Department of Hearing & Speech Sciences
Vanderbilt University Medical Center
Clinical Protocol

Policy Title: Vestibular Function Test
Providers: ASHA-Certified and state licensed audiologists.

I. Policy Statement:

The Vestibular Function Test (VFT) Protocol for the Vanderbilt Bill Wilkerson Center (VBWC) Balance Disorders Clinic was developed in order to familiarize clinicians and students with the various specialized diagnostic assessments used to evaluate patients who have been referred for dizziness and/or unsteadiness symptoms with the ultimate goal of identifying the presence or absence of peripheral and/or central vestibular system disorders.

II. Equipment and Supplies:

1. 2-channel electro/video-nystagmography (ENG and VNG) system
2. Water caloric irrigator
3. Air caloric irrigator
4. Rotational Chair system
5. Evoked Potentials system
6. Video Head Impulse Test system
7. Computerized Dynamic Posturography (CDP) system

III. Protocols:

A routine VFT consists of ENG/VNG, rotary chair sinusoidal harmonic acceleration, both cervical and ocular vestibular evoked myogenic potential (VEMP) examinations, and optimally a three-canal video head impulse test (vHIT) or minimally a horizontal canal vHIT. These tests allow for assessment of each of the five vestibular end organ structures, with full frequency response information for horizontal canals.

Referring physicians may also order CDP as a supplementary test. This test provides data about sensory organization, motor control, and adaptation to perturbed surfaces from a mostly static postural stability perspective.

It is essential that every patient who is evaluated in the balance disorders laboratory have undergone a recent comprehensive hearing evaluation. This examination should include pure tone air and bone conduction, immittance testing including acoustic reflex thresholds at 500 Hz, 1000 Hz and 2000 Hz. Having this information at the time of evaluation will minimize the risk of irrigating an ear with a tympanic perforation and will optimize the likelihood of identifying patients with superior canal dehiscence.

IV. Procedures:

Electro/Video-nystagmography (ENG/VNG)
The ENG/VNG is considered the “gold standard” for the identification of vestibular hypofunction. Specifically, it assesses the functional integrity of the horizontal semicircular

canals, superior vestibular nerves, and the connections between the cerebellar midline (vermis) and vestibular nuclei. Additionally, the ocular motor subsystems (i.e. saccades, tracking/pursuit, optokinetics, and gaze-holding mechanisms) as well as the presence or absence of benign paroxysmal positional vertigo (BPPV), spontaneous, and positional nystagmus are accordingly assessed.

The clinician should be aware that under normal circumstances patients will undergo videonystagmography. In rare circumstances, clinicians may opt for electronystagmographic recording techniques. These instances include where it is difficult/impossible for the software to "target" the pupil, or where the patient is wearing heavy eye makeup or where the patient is a young child and the patient's head will not support the goggles.

ENG - Correct Electrode Montage for Binocular Recording:

1. BLACK = Ground/Reference (applied to the center of the forehead FPZ)
2. RED = Right Horizontal Channel
3. BLUE = Left Horizontal Channel
4. GREEN = Up Vertical Channel
5. BROWN = Down Vertical Channel

Normative Data for ENG
Corneo-retinal potential (CRP) – Calculated with patient dark-adapted for at least 10 minutes. Then, the clinician calibrates the patient. Once calibration is complete it is possible to retrieve the value (review calibration) representing how many microvolts is a 10 degree eye deviation from midline. We recommend that clinicians use the 1st percentile values to determine whether there is evidence of an abnormally reduced corneo-retinal potential.

CRP (uV/10 deg) Percentiles (Jacobson & McCaslin, 2004)

Sex	1st (abnormal)	5th	50th	90th	95th	99th
Male	71	82	135	199	218	258
Female	90	108	172	245	273	282

VNG – Fit patient with VG-40 VNG Goggles

Calibration
Calibrate Horizontal and Vertical Channels.

