Operative Techniques in Otolaryngology 30 (2019) 162–170

Operative Techniques in Otolaryngology

Perioperative vestibular assessment and testing

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KEYWORDS
Vestibular testing;
VNG;
Caloric test;
Rotary chair test;
VHIT;
VEMP

Vestibular disorders can be difficult to accurately diagnose and manage. A careful history and focused physical examination are typically adequate to establish a diagnosis and initiate medical treatment. Vestibular testing is an important component of the work-up, but it is particularly essential for patients being considered for surgical intervention for a vestibular disorder, where the testing can be used to more definitively confirm a suspected diagnosis and to determine baseline vestibular organ function. In this article, we will first briefly review key components of the history and physical examination of patients with vestibular complaints. We will then discuss the most commonly used vestibular tests and their role in the preoperative assessment of patients undergoing vestibular surgery, including nystagmography, caloric testing, rotary chair testing, video head impulse testing, and vestibular evoked myogenic potential testing.

Introduction

The accurate diagnosis of vestibular disorders can be difficult, but it is particularly essential to confirm an accurate diagnosis before considering an invasive operative intervention. A thorough history and physical should yield a diagnosis in most cases. Vestibular testing may be used in surgical cases to confirm the diagnosis and site, as well as to establish baseline vestibular function. In this article we will briefly review key features of the clinical history and physical examination of patients with vestibular disorders. We will then describe the most commonly used vestibular tests and their application to particular vestibular disorders with surgical implications.

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http://doi.org/10.1016/j.otot.2019.07.012
1043-1810/

History

A structured dizziness questionnaire is often helpful. The term "dizzy" should be avoided in favor of more specific terms. Vertigo is an artificial sense of movement, which is typically spinning or rotating. Oscillopsia is a sensation of visual field movement, particularly with head motion, resulting from impairment of the vestibulo-ocular reflex (VOR). Disequilibrium is a feeling of instability and a perception that one could fall, while ataxia or imbalance are symptoms of true balance impairment while standing or walking, with associated gait instability and falls. Lightheadedness and presyncope are generally cardiogenic, systemic, or psychiatric in origin.

Temporal features are especially helpful. Precipitating events may be pertinent, such as an upper respiratory tract infection preceding vestibular neuritis or a head injury preceding benign paroxysmal positional vertigo (BPPV). Episodes lasting seconds to minutes are typically from BPPV, dysautonomia, perilymphatic fistula, superior semicircular canal dehiscence (SSCD), or vestibular paroxysmia. Episodes lasting minutes to hours are usually from Ménière's disease (MD) or vestibular migraine (VM). Symptoms lasting days to weeks can occur with peripheral vestibular loss (PVL) from varied causes (eg, MD, ototoxicity, vestibular neuritis, and vestibular schwannoma), SSCD, or persistent postural perceptual dizziness ("3PD"), which is a common somatoform cause of dizziness.

Triggers are important clues, such as lying supine with BPPV, noise with SSCD, grocery stores with 3PD, and stress or diet with MD and VM. VM is also often sensitive to weather changes and menses. Associated symptoms are also informative. Tinnitus, aural fullness, and hearing loss are typical of MD. Conductive hyperacusis and autophony are common with SSCD or perilymphatic fistula. Headaches, visual aura, nausea, photophobia, or phonophobia suggest VM.

Physical examination

A complete otolaryngological and neurological examination should be performed, and nystagmus (spontaneous and gaze evoked) should be documented. Peripheral nystagmus has a fixed direction while central nystagmus typically does not. Peripheral nystagmus is also suppressed by fixation, so Frenzel or videonystagmography (VNG) goggles are helpful, when available. Peripheral nystagmus is often horizontal or torsional, while central nystagmus is often vertical. The head shake maneuver involves shaking the head rapidly side-to-side for 20-30 seconds, which yields a transient nystagmus when horizontal canal function is asymmetric. Positional testing includes bilateral Dix-Hallpike and supine head roll maneuvers looking for vertigo and nystagmus in each position (see nystagmography section below).

The head thrust (or head impulse) test is highly sensitive for PVL. The patient is instructed to fixate on the examiner's nose. The gaze will shift when the head is briskly and unpredictably turned ipsilaterally in the plane of a semicircular canal with an impaired VOR, which is followed by a corrective saccade back to the examiner's nose.

Balance, gait, and proprioception can be assessed through a variety of methods, including a Romberg test and single leg stance. The clinical test of the sensory integration of balance is a more detailed bedside balance assessment that may be helpful in some cases.[1]

Testing

This article focuses on the selection and interpretation of vestibular tests as they pertain to surgical intervention. Interested readers are directed elsewhere for comprehensive details on test administration, though brief descriptions are given here. A preoperative audiogram is essential for patients undergoing vestibular surgery, but it is assumed that vestibular surgeons are familiar with the interpretation of audiometry, so this topic will not be discussed here.

