Vestibular Evoked Myogenic Potentials

– their use in basic routine clinical practice

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Fiona Barker has worked in Audiology since 1994. She began work in Reading but moved to her current position at East Berkshire Audiology Unit in Windsor, UK later the same year. During her time in post Fiona has worked to establish, maintain and develop the assessment service for patients with vestibular and other balance problems. She works closely with her colleagues in Hearing Therapy, Physiotherapy and Psychology to maintain a cohesive vestibular assessment and rehabilitation service.

Introduction

Most tests used in routine vestibular assessment give information about the function of the horizontal semicircular canal (bithermal caloric test, horizontal head impulse test, headshake test, rotary chair) and rely on measuring the function of the vestibular ocular reflex. The Vestibular Evoked Myogenic Potentials (VEMP) response is measured from the sternocleidomastoid muscle, arises from the saccule and therefore gives information about the inferior division of the vestibular portion of the VIII nerve. Stimulation is provided in the form of a high intensity acoustic stimulus. The test therefore gives information about a different part of the vestibular system from that more routinely assessed and can provide valuable additional diagnostic information (Colebatch, 2001).

VEMP testing has been advocated in the diagnosis of Menieres Disease and superior canal dehiscence but can also be of more routine use in clinical practice.

Recording the response

The amplitude of the response is affected by:

- Stimulus level
- Stimulus frequency (Welgampola and Colebatch, 2001)
- Tonic sternocleidomastoid (SCM) electromyography (EMG) activity during testing

The first two variables are within easy control of the clinician but the third has been less so without specialist equipment. However some EP systems now allow this to be monitored as part of routine data collection. This article gives some feedback on our initial experience with the ICS Chartr EP 200 and focuses on the importance of controlling this third variable.

Ways of analysing the response

VEMP responses vary highly across patients and so analysis has focused on comparing the right and left ears of an individual. This comparison can be made in several ways:

- Presence/absence at a suprathreshold level
- P1-N1 (also called P13-N23) amplitude ratio – this can be thought of an analogous to calculating a canal paresis in the bithermal caloric test
- Threshold - at single frequency and by plotting tuning curves across frequencies (Rauch et al, 2004)

In order for a valid comparison to be made between ears it is important that the tonic EMG activity in the SCM is monitored in some way.

The Importance of Consistent Muscle Contraction

SCM contraction is necessary during testing as the response being sought is a brief inhibition or relaxation of this contraction in response to the high intensity acoustic stimulus. The higher the level of muscle contraction, the larger the response.

Our clinic introduced VEMP testing 2 years ago. We were initially unable to monitor EMG activity either directly or indirectly during testing and were therefore limited to a very gross analysis of whether a response was present or not.

We began by using a head raised technique to achieve the required muscle contraction necessary to record the VEMP. This proved to be hard work for our patients particularly if they were elderly. We switched to using a head turn with pressure applied to a blood pressure cuff following the technique described by Vanspauwen et al (2006). This worked reasonably well. It reduced variability and did give us an indirect measure of muscle contraction. However we were keen to extend this so that we would be able to measure EMG activity directly and calculate the P1-N1 amplitude ratio. Our single channel EP system did not allow us to do this.

We were fortunate to be able to try the ICS Chartr EP 200 system which fit well with our existing ICS Chartr 200 VNG enabling testing to be integrated into our routine test battery.

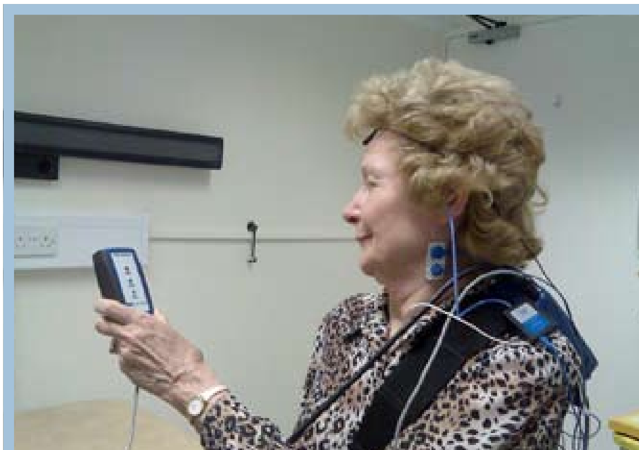

Fig. 1: System with VEMP monitor in use

This system allows the clinician and patient to monitor myogenic activity in the SCM during testing. This ensures more consistent muscle contraction within the patient's comfort and capability. This improves repeatability and enables corrected amplitude ratios to be calculated if needed.

Fig. 2: VEMP Monitor with 3 light display

The clinician can see a read-out of the muscle activation while the patient views a monitor with a 3 light display:

RED – muscle contraction is too high
GREEN – just right
BLUE – muscle contraction is too low

Importantly, the boundaries between these levels can be set by the clinician prior to the start of data collection so that the levels set are individual to that person, maintaining their comfort and ensuring better compliance. This has been of particular value with elderly patients and with those who have difficulty with contracting the relevant muscle. We can ensure they are getting good SCM contraction before the test begins so we know they are following the instructions correctly.

