

VESTIBULAR TESTING INTERPRETATION: DRILL AND PRACTICE

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INTRODUCTION AND SCOPE OF THE BOOK

Who Is This Book For?

We designed this book with a trainee or junior practitioner in mind. Prior books and papers have attempted to comprehensively survey vestibular testing and their clinical applications. We wanted to add to this excellent volume of literature by providing a readable, yet comprehensive overview of modern vestibular testing married to patient cases with real data. We felt that providing cases derived from real patient encounters would help solidify the concepts underlying vestibular function testing in a convenient, one-stop resource.

The first half of this book comprises an evidence-based review of the most commonly employed vestibular function tests. We have searched the literature to identify the most impactful papers relating to each test, and have identified the salient kernels of truth and wisdom. References are provided throughout this book, so the reader may dive deeper into the material when needed. As in other areas of medicine, we recognize that there is frequent equipoise when it comes to an objective appraisal of the designation of “best test” when exploring a diagnosis. In these situations, we offer our opinion grounded in years of experience testing and treating vestibular patients at a major academic medical center vestibular clinic.

What Do We Not Cover?

We should also outline what is outside the scope of this book. Caring for the vestibular patient requires an understanding of vestibular physiology, common tests employed to assess for deviations from normal-state physiology, as well as what to do next when a specific pathology is identified. We could

not possibly cover all there is to know about vestibular physiology while maintaining readability, therefore we refer the interested reader to specific peer-reviewed articles and books to fill those gaps when necessary.

Performing and interpreting vestibular function tests will hopefully lead to a short list of possible diagnoses. Depending on the diagnosis and your scope of training, you will be able to offer the patient a remedy. There are numerous peripheral and central vestibular disorders with specific therapies available for each. These therapies include highly specialized physical therapy, medications, and invasive surgical procedures and we’ll discuss the details of each treatment in its clinical context.

How to Use This Book

The utility of this book will largely be determined by the learner’s prior knowledge base on these topics. In the case of a trainee who is just starting to learn about vestibular testing, we recommend going through part one of this book to develop a foundation of the basics of various vestibular tests and their uses. After the trainee has a grasp of which test is used and why, we then recommend proceeding with reviews of the patient cases. It is our hope that the background provided in the first half of the book would help inform the trainee in analyzing the patient cases. For practitioners who are more experienced with vestibular testing, we’d recommend consulting the first part of the book as needed for touch-up on topics. The primary utility for experienced practitioners will be to work through the patient cases as “drill and practice.” The cases need not be approached in sequential order—they were designed independently of one another, so no intentional order is presented.



ABOUT THE AUTHORS



Matthew G. Crowson, MD, MPA, FRCSC is a Clinical Fellow in Neurotology-Skull Base Surgery at Sunnybrook Health Sciences Center. As an otolaryngology resident at Duke University, he developed a pointed interest in the diagnosis and management of patients suffering from vestibular disorders.

While not a frequent focus of other providers in otolaryngology, Dr. Crowson believes otolaryngologists are uniquely positioned to be the preeminent specialists in treating vestibular disorders. Through both his residency experience and training in vestibular rehabilitation through the American Physical Therapy Association, he hopes to help advance the field of vestibular medicine so that more patients have access to high quality, definitive care.



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then went to Nashville for a fellowship in neurotology with the Otology Group of Vanderbilt. He remained as faculty there for four years before coming to Duke. His interests are in vestibular disorders, skull base tumors, and diseases of the ear and hearing.

Chapter 1

OVERVIEW OF VESTIBULAR TESTING

Introduction to the Vestibular Testing Battery

There are many tests available to assess the peripheral vestibular system in the outpatient setting. The focus of this chapter is to provide a concise introduction to the most common tests, including how they can help and when they should be used.