Nystagmography

Nystagmography uses magnetic search coils, surface electrodes or video goggles to capture eye rotation and nystagmus. While magnetic search coils are used primarily in research settings, both electronystagmography (ENG) and VNG are in common use at clinical facilities, with VNG becoming more popular in recent years. Both ENG and VNG can track horizontal and vertical components of nystagmus with and without fixation, but VNG can also identify torsional component. The ENG/VNG battery includes the assessment of nystagmus, pursuit, saccades, and optokinetics, as well as positing/positional testing. The caloric test is covered separately in the subsequent section.

Nystagmography – performance

This procedure needs to be done in a dark room. After proper calibration of the recording system, the first task is to identify possible spontaneous nystagmus. The patient is instructed to stare at a visual target located approximately 1 meter away for a minimum of 15 seconds. The target is then removed and the patient is instructed to continue looking straight ahead for another 15 seconds. For gaze testing, the patient is instructed to keep the eyes on the visual target for a minimum of 15 seconds. The visual target is presented above, below, to the left, and to the right of center, respectively. Any spontaneous or gaze-evoked nystagmus identified during testing should be marked and measured using VNG software.

In oculomotor testing (pursuit, saccade, optokinetic nystagmus), the patient is instructed to follow the motion of the visual target. The visual target in saccadic testing will move randomly in the horizontal or vertical plane. After enough trials, the test can be stopped and 3 types of measures (velocities, accuracies, and latencies) will be calculated automatically by the software. In pursuit, the visual target moves smoothly in a sinusoidal fashion with several speeds/frequencies. The visual stimuli in optokinetics are moving black-and-white, vertical lines, which ideally should fill a minimum of 90% of the whole visual field. The main measure of pursuit and optokinetics is gain.

In positional/positioning test, the examiner administers bilateral Dix-Hallpike and supine head roll maneuvers, as well as a midline head hang maneuver to identify possible BBPV. When conducting the Dix-Hallpike test, the examiner should hold the patient's head (with video goggles in place) and tell the patient to lie down quickly from a sitting position on a flat table with the neck extended downward and head tilted to one side about 45°. The patient will be reminded to keep their eyes open for 30-60 seconds before returning to a sitting position again. For head rolls, the patient will be in a supine position on the table and the tester will move the head to one side for 30-45 seconds before changing to the other side. In the head hanging test, the tester has to provide support to the head as the patient lies

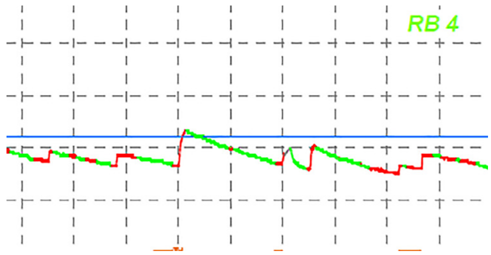

Figure 1 Videonystagmography (VNG) tracing demonstrating right-beating spontaneous nystagmus.

straight back until their neck is extended as much as possible with the head hanging below the plane of the table in the midline. The patient is asked about vertigo symptoms in each position and the goggles are used to detect any positional nystagmus.

Nystagmography – interpretation

On an ENG/VNG tracing the x-axis represents time and the y-axis represents degrees of eye rotation (horizontal tracing: positive = right and negative = left; vertical tracing: positive = up and negative = down). Nystagmus looks like a saw-tooth pattern, with short, steep lines for the fast phase and longer, wider-sloped lines in the opposite direction for the slow phase (Figure 1). Nystagmus direction is designated by the fast phase, while amplitude is determined by the mean slow phase velocity (SPV), which is the component that correlates to the vestibular response.

Peripheral nystagmus is typically gaze-suppressed and direction-fixed, though it is enhanced by gaze toward the fast phase (Alexander's law). Torsional nystagmus is universally peripheral, while vertical nystagmus is typically central. A helpful rule of thumb is to categorize peripheral vestibular disorders into hyperfunction and hypofunction. Nystagmus beats toward hyperfunctioning lesions and away from hypofunctioning lesions. Hyperfunctioning disorders include BPPV and SSCD, while hypofunctioning disorders include ototoxicity, MD (in between acute attacks), and vestibular neuritis (after the initial, acute phase). Spontaneous nystagmus is typically absent in chronic PVL once compensation has begun.

