Cervical Vestibular evoked myogenic potentials (cVEMPs) and Videonystagmography for assessment among Tinnitus cases

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Abstract

Background: Tinnitus is loosely defined as the internal perception of sound in the absence of external auditory stimuli. The majority of people will perceive sound in the absence of external stimuli, but it is worth noting as a general theme, this is not considered pathologic tinnitus. Patients experiencing tinnitus often describe it as a buzzing, hissing, whistling, chirping, squealing, or roaring sensation inside the ears or head. Tinnitus can vary in loudness from a quiet background noise, to one that appears to mask external sounds. The use of evoked potentials plays a vital role in diagnosing site of lesion in patients with vestibular impairments. The most common form of vestibular evoked potentials is vestibular evoked myogenic potentials (VEMPs). Vestibular evoked myogenic potentials (VEMPs) are short-latency, vestibular-dependent reflexes that are recorded from the sternocleidomastoid (SCM) muscles in the anterior neck (cervical VEMPs or cVEMPs) and the inferior oblique (IO) extraocular muscles (ocular VEMPs or oVEMPs). Abnormal cVEMP or oVEMP findings including latency, amplitude and threshold may be a sign of pathological conditions along the vestibulo-collic or vestibulo-ocular reflex pathways. Unilateral absence of both cVEMP and oVEMP responses may indicate a lesion localized at the vestibular end organs, otolith projections and nerve root entry, whereas central disorders or demyelinating pathologies of the vestibular nerve may present with delayed latencies of both reflexes. Videonystagmography (VNG) is a technique for recording eye movements for the purpose of assessing patients with suspected vestibular dysfunction. Infrared video cameras and digital video image analyses are used to isolate the location of pupil(s) so that a tracing of eye movement can be generated.

Keywords:

Introduction

Tinnitus is loosely defined as the internal perception of sound in the absence of external auditory stimuli. The majority of people will perceive sound in the absence of external stimuli, but it is worth noting as a general theme, this is not considered pathologic tinnitus. Patients experiencing tinnitus often describe it as a buzzing, hissing, whistling, chirping, squealing, or roaring sensation inside the ears or head. Tinnitus can vary in loudness from a quiet background noise, to one that appears to mask external sounds **(1)**.

Classification of Tinnitus

For the most part, tinnitus can be classified by the way it is experienced by the patient. For example, tinnitus can be unilateral or bilateral. Acute tinnitus can last for days to weeks, while chronic tinnitus is more persistent, lasting for greater than six months **(2).**

vibratory and non- vibratory

Additionally, tinnitus can be classified as vibratory or non- vibratory, further categorized as objective or subjective, and further categorized by the hypothesized site of lesion **(3)**.

Vibratory tinnitus, which follows a rhythm, occurs because the patient is able to hear one's own muscle contractions, eustachian tube movements, blood flow within the vascular system, and other activities near the ear **(3)**.

Nonvibratory tinnitus is attributed to a more central neural activity. Nonvibratory tinnitus is not rhythmic, but rather random. Central etiologies are hypothesized to arise from the temporal lobe, auditory nerve, or brainstem, whereas peripheral etiologies are believed to arise from the external auditory canal, middle ear, or cochlea. Most nonvibratory tinnitus is associated with hearing loss at the peripheral or cochlear level **(3)**.

Objective and subjective

If others can also hear the sounds experienced by the patient, the tinnitus is classified as objective. Objective tinnitus is far less common in all age groups, with an incidence of less than one percent. However, it is worth pointing out that some disagree with the labeling of tinnitus as objective **(4)**.

Subjective tinnitus is heard only by the patient. Subjective tinnitus can be vibratory or rhythmic in nature, but at a sound level that it is only experienced by the listener. Yet, subjective tinnitus is usually nonvibratory or irregular in pattern **(4)**.

Epidemiology

The scatter of prevalence estimates is wide, although most study results have shown rates of between 10% and 15% of the adult population. It is worth reiterating that of the estimated 50 million Americans with tinnitus, only 12 million seek treatment and only 2 million consider themselves debilitated by their tinnitus **(5)**.

Cervical Vestibular evoked myogenic potentials (cVEMPs)

Definition and types

The use of evoked potentials plays a vital role in diagnosing site of lesion in patients with vestibular impairments. The most common form of vestibular evoked potentials is vestibular evoked myogenic potentials (VEMPs). VEMPs are a part of the standard vestibular testing battery and when combined with other vestibular testing, such as caloric or head-impulse testing, allow assessment of the entire peripheral vestibular system **(6)**.

Vestibular evoked myogenic potentials (VEMPs) are short-latency, vestibular-dependent reflexes that are recorded from the sternocleidomastoid (SCM) muscles in the anterior neck (cervical VEMPs or cVEMPs) and the inferior oblique (IO) extraocular muscles (ocular VEMPs or oVEMPs) **(7)**.