Ocular Motility Testing

1. Saccades
2. Gaze
3. Tracking (Pursuit)
4. Optokinetics (OKN)

Positioning/Positional Testing
Conduct a minimum of the following tests and observe and analyze for the presence of spontaneous nystagmus, benign paroxysmal positional vertigo (BPPV), and or positional

nystagmus. In the case of BPPV and upon completion of all diagnostic assessments, treat patient with the appropriate canalith repositioning maneuver relative to the affected side and respective semicircular canal.

Spontaneous – completed in sitting position with vision-denied

Positioning – complete prior to static positional tests

1. Dix-Hallpike or side-lying – posterior canal BPPV but may observe anterior canal BPPV; horizontal canal BPPV less common but possible to observe
2. Roll Test – horizontal canal BPPV
3. Deep-head hanging – anterior canal BPPV

Positionals – note sitting/spontaneous may be considered a position

1. Supine
2. Head Right/Body Right (whole body positioning may be better to eliminate cervicogenic contribution related to rotation of the head)
3. Head Left/Body Left

Caloric Testing

The caloric examination is traditionally conducted as an Alternating Binaural Bithermal Test (e.g. right warm, left warm, right cool, left cool). However, if the Monothermal Warm caloric response asymmetry between ears is < 10% and if the two warm irrigations produce a mean peak nystagmus velocity of at least 11 deg/sec (Jacobson & Means, 1985;
Jacobson et al. 1995, Murnane et al. 2009) then the examination can be considered to be normal and cool water caloric irrigations are not required.

If there is a suspected or confirmed side of lesion the impaired ear should always be irrigated first. The reasoning behind that recommendation is that the affected side will generate a reduced response in most circumstances thus mitigating any nausea. Additionally, the first irrigation usually yields the largest response (due to patient anxiety and apprehension over what sensations to expect after the irrigation ends), Following these directions in most cases will permit the clinician to complete the two warm caloric irrigations at the very least.

Pay careful attention for significantly enhanced response in post-surgical ears soon after onset of irrigation. In these cases, it may only be possible to make a statement about presence/absence of response of the ear

Complete WARM water irrigations in each ear separately. THEN, if necessary, complete COOL water irrigations in each ear respectively.

The patient MUST be engaged in a tasking paradigm in order to maintain alertness and prevent suppression of the vestibulo-ocular reflex (VOR) caloric response.

If you are conducting an ENG examination, the patient's eyes MUST be CLOSED during the tasking portions of the test. One method of ensuring the patient's eyes are closed is to tape gauze "eye patches" over the patient's eyes. This decreases the likelihood the patient will open their

eyes during the caloric test. If you are conducting a VNG examination, the patient's eyes MUST be OPEN with the VNG goggles lid in the CLOSED position.

Once the examiner judges that the caloric response is beginning to wane it is important to administer the test for VOR suppression (AKA fixation suppression test). If conducting an ENG exam request that the patient open their eyes and fixate on a stationary target. If conducting a VNG exam request that the patient fixate on a stationary light inside their VNG goggles or flip the lid open and have then fixate on a stationary target. We are interested in knowing how completely the prefixation nystagmus velocity is attenuated with visual fixation. The response usually is expressed as a ratio of post fixation nystagmus velocity divided by the pre fixation velocity and that value is multiplied X 100 to provide the percentage.

NOTE: In our clinic, WATER irrigation is the preferred stimulus for caloric testing. However, in the case of a perforated tympanic membrane, pressure equalization tubes, surgical ear(s), etc. AIR irrigation should be attempted instead.