The oculomotor portions of the nystagmography battery (pursuit, saccade, optokinetic nystagmus) are of minimal significance to vestibular surgery, so their interpretation will not be covered here. Pursuit and saccade abnormalities indicate an oculomotor disorder or central vestibular dysfunction. Positional VNG can be helpful in evaluating BPPV, but ENG is less useful since it cannot detect torsion. The fast phase of nystagmus in BPPV is toward the affected ear. Posterior canal BPPV elicits vertigo and a geotropic, upbeating, torsional nystagmus in the Dix-Hallpike position. Horizontal canal BPPV elicits vertigo with a supine head roll maneuver accompanied by a horizontal nystagmus that is geotropic or apogeotropic, with the latter resulting from debris in the anterior segment of the canal or from cupulolithiasis.[2] Superior canal BPPV elicits vertigo and down beating nystagmus, with or without a torsional component, in the Dix-Hallpike or midline head hang positions.

Caloric test

Caloric testing remains the gold standard for diagnosing PVL, but it has limitations. It is specific to the horizontal canals, it cannot reliably diagnose bilateral vestibular loss, and it may be less tolerable for anxious or younger patients. Binaural, bithermal water caloric testing involves irrigating each ear canal sequentially with warm and cool water. The prevailing hypothesis is that this stimulates the cupula of the horizontal semicircular canals indirectly by eliciting an endolymph convection current from the temperature gradient.[3] This causes a nystagmus that is ipsiversive with warm water and contraversive with cool water. The relative magnitude of the slow phase responses is compared to determine if the horizontal canal VOR is impaired on one side. Additionally, ice water calorics can be used to confirm total loss ("areflexia") of horizontal canal function. Alternative approaches to caloric testing include monothermal and air caloric testing, but these are less reliable and not ideal for preoperative testing, so they are not discussed here.

Caloric test – performance

The patient is positioned on a flat table in the supine position with the head tilted up about 30° and video goggles in position. The temperature should be set at 44 °C for the warm water and 30 °C for the cool water. Each ear is sequentially irrigated with warm and then cool water for 30 seconds per stimulation for a total of 4 stimulation trials, altogether. Adequate time is given between each irrigation for resolution of subjective vestibular stimulation and nystagmus. Mental alerting tasks should be given during the test (eg, count numbers, name games, etc.). The recording of post-stimulation nystagmus should be continued until the peak velocity is reached and then visual fixation can be introduced.

Caloric test – interpretation

Binaural, bithermal caloric testing results are interpreted by calculating a unilateral weakness (UW) score, a directional preponderance (DP) score, and a fixation index (FI). These are calculated by first determining the peak SPV of nystagmus with warm and cool irrigation in each ear, yielding 4 separate SPV values (right warm, right cool, left warm, left cool). The UW and DP scores are calculated using the Jongkees formulae: (1) $UW = [(LC+LW)–(RC+RW)]/[(LC+LW+RC+RW] \times 100$; and (2) $DP = [(LC+RW)–(RC+LW)]/[(LC+LW+RC+RW] \times 100$. The FI is calculated using the formula developed by Demanez and Ledoux: $FI = SPV_{eyes\ open}/SPV_{eyes\ closed}$.[4] Currently these are typically calculated by computer software included with most caloric testing devices.

The UW score is also known as the reduced vestibular response score and is the most useful variable, as it is highly sensitive and specific for detecting a unilateral peripheral vestibular loss, though the lesion could be at any site between the horizontal semicircular canal and the root entry zone of the eighth cranial nerve at the cerebellopontine angle. Most centers use a normal UW score cut-off of 20%-25%. A large variety of vestibular disorders can cause an abnormal UW score, including MD, meningitis, vestibular schwannoma, and vestibular neuritis.

The DP score is much more controversial, and its role in the surgical vestibular patient is negligible. It is most commonly abnormal because of a spontaneous nystagmus. An abnormal FI indicates cerebellar dysfunction with the normal cut-off ranging between testing centers from 60% to 70%.

Rotary chair test

The rotary chair test is also specific to the horizontal canals, but it offers some advantages over caloric testing in certain settings. It can diagnose bilateral vestibular loss, it evaluates more natural frequencies of head rotation (caloric = 0.003 Hz; rotary chair = 0.01–0.64 Hz), and it is better tolerated by children and anxious patients. However, caloric testing is generally more sensitive for detecting unilateral vestibular loss,[5] and some vestibular losses may effect only a particular frequency range, resulting in a normal rotary chair test with an abnormal caloric test or vice versa. Therefore many patients may benefit from both tests prior to vestibular surgery, when available.

