

# Defining Dizziness: Acknowledging Vestibular Differential in Cardiopulmonary Diagnoses

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This clinical perspectives article provides a comprehensive and evidence-based overview of diagnosing and treating dizziness in complex patients. These patients typically present with overlapping comorbidities and symptoms that can create difficulty in discovering an accurate diagnosis and treatment plan. Vestibular dysfunction affects over 35% of adults older than 40 years, and that prevalence significantly increases with age. Eighty-five percent of adults older than 80 years had evidence of balance/vestibular dysfunction. We believe this differential diagnosis between cardiopulmonary and vestibular dizziness transcends all rehab environments across the continuum of care. We will provide evidence for vestibular background knowledge and clinical skills that intersects with evidence regarding pharmacology and competing cardiopulmonary diagnoses to provide clinicians with the framework, skills, and knowledge to differentially diagnose dizziness across multiple care settings. In addition, we will provide examples of appropriate interdisciplinary communication to assist the clinician in decision making and best practice management. (**Cardiopulm Phys Ther J. 2023;00:1–6**) *Key Words: dizziness, vestibular, vertigo, cardiovascular diagnosis, cardiopulmonary diagnosis, pharmacology*

Patients receiving physical therapy services across the continuum of care routinely complain of dizziness. Those with a history or primary diagnosis of cardiovascular or pulmonary disease are at increased risk for this nonspecific symptom, which is often multifactorial in etiology. Uncovering and treating the contributing factors to dizziness can be difficult even for experienced clinicians. Vestibular dysfunction is often underdiagnosed and undertreated in patients with dizziness, especially those with cardiovascular and/or pulmonary pathologies. An estimated 35% of adults older than 40 years have evidence of vestibular dysfunction,<sup>1</sup> with the odds continuing to increase with increased age and those

with diabetes mellitus. Patients with cardiovascular and pulmonary diagnoses are at increased risk for vestibular dysfunction due to the pathophysiology and pharmacologic treatment of their conditions. Physical therapists have a unique opportunity and skillset to fill this dizziness diagnostic gap, and vestibular differential diagnosis is emerging as an important clinical skill that all physical therapists should add to their toolbox. Physical therapists can contribute to diagnosis and treatment of vestibular disorders through thorough chart review, subjective history, patient examination, and skilled intervention. Improving physical therapists' understanding and confidence in vestibular differential diagnosis has the potential to improve patient symptoms, function, and quality of life as well as contributing to cost savings for health systems and is therefore an integral component of physical therapy practice. Recent articles by McArdle et al<sup>2</sup> and Lammers et al<sup>3</sup> highlight the diagnostic and treatment efficiency of trained vestibular physical therapists and the subsequent improvements in care, discharge disposition, and cost savings that can occur.

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Vestibular differential diagnosis in patients with cardiovascular and pulmonary presentations can be difficult and typically requires the clinician to rule in or rule out potential causes of dizziness, much like peeling the layers of an onion. The use of a systematic approach can improve clinician accuracy and confidence. We recommend the following comprehensive process to help clinicians accurately reason through differential diagnosis: (1) start with a thorough chart review, (2) implement strong subjective questioning regarding patient symptomology, and (3) use standardized oculomotor and vestibular examination techniques in conjunction with suggestive and functional testing. In addition, clinicians should seek to achieve a comprehensive understanding of common cardiovascular, pulmonary, and vestibular conditions; specifically, how they overlap in presentation (Fig. 1) and unique identifying features that will assist clinicians with putting the entire clinical picture together to identify and treat the appropriate diagnosis or combination of diagnoses.

A thorough chart review should focus on the history of present illness and recent medical course. For many patients with cardiovascular and pulmonary diagnoses, this may include review of medical providers' notes, tests performed, medication adjustments, and other medical interventions such as surgeries or other procedures. Particular attention should be directed to vital sign trends and indicators of cardiac output because many cardiovascular reasons for dizziness are due to consistent or transient changes in cardiac output (Table 1). In addition to the "typical" chart review, a review of patients at risk for or with suspected vestibular dysfunction should include identification of key vestibular descriptors (Table 2), review of medications and pharmacology specifically related to vestibular symptoms and dysfunction, and identification of vestibular risk factors. Key vestibular descriptors may include terminology such as dizziness, vertigo, imbalance, falls, and nausea/vomiting. More