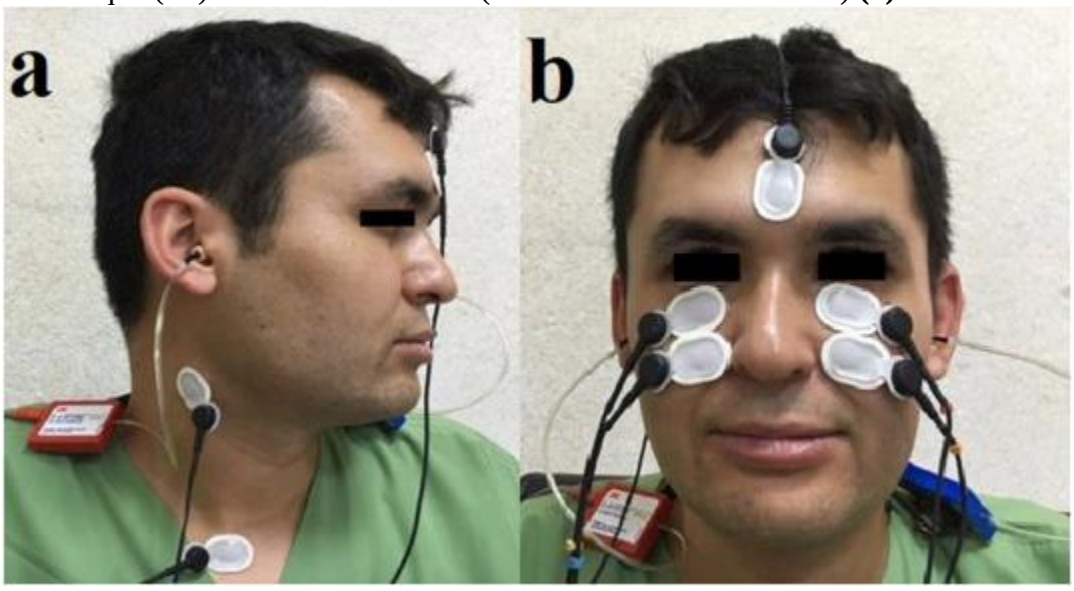

Figure (1): Electrode placement for cVEMP (a) and oVEMP (b) **(8)**

They are evoked by short bursts of sound delivered through headphones or vibration applied to the skull. As these stimuli have been shown to preferentially activate the otolith organs rather than the semicircular canals, VEMPs are used clinically as measures of otolith function **(7)**.

The cVEMP is a biphasic surface potential, with peaks at approx. 13 and 23 ms, recorded from electrodes arranged in a belly-tendon montage over the SCM muscle. Cervical VEMPs were first described by Colebatch et al. (9), who reported a click-evoked muscle reflex in the ipsilateral SCM, which was dependent upon vestibular, but not auditory, function. It scaled with stimulus intensity and the underlying SCM muscle activity and could be easily produced using standard evoked potential equipment and calibrated headphones. Intramuscular recordings later confirmed that the surface response is produced by a short inhibition of the SCM muscle **(9).**

As air-conducted (AC) sound preferentially activates the saccule, cVEMPs evoked by this stimulus can be used as a test of saccular function. cVEMPs are inhibitory (muscle relaxation) myogenic responses that are measured from the sternocleidomastoid (SCM) muscle in response to auditory stimulation. cVEMPs measure the vestibulo-collic reflex, where ipsilateral auditory stimulation results in inhibition of tonic contraction of cervical muscles, such as SCM. This response is thought to be primarily due to stimulation of the saccule and thus the inferior vestibular nerve **(10)**.

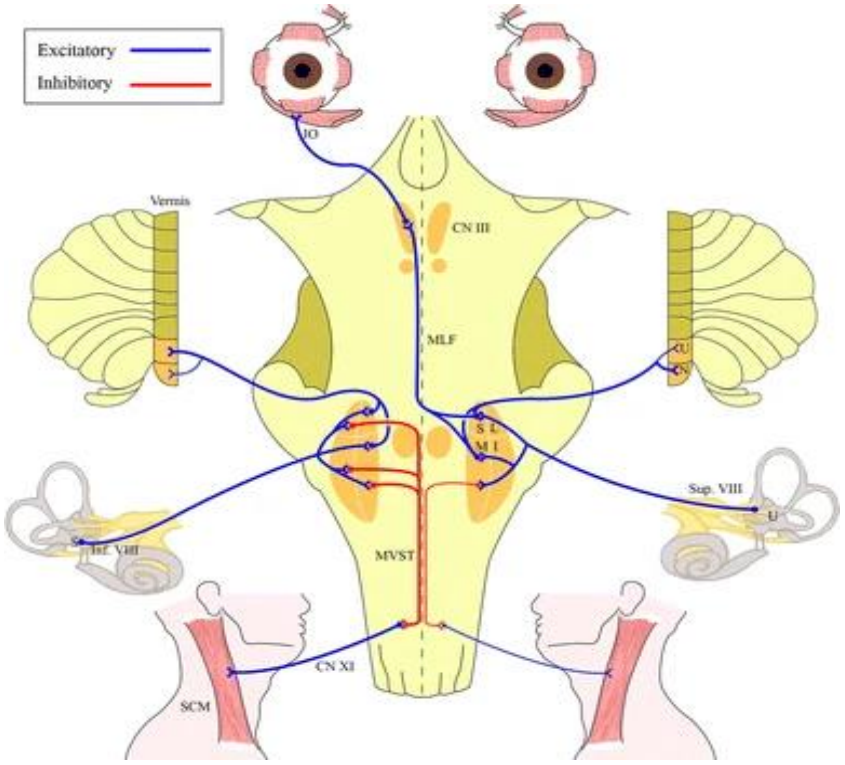

Figure (2): Schematic illustration of the anatomic pathways involved in the generation of ocular and cervical vestibular-evoked myogenic potentials (VEMPs). Cervical VEMPs are the result of inhibitory postsynaptic potentials on the ipsilateral SCM motoneurons and are mediated by the descending medial vestibulospinal tract (VST) within the medial longitudinal fasciculus (MLF) **(11)**