Focused History and Physical Examination

Practitioners could subject patients to every bedside and high-tech vestibular test available and fall short of making a diagnosis if they have neglected to perform a comprehensive history and physical exam. The history and physical exam is critical in the workup of a vestibular patient. These initial steps are quick, do not require specialized equipment, and can be performed in a variety of settings. Below, we will outline the pertinent aspects of the history and physical examination that should be evaluated before proceeding with vestibular testing. For a more detailed description on the topic, the interested reader is encouraged to utilize excellent resources that have been previously published and include *Balance Function Assessment and Management* by Gary Jacobson and Neil Shepard, as well as *Vestibular Rehabilitation* by Susan Herdman and Richard Clendaniel.^{1,2}

History

Clinicians have developed and published various questionnaires, tools, and algorithms to systemat-

ically assess vestibular patients' histories. The most important aspects of taking a history of a patient with "dizziness" is to:

1. Characterize the **sensations of dizziness** that the patient experiences—is it vertigo/disequilibrium, lightheadedness, imbalance?
2. Characterize the **temporal pattern of symptoms** (e.g., seconds, minutes, hours, days, constant),
3. Determine **associated otologic or other symptoms** (e.g., hearing loss, tinnitus, aural fullness, migraine), and
4. Explore triggering, **exacerbating and alleviating factors**.

Taking a thorough case history is of paramount importance, and should help the clinician generate a list of high probability diagnoses. At minimum, the above four history components should provide the examiner with a comprehensive picture of the patients' symptomatology. For instance, consider the most common peripheral vestibular diagnoses in the context of the above history features (Table 1–1):

As with many conditions in medicine, there are exceptions to the rule. The four-parameter history-taking strategy should be used as a guide, but not in isolation. Moreover, there are a few other peripheral vestibular diagnoses that should be considered if the patient's history and constellation of symptoms deviate from the patterns seen in the most common diagnoses. These may include labyrinthitis, third-window phenomenon, vestibular paroxysmia, and persistent postural-perceptual dizziness.

TABLE 1–1. Common Vestibular Diagnoses and Their History Clues

| Disorder | Temporal Pattern | Otologic & Associated Symptoms | Exacerbating/Alleviating Factors |
|---|--------------------------------|---|---|
| Vestibular migraine | Intermittent (minutes – hours) | No hearing loss. May precede or follow migraine headaches | Similar to known migraine risk factors (e.g., food, stress, hormonal changes, sleep pattern, medications) |
| Benign paroxysmal positional vertigo | Brief episodes (<= minute) | No hearing loss or other otologic symptoms. | Turning over in bed, looking up. History of prior head trauma. |
| Meniere’s disease | Intermittent (minutes – hours) | Low-frequency hearing loss, tinnitus, aural fullness during “flares.” | Dietary factors (sodium). Weather or pressure changes. Psychosocial stress. |
| Acute unilateral vestibular loss/ vestibular neuritis | Constant | No hearing loss or other otologic symptoms. | Any head movement. May follow a viral illness (e.g., upper respiratory tract infection). |

Diagnostic Criteria

There are several texts, review articles, and online resources that comprehensively outline the natural history, pathophysiology, and common symptoms of all common peripheral and central vestibular disorders. As of the writing of this manuscript, the main source for diagnostic criteria lies within the International Classification of Vestibular Disorders from the Bárány Society (ICVD; available at <http://www.jvr-web.org/ICVD.html>). To date, the ICVD has produced diagnostic criteria for vestibular migraine, Meniere’s disease, benign paroxysmal positional vertigo (BPPV), and vestibular paroxysmia. The critical elements of these manuscripts is reproduced below as it is helpful as a reference when framing an approach for history taking.

Benign Paroxysmal Positional Vertigo³. It is important to note that there are different forms of BPPV depending upon whether debris simply alters the hydrodynamics of the endolymphatic fluid within the semicircular canals (i.e., canalolithiasis) or adhere to the cupula (i.e., cupulolithiasis). Canalolithiasis and cupulolithiasis have different presentations, which are revealed on objective examination and provocative clinical maneuvers. As you will notice, the history for BPPV is largely the same regardless of the semicircular canal involved: “recurrent attacks of positional vertigo or positional dizziness provoked by lying down or turning over in

the supine position . . . with duration of attacks lasting <1 min.”³ The diagnostic criteria also include specific nystagmus findings seen during positional maneuvers (**Table 1–2**). We explain the mechanics of the positional maneuvers later in this book.

Vestibular Migraine⁴. Vestibular migraine is a relatively new diagnosis, and our knowledge base is still in its infancy. Vestibular migraine is not a “diagnosis of exclusion.” As the criteria below outline, there is more to making the diagnosis beyond vertiginous episodes temporally associated with migraine headaches. The International Classification of Headache Disorders (ICHD, third edition) has produced two diagnostic categories for vestibular migraine with a probability context, with the caveat that the symptom constellation cannot be explained by another official headache diagnosis (**Table 1–3**).