The correction for underlying muscle activity can be applied in 2 ways. First, and most easily using this system, if a patient is able to achieve good consistent contraction within the same boundaries on both sides then the VEMP amplitudes obtained can be compared directly.

Alternatively, the average EMG muscle activity during testing can be used to correct the P1-N1 amplitude obtained so that the corrected responses can be compared between ears.

The importance of correcting the raw figures is demonstrated in the following example:

	RIGHT ear	**LEFT ear**
P1-N1 amplitudes	27uV	64uV
EMG activity	35uV	62uV
Corrected value	27/35=0.77	64/62=1.03

On the face of it this indicated an asymmetry
(Amplitude difference between ears)/(Total amplitude response from both ears)x100
(37/91)x100 = 41%

If a 40% asymmetry is taken as the cut off for normal (Akin and Murnane, 2008) then this would be a significant result indicating a weakness in the right ear. However once corrected for the underlying EMG activity the calculation is as follows:

(Corrected value difference between ears)/
(Total corrected values from both ears)x100
(0.26/1.8)x100 = 14%

This shows that, once the effect of underlying tonic muscle activity has been taken into account there is in fact no significant difference between the ears in this case.

In general we have found the visual feedback from the display easy for patients to follow although we did have one person who misunderstood and thought she had to push harder when the light was red. Even after reinstruction she still found this confusing so we tried without the monitor in her case and this solved the problem. The clinician was still able to monitor the contraction and give verbal instructions accordingly. Patient feedback has been that they usually find the monitor easy to understand and that they enjoy the element of control it gives them in the test. They feel like active participants. They also find the test as a whole very easy to tolerate especially in comparison to some of the other tests they have taken part in.

We have found that a routine suprathreshold test takes about 20 minutes to complete but most of this is in fact explanation and preparation. It only takes 5-10 minutes to collect the data itself. We usually run 2-3 trials for each ear to get 2 repeatable responses which we then use for analysis.

At the moment we are running the test after calorics but we are considering moving it in the test battery to just prior to it. This is purely to get the test completed before the more potentially provocative caloric test. However on the small number of patients with whom we have not been able to complete caloric testing for whatever reason we have been able to then collect good VEMP data even after an abortive caloric.

Quick tips

- Run the test on 10-20 norms first to get a feel for the equipment and the response. It is much larger and therefore very different from the more well known auditory evoked potentials. You will also get a feel for the level of EMG activity required to elicit a good response from a patient.

- Consider introducing the VEMP initially for patients with a canal paresis so that you get a feel for how the results fit into and add to the existing test battery.

- Put the snappers on the electrodes before applying them to the skin. When doing conventional auditory EPs it is possible to apply the electrodes and then snap on the leads because the skull is hard and pressure can be applied without causing discomfort. This is not the case with the neck!

- Double electrodes are useful for the neck (one to record the response and one to record underlying EMG activity) rather than applying two single ones.

- The head turn alone is often enough to achieve adequate muscle contraction but if not then ask the patient to tuck their chin in and if necessary push into their hand.

- Some form of monitoring of muscle activity such as that provided by the ICS Chartr EP 200 is very helpful during testing. Indeed it is essential if the clinician wishes to compare the asymmetry between the P1-N1 amplitude from both ears in a valid manner. 100uV raw EMG activity is a good figure to aim for.

- Suggested stimulus parameters (taken from Akin et al Chapter 18 Balance Function Assessment and Management – see below for full details):

500Hz tone burst

Onset phase	rarefaction
Level	90-95dBnHL (120-125dB peak SPL)
Rate	5/sec
Rise/fall	2 cycles
Plateau	0 cycles
Gating	Blackman

Click

Polarity	Rarefaction
Level	95-100dBnHL (129-134dB peak SPL)
Rate	5/sec
Duration	100usec

- Suggested recording parameters:

Amplifier gain	5000x
Filter settings	10-1000Hz
Time window	100msec
Number of sweeps	150
Artifact rejection	off
Non-inverting electrode	Mid SCM
Inverting electrode	Top of the sternum
Ground electrode	Forehead

Fig. 3: VEMP electrodes applied to a patient

Conclusions

We have not yet explored the full possibilities of using VEMPs in our routine practice but we are already finding it a valuable addition to our routine test battery. I would encourage anyone considering trying this test to 'bite the bullet' and have a go. It is possible to carry it out using conventional EP equipment readily available in audiology departments. However anyone wishing to exploit the test fully must employ some method of monitoring the ongoing contraction of the SCM. It is a quick, non-invasive, well tolerated test that can yield valuable additional diagnostic information as part of a routine vestibular assessment.

References

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