Sinusoidal harmonic acceleration (SHA) testing is the most common protocol used in clinical settings, as it is generally the best tolerated and is most effective at detecting bilateral losses, while velocity step testing is often used as a confirmatory protocol, as it is more sensitive for detecting asymmetries. This article will focus on SHA, since velocity step testing is rarely used for surgical planning. Most rotary chair testing protocols also include visual-vestibular interaction testing, which is useful in detecting central vestibular dysfunction.

Rotary chair test – performance

The SHA test is conducted in total darkness, preferably in an enclosure. The patient is secured on the rotary chair with the video goggles in position, and then the chair rotations are initiated by the computer software. The patient is instructed to keep their eyes open and directed straight ahead. The oscillation frequencies are octaves of 0.01 Hz (ie, 0.01, 0.02, 0.04, 0.08, 0.16, 0.32, and 0.64 Hz). Mental alerting tasks should be given during the test. Adequate time is given between each rotation for resolution of subjective vestibular stimulation and nystagmus. Visual-vestibular interaction testing is then performed via the projection of lines or dots on the walls of the enclosure that rotate with (VOR fixation) or against (visually-enhanced VOR) the direction of chair rotation. Upon completion, the computer software will automatically generate graphs charting the key variables described in the interpretation section below. The graphs should be visually checked by the examiner, and manual adjustment may be necessary whenever the automatic calculations of the VOR variables appear to be inaccurate.

Rotary chair test – interpretation

Interpretation of rotary chair testing with SHA involves analysis of a plot of angular head velocity relative to eye SPV at each frequency tested. This yields 3 variables: (1) Gain, (2) Phase, and (3) Symmetry score. The software included with most rotary chair testing units produces a table charting these 3 variables at each frequency tested relative to age-based normative ranges (Figure 2a).

Gain is the eye SPV divided by the head velocity and is a reflection of the overall condition of the VOR response. Phase refers to the angular relationship (in degrees) between the timing of maximal eye velocity and maximal head velocity. Symmetry score indicates whether there is any laterality to a reduced VOR response.

At most natural frequencies the VOR gain is close to one and the phase is close to zero. However, the mechanical characteristics of the cupula cause the VOR to function less well at low and high frequencies, which is seen as a decreased gain and increased phase lead at lower frequencies (Figure 2a). Velocity storage is a mechanism in the brainstem that reduces this low frequency phase lead, so that the timing of the eye and head velocity are better matched, but this mechanism is lost when any part of the VOR pathway is impaired between the horizontal canal and the vestibular nucleus, which causes an increased low frequency phase lead. Thus, PVL will typically result in a low frequency gain decrease and phase lead increase (Figure 2b). The time constant of the VOR is another useful variable that is inversely proportional to the phase lead and is calculated within velocity step testing by most rotary chair software programs. A general rule-of-thumb is that a time constant of <12 seconds is suggestive of a unilateral PVL, while a time constant of <6 seconds is suggestive of a bilateral PVL. The symmetry score shifts toward the impaired side (up = clockwise/right; down = counterclockwise/left) with an acute PVL, but it will normalize for nonacute, compensated losses (Figure 2c).

Video head impulse test (VHIT)

VHIT was recently developed by Drs. Halmagyi and Curthoys as a quantitative extension of the bedside head impulse test. VHIT involves rotating the head in each semicircular canal plane (right and left horizontal; right anterior/left posterior or RALP; left anterior/right posterior or LARP) multiple times in rapid succession while the patient's vision is fixed on a projected target. The goggles include an accelerometer to confirm adequate velocity and VNG to track eye position relative to the target. Some of the benefits of VHIT over the caloric and rotary chair tests are that it evaluates all 6 semicircular canals individually, it evaluates the VOR at more natural frequencies of head rotation, it is relatively portable, and it is generally