Menière’s Disease⁵. The North American diagnostic criteria for Meniere’s disease have evolved over time through the input of standing committees (American Academy of Otolaryngology–Head and Neck Surgery [AAO-HNS] Committees on Hearing and Equilibrium in 1972, 1985, and 1995). For the sake of consistency, we have included (and adapted) the jointly formulated criteria by the Committee of the Bárány Society, the Japan Society for Equilibrium Research, the European Academy of Otolaryngology and

TABLE 1–2. Testing for Benign Paroxysmal Positional Vertigo (BPPV) variants

| BPPV Variant | Testing Maneuver & Findings |
|---|---|
| Canalolithiasis of the posterior canal (the most common variant) | Nystagmus that occurs seconds after performing the Dix–Hallpike or side-lying maneuver. The nystagmus is mixed torsional and up-beating and lasts less than one minute. The fast phase of the torsional component drives the upper pole of the eyes toward the lower (affected) ear. A positive response is nearly always accompanied by a sensation of spinning. |
| Cupulolithiasis of the posterior canal | Nystagmus elicited after a brief latency with the Dix–Hallpike or side-lying maneuver. The nystagmus direction is the same as above and the critical difference is it lasts over 1 minute. The patient commonly experiences a sensation of spinning, but it may be less intense than cases of canalolithiasis. |
| Canalolithiasis of the horizontal canal | Nystagmus elicited after a brief latency by the supine roll test. The nystagmus beats horizontally toward the lower ear with the head turned to either side (also known as “geotropic” direction changing nystagmus. <i>Important caveat: if the debris is free-floating in the anterior portion of the horizontal canal, it will beat ageotropic</i>) and lasts less than 1 minute. The larger amplitude nystagmus indicates the affected ear, i.e., if RB>LB, right ear is affected. Patients are typically extremely symptomatic. |
| Cupulolithiasis of the horizontal canal | Nystagmus elicited after a brief latency by the supine roll test. The nystagmus typically beats horizontally toward the uppermost ear with the head turned to either side (also known as “apogeotropic” direction changing nystagmus) lasting greater than 1 minute. <i>Important caveat: nystagmus in cupulolithiasis can beat in either direction, but the duration is typically longer than seen in canalolithiasis.</i> |

Adapted from Brevern et al. 2015.³**TABLE 1–3.** Diagnostic Criteria for Vestibular Migraine

| Diagnosis | (i) Episodes | (ii) History of Migraine | (iii) Migraine Features |
|-------------------------------------|--|--|---|
| Vestibular migraine | “At least 5 episodes with vestibular symptoms of moderate or severe intensity, lasting 5 minutes to 72 hours ” | “Current or previous history of migraine with or without aura according to the International Classification of Headache Disorders (ICHD)” | “One or more migraine features with at least 50% of the vestibular episodes: <ul style="list-style-type: none"> ■ Headache with at least 2 of the following characteristics: one sided location, pulsating quality, moderate or severe pain intensity, aggravation by routine physical activity ■ Photophobia and phonophobia ■ Visual aura” |
| Probable vestibular migraine | | “Only 1 of the criteria “ii” and “iii” (above) for vestibular migraine is fulfilled (migraine history or migraine features during the episode)” | |

Adapted from Lempert et al., 2012.⁴

Neurotology (EAONO), the Equilibrium Committee of the AAO-HNS, and the Korean Balance Society. Akin to vestibular migraine, Meniere's disease also has two diagnostic categories based on contextual probability (Table 1–4).

Vestibular Paroxysmia⁶. Vestibular paroxysmia is a diagnosis that has some historical overlap with benign paroxysmal positional vertigo and Meniere's disease. What makes this diagnostic criterion interesting is that it requires a treatment trial of an anti-epileptic (e.g., carbamazepine) with response to treatment. Like Meniere's disease and vestibular migraine, there is a diagnostic category with higher confidence followed by a "probable" category (Table 1–5).