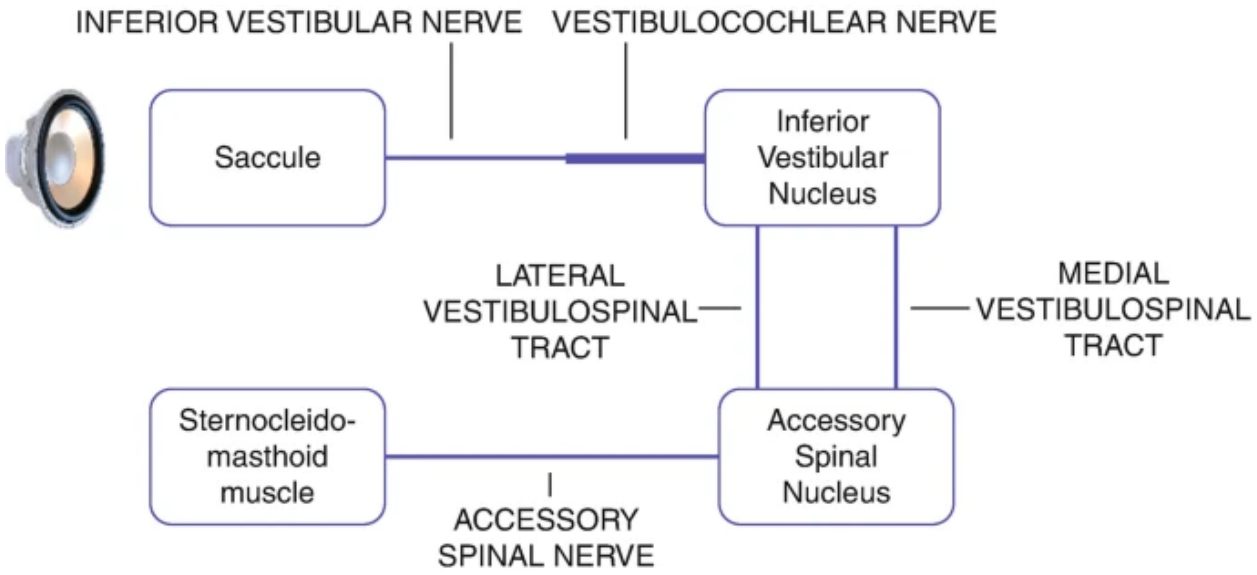

Figure (3): Pathways of the cVEMP **(12)**.

Testing involves having the patient turn away from the side of the stimulus to create tonic contraction of the SCM, which is needed to produce the response. Measurements of interest include the amplitude and latency of an initial positivity or the p13 response (approximately 13 ms following stimulation) followed by a negativity or the n23 response (approximately 23 ms). In the normal scenario, a response is obtained with a 500 Hz air-conducted tone burst stimulus between 75 and 90 dB nHL. The values are then used to create an amplitude asymmetry ratio between the two ears, with an asymmetry greater than 33–47% considered abnormal **(13)**

Threshold can also be measured and becomes more important when evaluating for third window disorders, mainly SCD. VEMP thresholds in normal patients cannot be elicited below 70–75 dB nHL unlike SCD patients, making it a useful measure when suspicion for these disorders is high **(6)**.