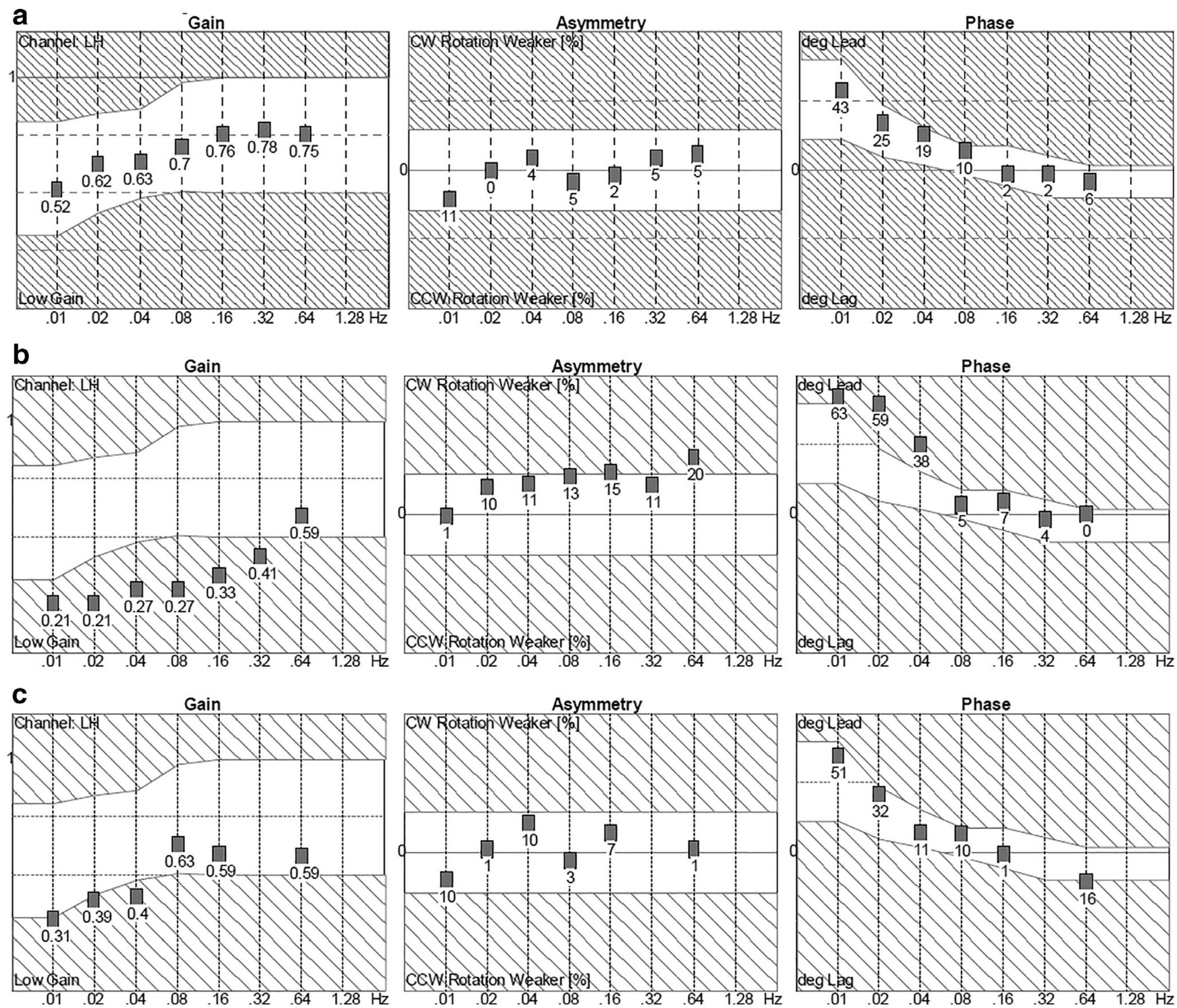

Figure 2 Rotary chair test reports in (a) patient with normal vestibular function, (b) patient with acute peripheral vestibular loss, and (c) patient with compensated vestibular loss.

better tolerated. However, VHIT is typically only abnormal in the setting of severe peripheral vestibular losses (eg caloric unilateral weakness of >40%).[6] Also, it is prone to blink artifact and is less reliable in patients with limited neck mobility. Therefore, VHIT is now considered a useful component of the vestibular test battery, but does not uniformly eliminate the need for caloric and rotary chair tests.

VHIT – performance

This procedure should be done in a well-lit room since low light levels will result in pupillary dilation, which degrades the data acquisition. After fitting the video goggles on the patient's head, the headband of the goggles must be tightened so that no slippage will occur when the head is in motion. The patient sits upright in a chair looking at a visual target, which is about one meter directly in the front of the patient. The tester should stand behind the patient with both hands on the patient's head. Calibration of the eye movement and optimization of eye image are required to ensure accurate VHIT measures. Head impulses are usually delivered in 3 planes, horizontal, LARP and RALP, and no more than 20 valid impulses are needed for each semicircular canal. Ideal head impulses are small head turns (eg, less than 20°) delivered abruptly to have proper peak head velocity. Most of VHIT software has a feedback feature that will inform the tester whether the impulse is a valid one or not. It is important to remind the patient not to blink frequently during head impulses, since excessive blinking can make the VOR gain calculation impossible or erroneous.