Irrigator Settings

1. WATER
   Temperatures
   Warm: 44 degrees Celsius
   Cool: 30 degrees Celsius
   Irrigation Duration: 20-25 seconds
   Flow Pressure: approximately 500 milliliters/minute
2. AIR
   Temperatures
   Warm: 50 degrees Celsius
   Cool: 24 degrees Celsius
   Irrigation Duration: 60 seconds
   Air Pressure: 8 liters/minute

Caloric Response Norms
Total Caloric Response: $\leq$ 22 deg/sec is ABNORMAL
Unilateral Weakness: $\geq$23% is ABNORMAL
Directional Preponderance: $\geq$28% is ABNORMAL

<u>Rotational Testing:</u>
The rotary chair test provides supportive information regarding the quality and degree of central nervous system compensation for mid-frequency horizontal canal stimulation when a loss of peripheral vestibular system function has been identified on the ENG/VNG, it also quantifies magnitude of bilateral vestibular hypofunction and is helpful in the identification of central vestibular system disorders such as a velocity storage deficit (Jacobson et al. 2004).

Sinusoidal Harmonic Acceleration (SHA)
The screening protocol consists of assessing the patient's VOR phase, gain, and symmetry measures for 0.02 Hz, 0.08 Hz, and 0.32 Hz). Recall that 0.01 Hz may also be used but increases

the chances of vegetative effects and abnormal phase lead may persist for 0.01 Hz, even after compensation.

If phase, gain, and symmetry measures are within normal limits at all three sample frequencies then the test is complete. However, if any abnormalities of VOR phase, gain or symmetry are noted then all adjacent frequencies should be completed (0.01, 0.04, and 0.16 Hz).

VOR fixation suppression testing should also be assessed as a cross-check for fixation suppression ability during caloric testing. The screening default VFX frequency is 0.08 Hz. If this frequency is determined to be normal then the test is complete. If it is determined to be abnormal then VFX should also be assessed at 0.04Hz and 0.32Hz.

Vestibular Evoked Myogenic Potentials (VEMPs):

There are two distinct VEMP examinations which are conducted in our clinic. Specifically, they are the cervical VEMP (cVEMP) and the ocular VEMP (oVEMP). Collectively, these tests evaluate the otolith organs and the respective divisions of the vestibular nerve which innervate them.

1. cVEMP:

This response assesses the functional integrity of the saccule and inferior vestibular nerve, as well as the descending pathways underlying both the vestibulospinal and vestibulocollic reflexes. Minimum of two runs are obtained to replicate.

Electrode Montage

Single Channel Setup

Channel 1 Active (Non-inverting) – Ipsilateral sternocleidomastoid (SCM)
Channel 1 Reference (Inverting) – Chin or other acceptable location
Ground (Common) – Forehead (Fpz)

Test Parameters

a. Transducer: Insert Earphones
b. Stimulus: 500 Hz Toneburst as standard; 4 kHz should also be presented when superior canal dehiscence (SCD) is suspected.
c. Polarity: Rarefaction
d. Intensity: 95 dBnHL as standard; 70 dBnHL trace is obtained as screener for SCD. If a response is present at 70 dBnHL then threshold should be determined.
e. Rate: 5.1/s
f. Gain: 5K
g. Filter Settings: 5-10 Hz to1.5-2 KHz
h. Sweeps: Minimum of 80

Latency and Amplitude Asymmetry Norms (2 SD limit; Piker et al.)

a. P1 Absolute Latency (msec) 20.53
b. P1 Interaural Difference (msec) 2.63
c. P1-N1 Amplitude Asymmetry Ratio 43%

2. oVEMP:

The oVEMP assesses the functional integrity of the utricle and superior vestibular nerve. Minimum of two runs are obtained to replicate.

Electrode Montage
Two Channel Setup (belly-tendon derivation)
Channel 1 Active (Non-inverting) – LEFT Infraorbital
Channel 2 Active (Non-inverting) – RIGHT Infraorbital
Channel 1 Reference (Inverting) – LEFT ipsilateral medial canthus
Channel 2 Reference (Inverting) – RIGHT ipsilateral medial canthus
Ground (Common) – Forehead (Fpz)

It is our recommendation that the belly-tendon derivation be used first. If the oVEMP is absent we recommend that the clinician replace the tendon inverting electrode with a reference placed 2 cm inferior to the active electrode at the infraorbital midline.