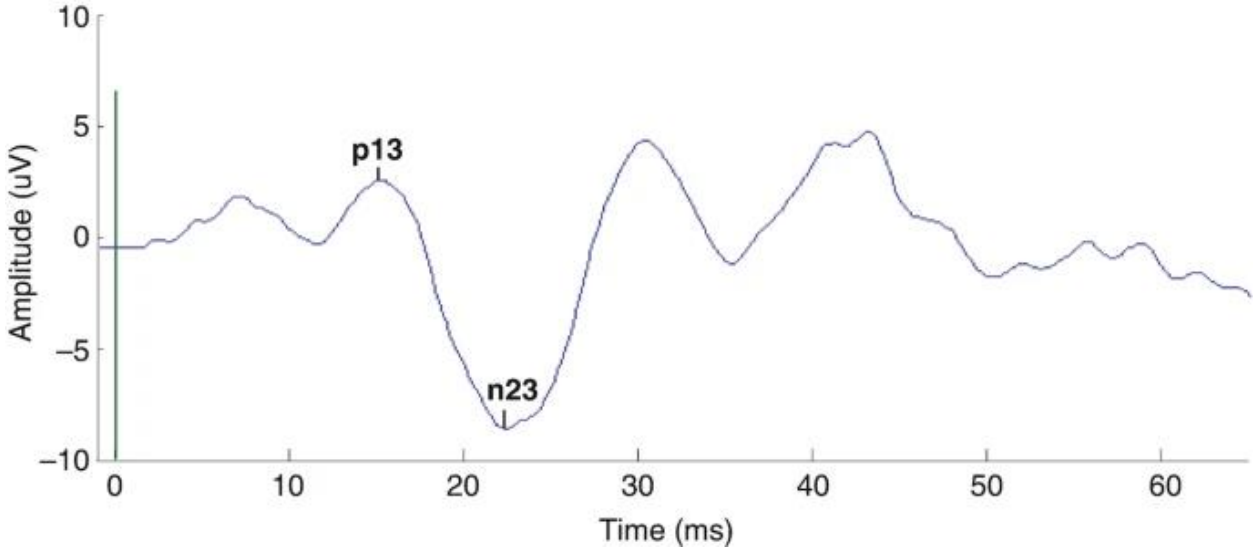

Figure (4): Cervical vestibular evoked myogenic potential (cVEMP) response recorded from the left sternocleidomastoid muscle in response to a 500 Hz tone burst stimulus at 90 dB nHL **(6)**.

The following parameters are employed for the interpretation of the responses **(12)**.:

Latencies

The latencies of P_1 or N_1 are affected by the type of stimulus (click or tone burst and stimulus frequency) but are not influenced by the stimulus intensity. Abnormal latencies have been reported in some otologic diseases, but most of the time, they are seen in patients with central vestibular disorders, particularly in multiple sclerosis. As a rule, the latencies are not as clinically useful as other parameters

Amplitudes

These are usually defined as the difference between the averaged levels of P_1 and N_1. They may vary from a few μv to 300 μv, or more.

Asymmetry

This is usually defined as the difference between the amplitude of each side divided by their sum. Values of 35–40% are considered clinically significant. In patients with vestibular neuritis or vestibular schwannoma, VEMPs can identify the involved branch of the vestibular nerve. About half of the patients with Menière's disease have abnormal VEMP asymmetries.

Thresholds

This is the minimal sound intensity that produces a response. In cases of suspected superior canal dehiscence, the thresholds are more useful than the amplitude or asymmetry. Low thresholds (less than 80 dB HL) are considered abnormal and are found in all patients that complain of symptoms resulting from loud sounds, particularly the Tullio phenomenon.

Test method

Auditory stimulation, usually at low frequency and high intensity, presented to the external auditory canal (air conduction) travels through the middle ear to reach the vestibule via the vestibular window. This stimulation induces displacement of endolymph in the vestibule, allowing mechano transduction following stimulation of the hair cells **(14)**.

The auditory stimulus canal so be presented by bone conduction to reach the vestibule while bypassing the outer ear and middle ear. Auditory stimulation by air conduction is usually performed. The stimulation parameters that ensure a satisfactory response area Tone Burst with a frequency of 500 Hz, starting at an intensity of between 90 and 100 dB nHL and lasting 7 ms. A 0.1 ms click can also be used. A preliminary audiometric assessment is essential. Sensorineural hearing loss does not influence VEMP responses, but even mild conductive hearing loss may prevent detection of VEMP **(15)**.

This limitation can be overcome by using bone-conducted stimulation with a B-71 transducer placed on the tip of the mastoid process. The transducer can also be placed on the forehead, but in this case, higher intensity stimulation is required. Stimulation is delivered atan intensity of 70 dB nHL, with a duration of 10 ms and usually ata frequency of 250 Hz **(15)**.

Bone-conducted stimulation triggers a bilateral VEMP response. The repetition frequency giving the highest amplitude responses for these two types of stimuli is 5 per second **(16)**

Method or recording of cVEMPs

The cVEMP is recorded from surface electrodes placed over the SCM during a tonic contraction of the muscle. During each trial, which typically lasts approx. 30 sec, stimuli are delivered to the ear (AC stimulation) or skull (BC stimulation) and the patient is asked to activate the SCM muscle/s of interest **(17)**.

- **Patient positioning**

The patient is placed in a semi-seated supine position. The sensors are connected to the 4 electrodes necessary to carry out the test. Epidermal stripping at the sites of the electrodes using abrasive conductive paste is performed before the test in order to decrease skin impedance. The examiner must ensure that skin impedance is less than 10 kΩ (indicated by an indicator light) before starting the recording **(18)**

- **Electrode placement**

Most laboratories follow the neurophysiological convention of placing the inverting electrode over the active recording site, resulting in upward deflections of negative polarities. Following this convention is helpful for comparison of traces across centres and publications, but not critical. The active electrode should be placed on or slightly above the middle of the anterior arm of SCM, as this is the approximate location of the motor point **(9).**

Amplitudes will be largest and latencies shortest at this point. Placing electrodes significantly above or below this point can lead to prolonged latencies and, at the extremes of the muscle, polarity inversions **(7)**.

Care should also be taken when using a head turn technique that electrodes positioned with the head in neutral position are symmetrical and remain in place over the muscle belly after the head is turned.

Isometric contraction is less likely to change relative electrode locations. For patients with SCM muscles that are difficult to discern, it is recommended to palpate or having the patient contract the muscle to reveal its location. If this does not work then an electrode can be placed at the midpoint of the distance between the mastoid and medial clavicle, but care is required to ensure that the muscle has not itself been subject to some pathology. The reference electrodes are usually placed bilaterally on the medial clavicles, though some recording systems have only one reference electrode available, which is usually placed in the midline on the upper sternum. The ground electrode is typically placed near the other electrodes or on the head **(19)**.
Good neurophysiological practice should be followed regarding electrode impedance, in particular to prevent mains (50/60 Hz) electrical interference. Fortunately, impedance is generally not as critical as for evoked potentials of cortical origin, however, electrical interference can occasionally be mistaken for EMG potentials and will artificially inflate estimates of contraction strength and so should be avoided **(10)**.

