mu v$ .  $R_{2_i}$  and  $R_{2_c}$  latencies obtained by stimulating the affected side were delayed (45.1 and 45.8ms). All other parameters remained unchanged. At the same time the patient's clinical condition had improved. Numbness and impaired sensation over the face, limbs and trunk were still present, but nystagmus, diplopia, ataxia, horner and hiccup had decreased considerably. On day 30 the patient underwent brain MRI, which disclosed a right dorsolateral medullary infarct.

A final investigation was performed on day 60. Right  $p_{13-n_{23}}$  amplitude had now increased to  $235.2\mu v$  and was approximately equal to that obtained by left ear stimulation.  $R_{2_i}$  and  $R_{2_c}$  were still delayed (45.1 and 45.7ms). The patient was presenting impaired pain and thermal sensation over the right half of the face and contralateral limbs and trunk, as well as considerable dysphagia. Horner syndrome, nystagmus, diplopia, ataxia and hiccup were absent.

## DISCUSSION

VEMPs recovery paralleled that of the majority of clinical symptoms in our patient. The amplitude of the  $p_{13-n_{23}}$  wave was initially close to zero on the affected side. At the same time the full range of symptoms that may be caused by a lateral medullary lesion were present, including those related to damage of the ipsilateral vestibular nuclei and restiform body: nystagmus, diplopia and ataxia. During the course of the disease these symptoms slowly subsided and finally disappeared, while the  $p_{13-n_{23}}$  amplitude gradually increased until it became equal to that of the contralateral wave (Figure 1).

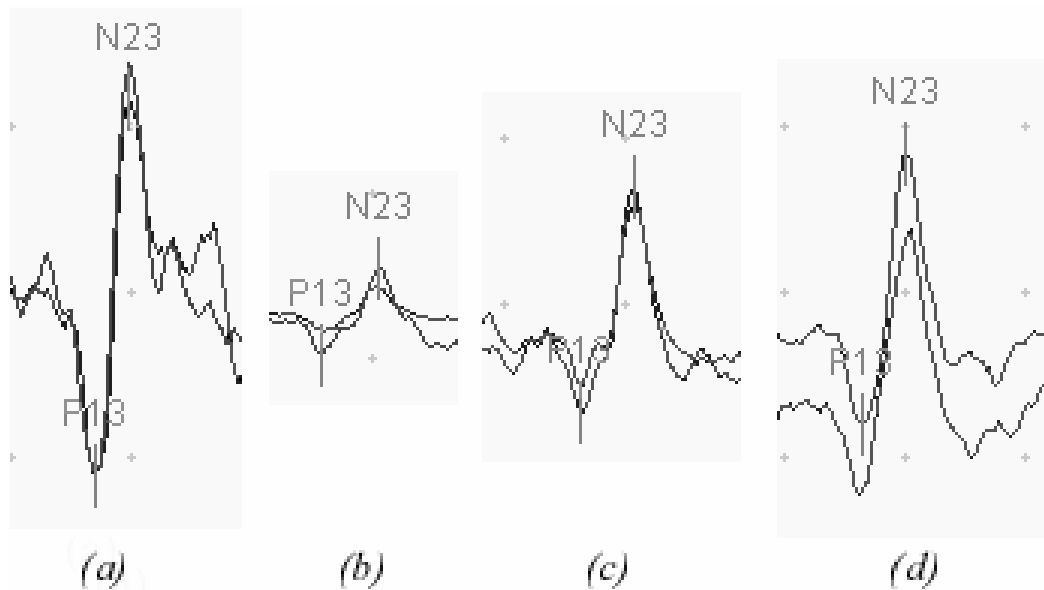


Figure 1: (a) left VEMPs of our patient during the follow-up period. (b) right VEMPs at day 10, (c) at day 29 and (d) at day 60. Right VEMPs amplitude progressively increases, until it becomes approximately equal to that of left VEMPs.

VEMPs represent myogenic responses evoked by acoustic stimulation delivered to the saccule, transmitted mainly via the inferior vestibular nerve to the ipsilateral vestibular nuclei, vestibulospinal tract and cervical muscles (Ferber-Viart, 1999). They are currently used in the evaluation of peripheral vestibular disorders, such as vestibular neuronitis, Meniere disease and herpes zoster oticus (Ferber-Viart, 1999). VEMPs have also been applied to the study of the central vestibulopathy caused by Multiple Sclerosis (Sartucci, 2002; Versino, 2002).