Test Parameters

a. Transducer: Insert Earphones
b. Stimulus: 500 Hz Toneburst
c. Polarity: Rarefaction
d. Intensity: 95 dBnHL as standard; 4 kHz should also be presented when superior canal dehiscence (SCD) is suspected.
e. Rate: 5.1/s
f. Gain: 100K
g. Filter Settings: 1-10Hz to 1-2KHz
h. Sweeps: Minimum of 150

Latency and Amplitude Asymmetry Norms (2SD; Piker et al. 2001)

a. N1 Absolute Latency (msec) 2.47
b. N1-P1 Amplitude Asymmetry Ratio 33%

<u>Video Head Impulse Testing (vHIT):</u>

This test is based on the head thrust bedside exam. Rapid acceleration of the head in the plane of a given pair of semicircular canals will generate a VOR response that will allow the eyes of the normal patient to remain directed at a visual target. Patients with impaired VOR will generate a catch-up saccade to redirect the eyes back to the target. Using vHIT technology allows the examiner to ensure correct plane of stimulation, adequate acceleration to elicit VOR response, and quantification of VOR gain along with any saccadic activity.

Administration

1. Place goggles with camera/accelerometer and calibrate according to system.
2. Goggles should be tightly coupled to patient to avoid slippage.
3. Do not touch goggle or coupling straps.
4. Record 8 – 10 impulses in the plane of the horizontal semicircular canals.
5. Record 8 – 10 impulses in the RALP and LARP planes, if possible.

Interpretation

1. Normal horizontal gain is ≥0.8; normal vertical gain is ≥0.7. VOR gain values below these levels indicate semicircular canal impairment.
2. Sensitivity of this high-frequency test increases with caloric (low—frequency test) asymmetry at 39.5%.
3. Patients with definite Meniere's disease may exhibit pattern of caloric weakness in the presence of normal vHIT
4. Overt saccades occur after head impulse (>200 ms) and may be visible to the examiner using head impulse testing.
5. Covert saccades occur during head movement impulses (<200 ms) and are only recordable with technology.
6. There is evidence that as covert saccades appear and become more organized, dynamic visual acuity performance improves. This may be an indicator of VOR compensation.

Computerized Dynamic Posturography (CDP):

CDP, specifically the Sensory Organization Test (SOT) provides a cross-check for the ENG/VNG and rotational tests, it provides evidence of impaired somesthetic system function and/or the ability of the central nervous system to accurately integrate visual, vestibular, and somesthetic information during a task of static postural stability.

Administration

1. Fit the patient with an appropriately sized safety harness (i.e. adjust and secure shoulder, waist, and leg straps) and connect the harness to the overhead bar straps.
2. Assure proper placement of the feet on the platform force plates.
3. Conduct a minimum of two trials each for SOT Conditions 1-6 and analyze your results.

   Condition 1: Eyes open, fixed surface, fixed visual surround

   Condition 2: Eyes closed, fixed surface

   Condition 3: Eyes open, fixed surface, sway-referenced visual surround

   Condition 4: Eyes open, sway-referenced surface, fixed visual surround

   Condition 5: Eyes closed, sway-referenced surface

   Condition 6: Eyes open, sway-referenced surface and visual surround

Interpretation

Results are compared to normative data and the following patterns can be observed

Pattern	Over reliant on:	Problem Conditions
Vestibular Dysfunction	Visual and somatosensory	SOT 5, 6
Visual and Vestibular Dysfunction	Somatosensory	SOT 4, 5, 6
Somatosensory and Vestibular Dysfunction	Vision	SOT 2, 3, 5, 6
Visual Preference	Vision	SOT 3, 6

Vestibular Dysfunction and Visual Preference	Vision	SOT 3, 5, 6

V. Required Clinician Education/Supervision to Ensure Competency:

All new clinicians or clinicians new to this clinical service are required to complete a focused evaluation of clinical practice with an assigned senior clinician. The senior clinician will work with the supervisor to establish competency.