EMG settings

The gain should be set to around 2000 for cVEMPs, with a sampling rate of approx. 2–5 kHz. Filter settings are typically from approx. 1–5 Hz (high pass, low cut, i.e. just above DC) to approx. 200 Hz to 1000 Hz (low pass, high cut). The main frequency content of the cVEMP is around 40–60 Hz, which is well within these limits **(19)**.
The duration of each frame is restricted chiefly by the repetition rate. The cVEMP itself ends around 30–40 ms after stimulus onset, but is often followed by several additional waves. It is common to end the recording from 50 to 100 ms after stimulus onset **(20)**.
Pre-stimulus EMG should always be recorded if possible (at least 10–20 ms), even if it will not be used to measure the background tonic muscle contraction. The pre-stimulus EMG is used to gauge the level of background noise in the recording, from which the response peaks are detected. Reliable VEMPs are those that consistently exceed the residual background EMG seen in the pre-stimulus trace. The usual repetition rate is typically around 5 Hz. Rates of up to and including 10 Hz are associated with good VEMPs, but above this there is a decrease in cVEMP amplitude. Stimulus rate also affects the perceived loudness of a stimulus **(21)**.

Number of repetitions and trials

While the optimal number of repetitions will depend upon the signal-to-noise ratio for each recording, the standard number of repetitions should be about 100–200. Fewer repetitions may be needed in patients with large reflexes, and the recording can be stopped early to reduce sound exposure if needed **(7)**.
More repetitions may be needed for patients with small or absent responses. In this case, it is recommended to perform two longer trials (e.g. at least 150–200 repetitions) rather than multiple shorter trials (e.g. 50–100 repetitions), as longer trials improve the signal-to-noise ratio by averaging out more of the background contraction. When using tendon hammer taps, fewer repetitions are delivered, in part because the stimulus usually produces robust responses and can be uncomfortable if repeated too often **(7)**.