VEMPs abnormalities in our patient are consistent with his anatomical lesion: the vestibular nuclei are located dorsolaterally at the limit of the medulla and the pons, an area that was shown to be damaged in MRI and that is typically affected in Wallenberg syndrome (Victor, 2001). Of interest is the fact that although wave amplitude significantly decreased, their latency remained normal. Previous reports yielded conflicting results on this issue; VEMPs have been found to be absent, delayed (Itoh, 2001; Chen, 2003) or diminished (Itoh, 2001) in patients with brainstem infarct or hemorrhage. It has also been suggested that wave latencies are increased in demyelinating diseases, such as multiple sclerosis, in which the conduction of signals along neural axons is decelerated (Version, 2002). Our case favors the view that stroke, which is characterized by neural cell destruction, mainly affects the amplitude of VEMPs responses, rather than their latency.

The latencies of the R2<sub>i</sub> and R2<sub>c</sub> blink reflex components obtained by stimulation of the affected side were initially prolonged in our patient and remained so two months after the stroke. This is in agreement with a previous report, in which R2<sub>i</sub> and R2<sub>c</sub> responses were delayed in 75% of the studied patients with Wallenberg syndrome and returned to normal after a mean period of seven months (Vila, 1997). Unfortunately, our patient was lost during follow up, thus it was not possible to determine whether the blink reflex became normal after the two-month period.

VEMPs and the blink reflex evolved differently; both were affected on stroke onset, yet VEMPs returned to normal within two months, as opposed to the blink reflex which remained pathological at that time. This behavior is consistent with the different neural pathways involved in the two responses. The R1 blink reflex response is mediated by the ipsilateral principal nucleus of the trigeminal nerve and by that of the facial nerve, both located at the middle pons, while R2<sub>i</sub> and R2<sub>c</sub> are mediated by the medullary and spinal nuclei of the trigeminal nerve (Cruccu, 2005). Thus, faster recovery of the dorsolateral medullo-pontine area compared to that of the lower medulla could lead to earlier normalization of VEMPs than R2<sub>i</sub> and R2<sub>c</sub>. R1 was always normal. In addition, clinical recovery paralleled that of brainstem reflexes; nystagmus, diplopia, ataxia and Horner syndrome, which are mediated by the vestibular nuclei and their neighboring restiform body and descending sympathetic tract, subsided as VEMPs improved. Numbness and impaired sensation over the face, which are mediated by the trigeminal nerve and its nucleus, were still present at two months. On the other hand, BAERs were normal in our patient. This was expected, since they ascend the central auditory pathway in the brainstem, via the pontine cochlear nuclei. These structures are typically not affected in Wallenberg syndrome (Victor, 2001).

VEMPs following Wallenberg syndrome have been recorded in one previous study (Itoh, 2001), in which wave amplitude was diminished ipsilateral to the lesion in two of the four studied patients (50%), while it was normal in the remaining two. The authors also found that BAERs were normal in their study group. These results are consistent with ours. However, in Itoh (2001) the authors performed a single neurophysiology investigation, whereas we performed multiple ones, to determine whether clinical recovery is reflected in VEMPs.

A limitation of VEMPs is that they require a certain degree of cooperation. The patient needs to be able to hold his head a few centimeters above the pillow for approximately 50 seconds, which is the duration of each recording. Thus, it may not be possible to obtain them during the first days after stroke, when such cooperation is impossible. In our case, neurophysiological investigation became feasible on day ten. From then on, we were able to obtain consecutive recordings, which, together with the findings of the neurological examination, allowed us to monitor how the lower pons and upper medulla was recovering from stroke.

In conclusion, the presented case demonstrates that VEMPs constitute a useful tool that can complement other existing neurophysiological techniques in the evaluation of brainstem function. VEMPs, BAERs and the blink reflex are mediated by different neural pathways and can thus be combined to allow better localization of brainstem lesions, and to monitor their evolution. Here we have studied stroke, but the same method might be applicable to lesions of other types, such as tumors or demyelinating foci. Further studies on a larger number of patients are warranted, in order to determine the validity of our findings, as well as to investigate whether VEMPs have prognostic value concerning the recovery of brainstem stroke.

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