advanced terminology used by specialty providers may include terms such as oscillopsia or nystagmus. These can be contrasted with cardiopulmonary-specific descriptors such as syncope or presyncope, orthostasis, diuresis, and dyspnea or breathlessness. Identifying consistent use of terminology in the chart can help clinicians build a clinical picture before beginning their evaluation. Medication review should target medications that can cause symptoms of dizziness or produce unintended vestibular dysfunction through ototoxicity. Some examples for increased consideration include loop diuretics, aminoglycosides, insulin, and other cardiac medications. Specifically, aminoglycosides and other antibiotics that target the 30S ribosomal subunits have multiple toxic properties, one of which is ototoxicity.<sup>4</sup> This manifests clinically as irreversible auditory and vestibular damage resulting from an accumulation of high concentrations of aminoglycosides in the perilymph and endolymph of the inner ear.<sup>4,5</sup> In addition, the prototypical loop diuretics such as furosemide, bumetanide, and torsemide are generally well tolerated as a class for their effects on renal electrolyte management; loop diuretics are also associated with dose-dependent ototoxicity. This ototoxicity is also secondary to the impact of the drug on the endolymph.<sup>4,5</sup> Other drugs such as insulin, beta-blockers, antiarrhythmics, and other cardiac medications may induce comparable symptoms of lightheadedness or dizziness through other biopharmaceutical pathways and, although are not directly ototoxic, are crucial to any differential diagnosis of the patient with dizziness. A full review of medications, their pharmacology, and potential effects on dizziness symptoms is beyond the scope of this review, but it should be noted that some medications such as Lasix/furosemide (a common diuretic) can affect both the cardiovascular and pulmonary systems<sup>5,6</sup> (removing fluid can result in orthostasis) as well as the vestibular system (high dosages can be ototoxic). Finally, clinicians should identify other vestibular risk

## Vestibular vs Cardiopulmonary Symptom Patterns

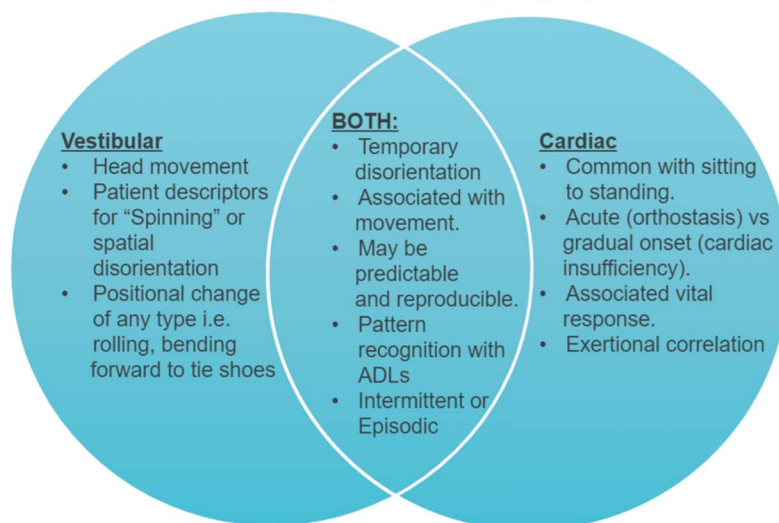


Fig. 1. Vestibular versus cardiopulmonary symptom patterns.

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**TABLE 1**

Common Cardiovascular Differential Diagnosis with Predominant Dizzy Differential

Diagnosis	Symptoms
Aortic stenosis	Gradual onset of dizziness with activity due to decreased cardiac output
Orthostatic hypotension	Acute onset light-headedness with positional change to upright due to fluid shift and decrease in blood return.
Abnormal cardiac rhythms	Dizzy/light-headed due to cardiac output
Volume overload	Can lead to orthostatic hypotension due to rapid removal of fluid likely secondary to pharmacologic intervention or fluid shift.
Dyspnea/SOB	Anxiety-related dizziness or light-headedness

factors such as advanced age, hypertension, diabetes, polypharmacy, osteoporosis, vitamin D deficiency, and prolonged immobility that may further increase a patient’s risk of vestibular dysfunction.

After a thorough chart review, the physical therapist will have formulated a few hypotheses regarding potential causes of dizziness symptoms and will use their subjective examination to further rule in or rule out those hypotheses. Subjective questioning regarding the patient’s symptomology may be the most important tool in the therapist’s toolbox. This is especially true in patients with a variety of cardiovascular or pulmonary diagnoses with varied levels of acuity, where the number of potential causative factors is high and time to perform testing may be limited. Clinicians should ask probing questions aimed at defining the patient’s dizziness symptoms. These should include questions regarding tempo/time (acute onset, chronic onset, and spells) and type of symptoms (vertigo, imbalance, oscillopsia, light-headedness, and fainting)<sup>7</sup> (Table 3). These questions are meant to discriminate between vestibular and nonvestibular causes and to differentiate potential vestibular diagnoses. In addition, the clinician should develop an understanding of the circumstances under which patients experience their symptoms (head motion induced, position changes, or spontaneous onset).<sup>7</sup> The results of subjective questioning in conjunction with previous chart review should result in a refined diagnostic hypothesis(es) which will guide the clinician in determining the tests and measures that need to be performed to further support or refute their hypothesis(es). The subjective line of questioning and patient responses will also help the clinician to prioritize which tests and measures are most essential to perform in settings with numerous time constraints or in patients with limited capacity to tolerate testing.