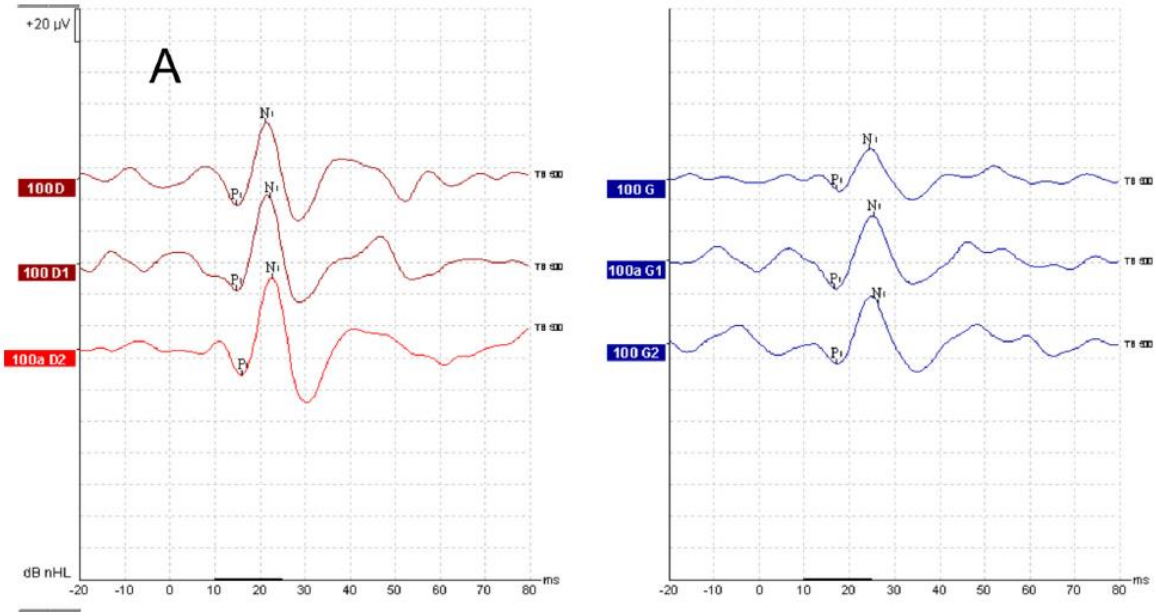

Figure (5): Normal cVEMP (A) (right ear in red and left ear in blue) **(18)**

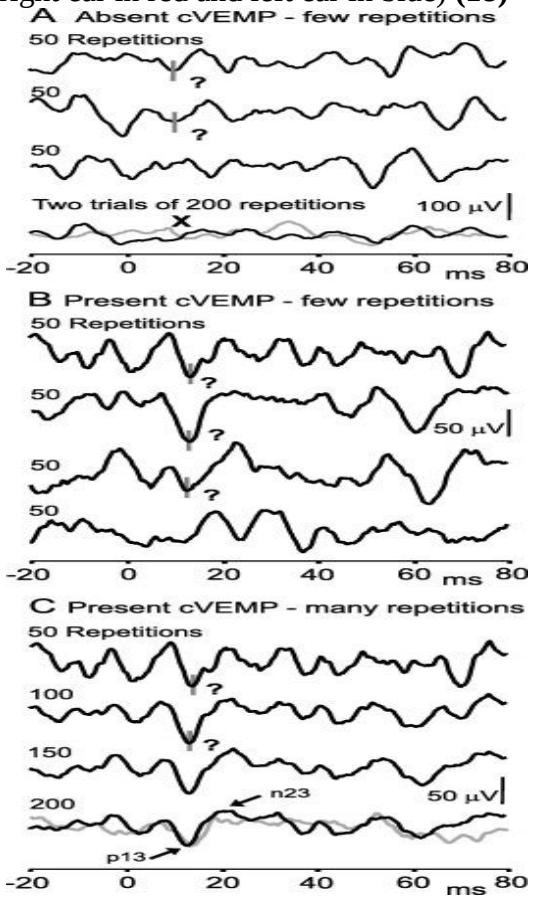

Figure (6): Effect of number of stimulus repetitions on cVEMPs. In part A, data are from a single subject stimulated with 500 Hz. In parts B and C, data are from a different single subject tested with the same stimulus. Part B shows data from a trial with 200 stimulus repetitions, separated into four consecutive sets of 50 repetitions **(7)**.

Role of VEMP testing in the diagnosis of common vestibular diseases

Abnormal cVEMP or oVEMP findings including latency, amplitude and threshold may be a sign of pathological conditions along the vestibulo-collic or vestibulo-ocular reflex pathways. Unilateral absence of

both cVEMP and oVEMP responses may indicate a lesion localized at the vestibular end organs, otolith projections and nerve root entry, whereas central disorders or demyelinating pathologies of the vestibular nerve may present with delayed latencies of both reflexes **(22)**

VEMP testing constitutes an important part of the vestibular test battery and provides either diagnostic or assistive contributions in the clinical evaluation of common vestibular diseases such as superior canal dehiscence syndrome (SCDS), Ménière's disease (MD) and vestibular neuritis (VN). SCDS was first described by Minor et al., in 1998 and the disease is characterized by a defect nearly always located in the bone overlying the superior semicircular canal (SCC). In the diagnosis of SCDS, recognition of the defect with temporal bone computed tomography scans is essential. Nevertheless, VEMP findings can also provide significant data regarding diagnosis and defect functionality. Significantly lower cVEMP thresholds were demonstrated in patients with SCDS. Corrected cVEMP amplitude values have 100% sensitivity and 93% specificity in SCDS diagnosis **(23)**

It was reported that successful canal plugging resulted in normalization of reflex thresholds, therefore VEMP testing may also be useful in monitoring the effectiveness of plugging surgery in SCDS. However, VEMP recordings are particularly amenable for unilateral SCDS by means of interaural comparison rather than bilateral vestibulopathy **(8)**

Although MD is usually diagnosed by clinical criteria, laboratory tests such as caloric test are also performed to support the diagnosis in some cases. Reduction of ipsilateral cVEMP amplitudes has been reported in different studies with a prevalence of around 50% in MD **(10)**.

VEMP testing enables demonstration of a vestibular loss in MD but there is not sufficient evidence regarding the usefulness of VEMP in diagnosing MD. However, it can be used for monitoring the status of vestibular dysfunction during the disease process **(10)**.

Vestibular neuritis is an acute vestibular pathology that is mostly diagnosed by the typical clinical signs of acute unilateral loss of vestibular function. VEMP testing is suggested to indicate the pattern of vestibular nerve involvement in VN whether the disease affects the superior, inferior division of the nerve or pan-neuritis **(7)**.

However, sufficient data does not exist in the literature concerning VEMP findings that would frankly determine which vestibular structures are influenced in VN. Data are also insufficient regarding the role of VEMP in the diagnosis of other vestibular diseases such as in the literature, hence VEMP testing may not be useful in the diagnosis of these pathological conditions **(10)**.

Videonystagmography

Videonystagmography (VNG) is a technique for recording eye movements for the purpose of assessing patients with suspected vestibular dysfunction. Infrared video cameras and digital video image analyses are used to isolate the location of pupil(s) so that a tracing of eye movement can be generated. The emergence and mass adoption of VNG is, in itself, a relatively recent advance. Before the pupil-tracking algorithms for VNG became ready for clinical use, the preferred technique for monitoring eye movements was electronystagmography (ENG) **(24)**.

ENG involves the use of electrodes placed close to the eyes to measure the corneoretinal potential (CRP). Voltage changes in the CRP from the difference between the positively charged cornea and the negatively charged retina are amplified, and subsequently captured within the resultant tracing. VNG testing has some distinct advantages over ENG **(25)**.

In particular, VNG testing allows clinicians to observe the patient’s eye movements in real-time; with ENG, eye movements have to be inferred from the tracings, particularly for components of the test that are completed without fixation. With VNG, there is an option to record the video for documentation and later review **(26)**.

In addition, VNG testing does not rely on the CRP, the magnitude of which can be impacted by the level of illumination within the testing room and other factors such as retinal health. The quality of ENG tracings can be further diminished by noise (ambient or from muscle activity/ blinks), though VNG is not immune to artifact **(26)**.