The clinician will participate in clinic with senior clinicians for 4 – 8 weeks, depending on the experience level of the clinician and how quickly competency is established. Competency is established when the supervised clinician demonstrates independence in administration, interpretation, and documentation for all diagnostics in the VFT. Further, it is expected that the clinician will also be proficient with identification and management of all types of benign paroxysmal positional vertigo (BPPV) at this time.

When the supervisor determines these criteria are met, the supervised clinician is deemed competent to serve their own templated clinic.

If the clinician does not demonstrate competency, the supervising clinician offers feedback for methods of improvement, then they continue with supervised clinical experiences until the supervising audiologist determines that competency has been met. If this is not achieved within the six months of focused evaluation, the supervisor may choose to remove the clinician from this service or continue with supervised training to develop competency.

Annual competency is maintained through participation in continuing education specific to vestibular assessment and management, chart review, and/or direct observation by supervisor or peer.

VI. Documentation:

Results are interpreted and documented in a written report in eStar. Reports should be completed in a timely manner and promptly routed to referring physicians (i.e. within 24 hours of examination).

1. Billing/Coding:
    a. ENG/VNG
        92540 Basic vestibular evaluation
        92537 Caloric vestibular test with recording, bilateral; bithermal (i.e., one warm and one cool irrigation in each ear for a total of four irrigations)
        92538 monothermal (i.e., one irrigation in each ear for a total of two irrigations)
        92547 Use of vertical electrodes (ENG only)
    b. Rotary Chair
        92546 Sinusoidal vertical axis rotational testing
    c. VEMP

92517 Vestibular evoked myogenic potential testing, with interpretation and report; cervical (cVEMP)
92518 Vestibular evoked myogenic potential testing, with interpretation and report; ocular (oVEMP)
92519 Vestibular evoked myogenic potential testing, with interpretation and report; cervical AND ocular (cVEMP/oVEMP)

d. vHIT

92700 This is a non-specific otolaryngology code and there is appropriate documentation that auto-populates the eStar note to fulfill the necessary requirements for reimbursement until a dedicated CPT code is developed and approved.

e. CDP

92548 Computerized dynamic posturography, sensory organization test

VII. References:

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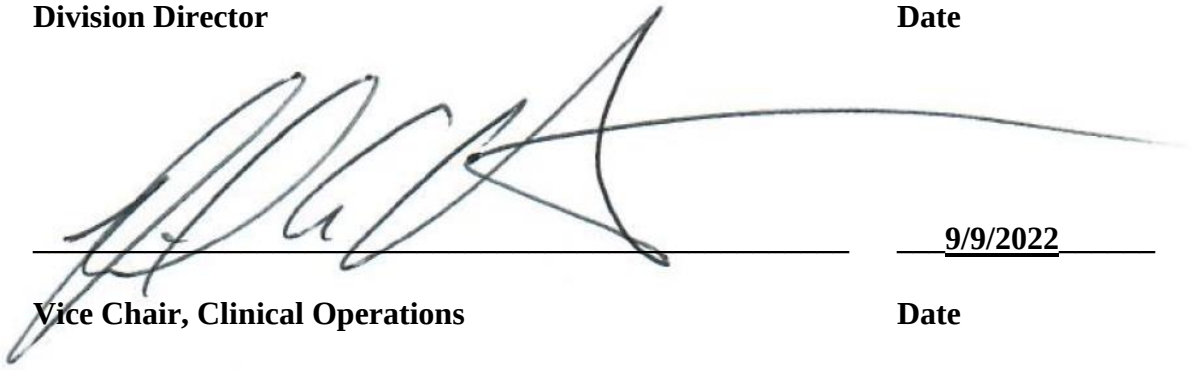
VIII. Approval:

9/9/2022

Division Director **Date**



9/9/2022

Vice Chair, Clinical Operations **Date**