Persistent Postural-Perceptual Dizziness⁷. Persistent postural-perceptual dizziness (also known as

"3PD" or PPPD) is a newly described diagnosis that has taken other names over time, including visual vertigo, phobic postural vertigo, space-motion discomfort, and chronic subjective dizziness.⁷ While the disorders have different gradients of symptoms reported in their respective literatures, the ICVD has opted to consolidate this phenomenon under the broader classification of persistent postural-perceptual dizziness (Table 1–6).

Bilateral Vestibulopathy⁸. The symptoms of bilateral vestibulopathy can be debilitating owing to the failure of both peripheral vestibular systems and the functional deficits that result. In many cases, these patients are debilitated by imbalance and difficulty stabilizing their visual world with head movement (oscillopsia). The diagnostic criteria include both symptoms and objective test findings (Table 1–7).

TABLE 1–4. The 2015 Diagnostic Criteria for Meniere's Disease

| Diagnosis | (i) Episodes | (ii) Audiogram Findings | (iii) Aural Symptoms |
|-----------------------------------|---|---|---|
| Definite Meniere's disease | "2 or more spontaneous episodes of vertigo, each lasting 20 minutes to 12 hours" | "Low- to medium-frequency sensorineural hearing loss in one ear, defining the affected ear on at least one occasion before, during, or after one of the episodes of vertigo." | "Fluctuating aural symptoms (hearing, tinnitus, or fullness) in the affected ear" |
| Probable Meniere's disease | "2 or more episodes of vertigo or dizziness, each lasting 20 minutes to 24 hours" | N/A | |

Adapted from Lopez-Escamez et al., 2015.⁵

TABLE 1–5. Diagnostic Criteria for Vestibular Paroxysmia

| Diagnosis | Episodes | Duration | Other Features |
|---------------------------------------|---|-----------------------|--|
| Vestibular paroxysmia | "At least 10 attacks of spontaneous spinning or non-spinning vertigo" | "Less than 1 minute" | <ul style="list-style-type: none"> ■ "Stereotyped phenomenology in a particular patient" ■ Response to a treatment with carbamazepine/oxcarbazepine" |
| Probable vestibular paroxysmia | "At least 5 attacks of spinning or non-spinning vertigo" | "Less than 5 minutes" | <ul style="list-style-type: none"> ■ "Spontaneous occurrence or provoked by certain head movements" ■ Stereotyped phenomenology in a particular patient" |

Adapted from Strupp et al., 2016.⁶



TABLE 1–6. Diagnostic Criteria for Persistent Postural-Perceptual Dizziness

| Symptoms | Symptom Triggers | Causative Factors | Functional Impact |
|--|--|--|---|
| <p><i>“1 or more symptoms of dizziness, unsteadiness, or non-spinning vertigo are present on most days for 3 months or more.</i></p> <p><i>Symptoms [last for hours], but may wax and wane in severity.</i></p> <p><i>Symptoms need not be present continuously throughout the entire day.”</i></p> | <p><i>“Persistent symptoms occur without specific provocation, but are exacerbated by three factors:</i></p> <ol style="list-style-type: none"><i>1. Upright posture,</i><i>2. Active or passive motion without regard to direction or position, and</i><i>3. Exposure to moving visual stimuli or complex visual patterns.”</i> | <p><i>“Precipitated by conditions that cause vertigo, unsteadiness, dizziness, or problems with balance including acute, episodic, or chronic vestibular syndromes, other neurologic or medical illnesses, or psychological distress.</i></p> <ol style="list-style-type: none"><i>1. When the precipitant is an acute or episodic condition, symptoms settle in as the precipitant resolves, but they may occur intermittently at first, and then consolidate into a persistent course.</i><i>2. When the precipitant is a chronic syndrome, symptoms may develop slowly at first and worsen gradually.”</i> | <p><i>“Significant distress or functional impairment”</i></p> |