Figure (7): Videonystagmography goggles contain video cameras that allow the patient's eye movements to be recorded for viewing analysis **(27)**

With VNG, it is also possible to recognize torsional eye movements. Currently, torsional eye movements are identified most successfully when observed directly from a video recording, though most VNG systems now offer algorithms for detecting torsional movement with varying degrees of reliability **(25)**.

The ability to identify torsional eye movements can be helpful in recognizing benign paroxysmal positional vertigo (BPPV), one of the most common causes of vertigo. Torsional analysis is not possible with ENG. VNG systems can generally sample at higher rates than ENG and do not require low frequency filtering; the additional detail from the superior signal processing allows for the ability to recognize more subtle clinical findings **(25)**.

In a publication by Martens et al., measureable nystagmus was detected in at least one of the 6 testing positions for 88% of participants with no history of vestibular complaints. However, the nystagmus was generally of low velocity ($\leq$ 5 deg/s for horizontal movements); for the Dix-Hallpike, the nystagmus was not paroxysmal **(28)**.

It is worth noting that ENG is still considered to be an acceptable approach for vestibular assessment. Some populations are more challenging to evaluate successfully with VNG due to the physical fit of the goggles (e.g., small children). In addition, some patients find it difficult to keep their eyes open without blinking excessively; with ENG, the patients eyes can remain closed for most of the test **(25)**.

Monothermal Calorics

The traditional caloric test is administered bithermally, wherein the patient's ears are irrigated with both a warm and cool stimulus and then analyzed. Unfortunately, the full bithermal battery is time-consuming (and therefore, costly) to administer and caloric testing can be a source of patient discomfort **(29)**.

The potential utility of a monothermal screen by retrospectively comparing the results of the warm and/or cool screen to the results from the bithermal test. Most have shown that a monothermal warm screen can be used to reduce the testing time and patient discomfort for a large proportion of patients and can be accomplished with a very low false-negative rate. To optimize the predictive accuracy of the monothermal test, a warm screen is preferable to a cool screen. To guarantee the value of the monothermal warm screen, a high sensitivity (low false-negative rate) is essential. The specificity for the monothermal warm screen is generally quite low; this is of little consequence because patients whose inter-ear difference (IED) values exceed the determined normal criterion for the warm screen continue to complete the entire bithermal test. According to a systematic review of the literature by Adams et al., when a bithermal unilateral weakness

(sometimes referred to as canal paresis) cut-off of 20 or 25% is assumed, an IED criterion set at ≤ 15% for the monothermal screen achieved a low false-negative rate (≤ 5%) and reduced the number of patients requiring the full bithermal caloric test to between 49 and 57%. Establishing a minimum SPV value (<11 deg/s) for each irrigation and excluding/ adjusting for significant spontaneous nystagmus may also improve the sensitivity of the results, though further investigation is needed **(30)**.

Air versus Water Calorics

Compared with water caloric irrigation systems, air caloric systems have some practical benefits: they tend to be more portable than water systems, they reach the desired testing temperatures more rapidly, and they do not require a nearby water source. In addition, air calorics can be performed safely even when a tympanic membrane perforation or other contraindications to water calorics (e.g., presence of mastoid cavity) are present. These factors have likely contributed to the adoption of air caloric systems in many centers. No standards for air calorics have been approved by the American National Standards Institute (ANSI). One concern with air calorics is the potential for unexpected sources of variability. Even the size of the speculum that is used can influence the SPV values obtained; smaller speculums (2.5 mm) generate nystagmus that is nearly twice that of the SPV values generated with larger (4 mm) speculums on average **(31)**.

It appears that the speculum size has an impact on the speed of the air flow as it enters the ear canal. The general consensus in the literature indicates that air calorics yield unilateral weakness values that are comparable to water calorics. However, the literature also indicates that the average SPV values obtained with water as the caloric medium are significantly larger than the values obtained with air. Indeed, one study comparing water and air caloric media found that almost 6% of the normal group had abnormal caloric results with air while none had abnormal results with water Recent publications investigating water and air as caloric mediums have identified new considerations and potential approaches that may help in generating equivalent responses across the two approaches **(31)**.

Table (2): Advantages of Videonystagmography (VNG) **(12)**.

Videonystagmography (VNG)
Records eye movements directly with infrared cameras
Recording sensitivity = 0.1
Not affected by any extrinsic factors
All oculomotor tests can be studied in detail
Rotatory eye movements can be recorded
Videos can be reviewed and played in slow motion
Each eye can be recorded separately
It is not affected by any eye condition, except congenital blindness

Examination

The VNG examination room should be large enough to accommodate the examiner, patient, and a person accompanying the patient. This environment should also be large enough to allow the clinician to move around freely. An ideal room for VNG testing is at least 10 feet wide and 14 feet long. These dimensions provide for enough room to have a sink, casework for the equipment to sit on, an examination table, and a stool for the examiner. Besides the dimensions, there are some key features that should be in the room **(32)**

First, the room should have appropriate ventilation and a thermostat so that the room can be heated and cooled as needed. For example, in a hospital setting, an inpatient may arrive at the appointment wearing only a gown, or in cases of patients with severe motion intolerance, a cool room helps mitigate the effects of nausea **(32)**

Another key feature is the ability to have nearly complete darkness. Although most of the testing is done with dim light, there may be occurrences where it is desirable to have nearly complete absence of light (e.g., during the caloric testing or when there is a need to increase pupil size to help the VNG system track the eye) **(32)**