VHIT – interpretation

VHIT reports provide tracings of the eye movements and the head movements in each canal plane (Figure 3), which allows for the qualitative recognition of corrective saccades, either covert (during the head movement) or overt (after the head movement), which are considered diagnos-

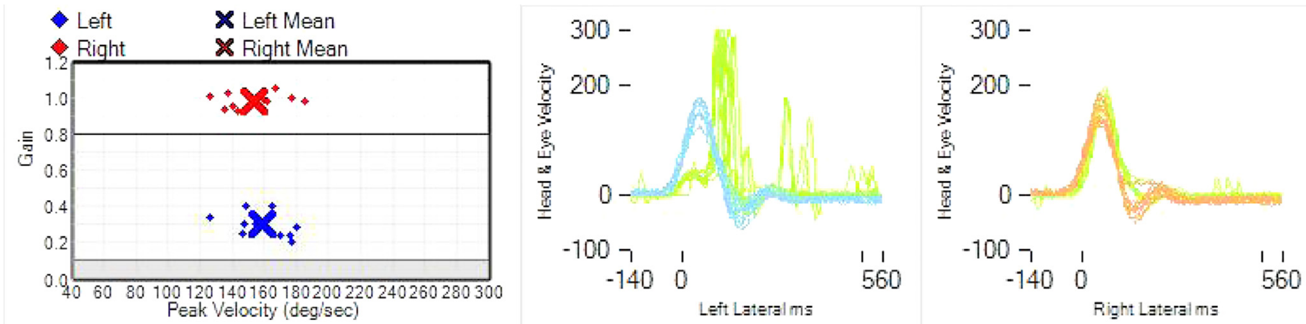

Figure 3 Video head impulse test (VHIT) report showing horizontal semicircular canal tracings in a patient with left vestibular neuritis. The VOR gain is reduced on the left side as represented by the blue X in the table on the left. The tracings on the right represent the head and eye movements, which are noted to be well-matched on the normal right side, but with a delay and corrective saccades in the eye responses on the left. VOR, vestibulo-ocular reflex.

tic of a loss in the tested canal when found consistently with rotations toward the affected side in that canal plane. Average VOR gain values for each tested canal are also provided, which are of variable utility. Generally, a VOR gain value of <0.8 is considered diagnostic of a loss in the tested canal.

Vestibular evoked myogenic potential test (VEMP)

VEMP testing uses EMG electrodes to detect electrical activity in the sternocleidomastoid (SCM) muscle in cervical VEMP (cVEMP) or the extraocular muscles in ocular VEMP (oVEMP) in response to air and/or bone conducted sound stimuli. The cVEMP response has been attributed to stimulation of the saccule and transmission via the inferior vestibular nerve, which produces an inhibitory response from the vestibular nucleus to the spinal accessory nucleus in the brainstem. This causes a brief relaxation of a tonically contracted SCM muscle, which is registered on the EMG tracing as a positive deflection (p1) followed by a negative deflection (n1) (Figure 4a). In contrast, oVEMP has been attributed to stimulation of the utricle and transmission via the superior vestibular nerve, which evokes an excitatory response from the vestibular nucleus to the oculomotor nucleus in the brainstem. This causes a brief contraction of the inferior oblique muscle, which is registered on the EMG tracing as a negative deflection (n1) followed by a positive deflection (p1) (Figure 4c). The anatomic basis of oVEMP remains more complicated and controversial than that of cVEMP.

VEMP test – performance

There are different methods to conduct the VEMP test, and the one described here is one of the simplest. For cVEMP, EMG electrodes are placed on the SCM muscle, with one on the muscle belly and the other on the muscle tendon near the clavicle. A ground electrode is also placed, typically on the forehead. During the test the patient is instructed to turn the head away from the side of stimulation to have a sufficient ongoing EMG level. Typical acoustic stimuli are 500 Hz tone-bursts delivered via earphones. The initial intensity of the stimulation should be at a high level (eg, 90 dB nHL) so that a clear cVEMP response can be detected. The intensity of the stimuli can be turned up or down to search for the cVEMP threshold (the lowest intensity at which cVEMP response can still be identified). Once a clear cVEMP response is acquired, the P1/N1 peak can be marked and amplitude along with latency will be calculated by the software.

For oVEMP, the recording electrodes are placed under the eye directly below the pupil. During the test, the patient is instructed to look up (ie, up gaze) with minimized eye blink. The oVEMP waveform will appear different from the cVEMP waveform, since it typically features multiple peaks and troughs. Nonetheless, the most import ones are the initial negative peak around 10 milliseconds, called n1, and the positive peak right after n1, called p1. Once n1 and p1 are marked, the amplitude of VEMP is calculated automatically by the software.