Adapted from Staab et al., 2017.⁷

TABLE 1–7. Diagnostic Criteria for Bilateral Vestibulopathy

| Diagnosis | Symptoms | Test Findings |
|--|--|---|
| Bilateral vestibulopathy | <p><i>“Unsteadiness when walking or standing plus at least one of:</i></p> <ol style="list-style-type: none"><i>1. Movement-induced blurred vision or oscillopsia during walking or quick head/body movements</i> <p><i>AND/OR</i></p> <ol style="list-style-type: none"><i>2. Worsening of unsteadiness in darkness and/or on uneven ground”</i> <p>In addition: <i>“No symptoms while sitting or lying down under static conditions.”</i></p> | <p><i>“Bilaterally reduced or absent angular VOR function documented by:</i></p> <ol style="list-style-type: none"><i>1. Bilaterally pathological horizontal angular VOR gain <0.6, measured by the video-HIT and/or scleral-coil technique,</i><i>2. Reduced caloric response (sum of bithermal max. peak [slow phase velocity] on each side <6°/sec)</i> <p><i>AND/OR</i></p> <ol style="list-style-type: none"><i>3. Reduced horizontal angular VOR gain <0.1 upon sinusoidal stimulation on a rotatory chair (0.1 Hz, Vmax = 50°/sec) and a phase lead >68 degrees (time constant <5 sec).”</i> |
| Probable bilateral vestibulopathy | | <p><i>“Bilaterally pathological bedside horizontal head impulse test”</i></p> |

Adapted from Strupp et al., 2017.⁸

Physical Examination

The physical examination of the dizzy patient is as much about ruling out “red flags” for serious central nervous system pathologies as it is about recognizing positive peripheral vestibular signs. If a “red flag” is identified, the patient should be promptly referred to the appropriate specialist (i.e., neurology for signs indicative of a central lesion, emergency department for acute cerebrovascular accident, cardiology for arrhythmia). Below, we will briefly outline several signs to look for that can be seen in the presence of a peripheral vestibular disorder.

General

A quick examination of the patient’s general comportment will provide insight into the patient’s functional integrity. Patients may ambulate independently or appear tentative and unsure. Patients with chronic disequilibrium may have walking aids or require the use of a wheel chair. Anxiety may manifest as nervousness when patients discuss their case, and some may be tearful.

Head and Face

Cranial nerve deficits of interest in examining the head and face include:

- II—The optic nerve: Does the patient endorse visual deficits? Blindness?
- III, IV, VI—The oculomotor, trochlear, and abducens nerves: Does the patient endorse double vision?
- V—The trigeminal nerve: Does the patient have facial paraesthesia? Hypoesthesia?
- VII—The facial nerve: Does the patient have facial weakness/paresis? Twitching? Synkinesis?
- IX/X—The glossopharyngeal and vagus nerves: Does the patient have uvular deviation?
- XII—The hypoglossal nerve: Does the patient have symmetric tongue movement and strength?

Eyes

In addition to the relevant cranial nerves noted above, a significant amount of information can be obtained from the eyes as there is an intimate link

between the vestibular and oculomotor systems. An examination of the eyes is completed extensively as part of the vestibular testing battery described later.

Ears

In many cases of benign vestibular pathology, the ear examination will be grossly normal. However, it is important to assess for external auditory canal and middle ear pathology on otoscopic evaluation. Does the external canal or middle ear have signs of acute or chronic infection? Are there masses or lesions consistent with a neoplasm/tumor or other invasive process (e.g., glomus tumors, cholesteatoma, malignancy)? Are there clues to external, middle, or inner ear anatomical anomalies (e.g., microtia, external auditory canal stenosis, encephalocele/meningocele, cerebrospinal fluid [CSF] otorrhea)? Is subjective and objective (tuning fork) hearing normal?

Neck

In most causes for peripheral vestibular dysfunction, there are no significant findings during the examination of the neck. Rare cases such as skull base masses (e.g., glomus tumors, temporal bone malignancy) may manifest with a palpable mass. While not for diagnostic purposes, it is prudent to evaluate the neck for range of motion, as components of the vestibular testing battery and treatments require manipulation of the neck. Before attempting neck manipulations, the patient should be queried as to any pre-existing musculoskeletal conditions or known mechanical limitations affecting the neck.

Neurologic

In addition to the cranial nerve examination completed as part of the “head and face” exam noted above, it is prudent to assess for focal neurologic deficits given the crossover in vestibular symptoms between peripheral and central causes. The practitioner should assess upper and lower extremity flexor and extensor strength. Does the patient have a unilateral weakness? Is handgrip strength symmetric? A provider should have the patient perform tests of cerebellar function, including the Romberg as well as tests for dysdiadochokinesia (e.g., rapidly alternating hand movements, “point-to-point” finger coordination, heel-to-shin tests). Is the patient able to articulate without dysarthria or significant