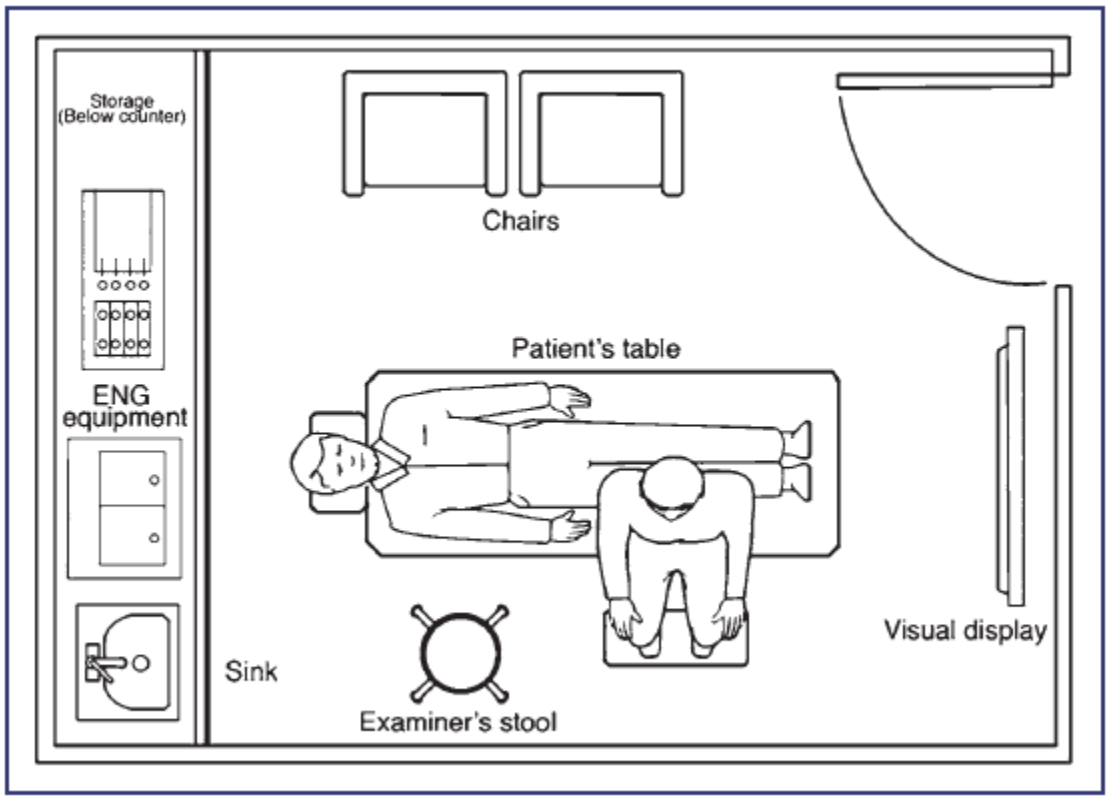

Figure (8): Illustration of a layout of a typical VNG laboratory **(32)**

Table (3): Equipment Used in a Conventional ENG/VNG Laboratory **(32)**

Equipment	*Use*
Examination table	Should be either a hydraulic or mechanical table that allows for positioning the patient anywhere from sitting to supine. An additional feature is the ability to remove the headrest for tests such as the Dix-Hallpike maneuver.
Caloric irrigator	Deliver caloric stimulus; can be air or water.
Recording system	Should be capable of measuring and recording eye movements using VNG or ENG.
Cabinet for supplies	Storage of supplies and patient-counseling materials.
Examination stool	For examiner to sit with patient and take case history and deliver caloric stimulus.
Visual stimulation system	Should be capable of producing appropriate stimuli for oculomotor testing (e.g., light bar or projector).

Videonystagmography Tests (27)

I- Vestibular Function Tests

1- Presence of abnormal eye movements and whether the movements change with head position
a- Positioning test (Dix-Hallpike maneuver).
b- Positional test.
c- Gaze test
2- Vestibular oculomotor function
a- Bithermal caloric test
b- Headshake test

II- Non-vestibular Tests

3- Visual oculomotor function or non-vestibular (tracking) eye movements

a- Saccade test

b- Tracking test

c- Optokinetic test

Conclusion:

VEMP testing constitutes an important part of the vestibular test battery and provides either diagnostic or assistive contributions in the clinical evaluation of common vestibular diseases such as superior canal dehiscence syndrome (SCDS), Ménière's disease (MD) and vestibular neuritis (VN). SCDS was first described by Minor et al., in 1998 and the disease is characterized by a defect nearly always located in the bone overlying the superior semicircular canal (SCC). In the diagnosis of SCDS, recognition of the defect with temporal bone computed tomography scans is essential. Nevertheless, VEMP findings can also provide significant data regarding diagnosis and defect functionality. Significantly lower cVEMP thresholds were demonstrated in patients with SCDS. Corrected cVEMP amplitude values have 100% sensitivity and 93% specificity in SCDS diagnosis. It is worth noting that ENG is still considered to be an acceptable approach for vestibular assessment among tinnitus cases. Some populations are more challenging to evaluate successfully with VNG due to the physical fit of the goggles (e.g., small children).

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