VEMP test interpretation

There are primarily 3 variables that are used to interpret VEMP testing results: peak amplitude, latency, and threshold. The normative ranges vary by lab since the equipment and testing conditions can differ. The interpretation of VEMP primarily has two roles in perioperative planning for vestibular surgery. One is to determine whether a vestibular loss at the level of the otolith organs or the vestibular nerves is present. Such a vestibular loss is detected by any or all of the following results in a given ear: absent response, reduced amplitude, prolonged latency, or increased response threshold. The other role is to confirm the presence of a third window condition, especially in SSCD, which consists of a decreased threshold and increased amplitude in the affected ear (Figure 4b).

Protocols

In many cases it may be prudent to obtain as comprehensive an assessment as possible of the baseline status of a patient's vestibular system prior to surgically manipulating the inner ear. However, some vestibular tests may not always be covered by insurance, may include high copays or deductibles for many patients, and may be unpleasant or distressing for some patients. Additionally, many clini-

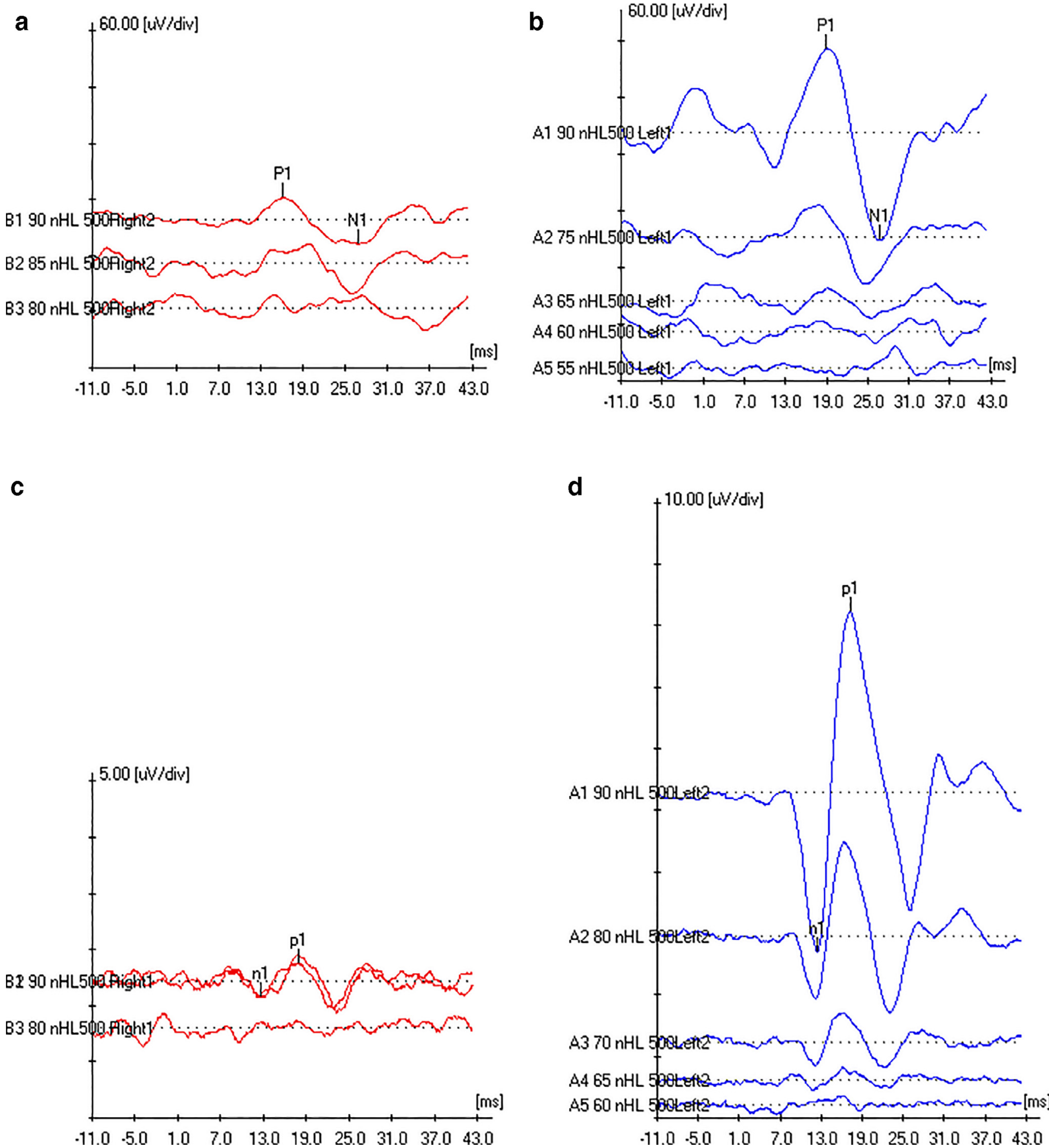

Figure 4 Vestibular evoked myogenic potential (VEMP) testing reports: (a) Normal cervical VEMP response, (b) Cervical VEMP in a patient with superior canal dehiscence demonstrating typical high amplitude and low threshold, (c) Normal ocular VEMP response, (d) Ocular VEMP in the same patient with superior canal dehiscence demonstrating typical high amplitude and low threshold.

cal vestibular testing centers only have the equipment and capabilities to perform some of the tests described in this article. Therefore, specific protocols will vary between individual surgeons, centers, and patients. Specific tests that have particular relevance to certain vestibular disorders and surgeries are outlined below, though it should be kept in mind that not all tests listed are necessarily required for the surgical management of the disorders listed, and also many surgeons and centers may prefer a more extensive test battery for the preoperative work-up of patients undergoing procedures for these disorders when feasible.

Ménière's disease

Vestibular testing is frequently helpful in establishing the diagnosis of MD, but no vestibular test is highly sensitive and specific for the diagnosis, and the diagnostic criteria for MD are based only on subjective symptoms and audiologic findings.[7] Vestibular testing is helpful to determine if a MD patient is a candidate for operative interventions that intentionally reduce vestibular function, which include intratympanic gentamicin therapy, vestibular nerve section, and labyrinthectomy. It is important to determine the status of vestibular function in the contralateral ear prior to these procedures, since bilateral involvement can occur in as many as 50% of patients, though the reported prevalence of bilateral involvement varies widely.[8] If a severe vestibular loss is present in the contralateral ear then such procedures would result in bilateral vestibular loss, which would prevent central compensation and potentially result in persistent post-operative balance impairment and oscillopsia. Vertigo symptoms in many patients with bilateral MD may be severe enough to warrant proceeding with such procedures regardless of the vestibular status of the other ear, particularly given that bilateral vestibular loss is possible from the natural progression of the disease itself in such patients. However, such decisions should ideally be made in an informed manner with a full understanding of the risks involved, which is best determined with preoperative testing. Testing for this indication may start with caloric testing and rotary chair, VHIT, and VEMP testing can be very useful in this setting. Caloric testing alone is generally adequate for this indication. The role of perioperative vestibular testing in nonablative procedures for MD, such as endolymphatic sac decompression and cochleosacculotomy, is minimal.

BPPV

Semicircular canal occlusion for treatment-resistant BPPV should ideally be preceded by confirmatory positional VNG documenting involvement of the canal being treated. The role of other vestibular tests in this setting is minimal.

SSCD

VEMP testing is routinely performed as a confirmatory test for SSCD as outlined above under the section on VEMP. Additionally, VNG can be useful to document the stimulation of nystagmus in the plane of the affected superior canal with a Valsalva maneuver or with ear canal pressure induced by tragal compression or a pneumatic bulb.

Sensorineural hearing loss

Many centers routinely obtain a vestibular test battery prior to simultaneous, bilateral cochlear implantation or prior to sequential implantation of the second ear in patients with sensorineural hearing loss.[9,10] The specific indications for preoperative vestibular testing are not well-defined, though it should be considered particularly in patients with an unknown etiology of hearing loss or with an etiology that is commonly associated with vestibular dysfunction (eg MD, Usher syndrome, meningitis, etc.) or for patients who have had specific issues with dizziness and/or imbalance. Loss of vestibular function in the implanted ear is a known risk of cochlear implant surgery, so the testing results can help the surgeon and the patient/parents to make an educated decision about whether or not to implant both ears and/or the second ear if the risk of causing a bilateral vestibular loss is high. Preoperative vestibular testing may also be helpful in deciding on which ear to implant when a unilateral implant is planned, but the hearing loss is relatively symmetric between both ears.

Bilateral vestibular loss

A comprehensive vestibular test battery is essential to confirm the presence of complete bilateral vestibular areflexia prior to consideration of vestibular implant surgery. This should ideally include VNG with binaural, bithermal caloric testing, rotary chair testing, VHIT, cVEMP, and oVEMP.

Conclusions

The role of vestibular testing in the perioperative evaluation of patients being considered for vestibular surgery varies greatly by the disease being treated and the surgery planned. The tests selected may also vary by availability at different testing facilities and by the tolerance or physical limitations of the patient being tested. It is important for the vestibular surgeon to be familiar with the basic interpretation of the most common vestibular tests in order to keep their patients well-informed of the potential risks and to help make their procedures as safe and effective as possible.

Disclosure

The authors reported no proprietary or commercial interest in any product mentioned or concept discussed in this article.

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