**TABLE 2**

Key Words for Differentiation of Cardiovascular Versus Pulmonary Symptoms

General Vestibular Keywords	Cardiopulmonary Specific Keywords
Dizziness	Syncope/presyncope
Vertigo or spinning	Orthostasis or light-headedness
Unsteadiness or falls	Fatigue
Disequilibrium or disorientation	Dyspnea with exertion or laying down
Nausea/vomiting	Dizziness with palpitations
Swimming/waves sensations	Chest pain, discomfort, or heaviness

Additional subjective questions should be directed toward the presence or absence of red flag symptoms. The cardiovascular and pulmonary systems are intimately connected to the neurologic system and can often lead to acute, subacute, or chronic neurologic events that can cause dizziness symptoms. The physical therapist should question the patient regarding symptoms usually consistent with posterior circulation or posterior fossa dysfunction including dysarthria, dysphagia, discoordination, diplopia and other neurologic symptoms such as numbness or weakness on side of the body or face.<sup>7</sup> Appropriate identification of the presence of these symptoms and their tempo, type, and circumstances will best aid the physical therapist in decision making regarding the need for referral and in the ability to treat the patient. In the absence of a known neurologic diagnosis, it is best to refer patients with newly discovered red flag symptoms to either the emergency department or their referring physician depending on the acuity of their symptoms. Chronic stable symptoms may not require emergent referral to an emergency department, but changing chronic symptoms or new/acute symptoms typically warrant emergent triage.

The final piece of the differential diagnosis puzzle is performance and interpretation of relevant oculomotor, vestibular, suggestive, and functional testing.<sup>7</sup> This examination may also include close monitoring of vital signs with positional changes or during activity to assess for orthostatic hypotension or cardiac insufficiency. It should also include items more consistent with a “typical” physical therapy examination (such as strength testing, sensory testing, coordination testing, in addition to others as determined by patient presentation). Instructional performance of these examination techniques is beyond the scope of this article, but they are important skills to practice and master to ensure appropriate evaluation of their findings. Oculomotor examination, which is a combination of ocular range of motion, saccades, and smooth pursuit testing, should be performed to provide baseline information about eye movements. This information is necessary for ruling out red flags and for appropriate observation during more provocative testing (because the

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TABLE 3

Common Differential Diagnosis Based on Temporal Presentation

Temporal Component	“Dizziness” Presentation	Differential Diagnosis
Episodic <60 s	Provoked by head movement	BPPV Vertebrobasilar infarct Uncompensated stable labyrinthitis
Episodic <60 s	Spontaneous onset	Transient ischemic attack Anxiety Orthostasis Arrhythmias
Episodic—min/h <24 h	Provoked by head movement	Uncompensated stable labyrinthitis Migraine Sinus congestion
Episodic—min/h <24 h	Spontaneous onset	Labyrinthine disorders Pharmacologically induced Dehydration
Episodic—min/h >24 h	Spontaneous onset	Migraine Anxiety Cardiovascular differential Pharmacologically induced
Days	Spontaneous and provoked by head movement	Vestibular neuritis Vascular event
Days	Spontaneous and provoked by head movement and hearing loss	Labyrinthitis Posterior inferior cerebellar artery or anterior inferior cerebellar artery stroke
Continuous	Possibly exacerbated by head movement	Central vestibular disorder Anxiety

eyes are the window to the vestibular system). For example, if a patient has a baseline cranial nerve palsy affecting range of motion in 1 eye, the therapist may choose not to view that eye during positional tests for benign paroxysmal positional vertigo (BPPV). The restricted range of motion may affect the evaluation of the expected or resulting nystagmus pattern during testing. Red flag signs during oculomotor testing for patients without previously diagnosed neurologic conditions include hypometric or hypermetric saccades (under or overshoot), slow or increased latency saccades, and restricted eye range of motion.<sup>7</sup> Any subjective patient report or objective correlation with diplopia, dysphagia, dysarthria, or dysmetria should also be considered as red flags, and referral for further medical workup is appropriate.

Vestibular special tests include assessment of gaze-evoked and spontaneous nystagmus, head impulse/head thrust testing, vestibulo-ocular reflex (VOR) cancellation, and positional testing for BPPV.<sup>7,8</sup> Often assessment of gaze-evoked and spontaneous nystagmus can be performed in conjunction with ocular range of motion testing. For more novice “vestibular” physical therapists, these tests can be performed separately to allow the therapist a more focused time to evaluate the results of each test. Red flag symptoms for vestibular special tests include gaze-holding nystagmus where the fast phases change direction

with gaze (ie, right-beating nystagmus in right gaze holding and left-beating nystagmus in left gaze holding), purely torsional spontaneous or gaze-evoked nystagmus or during positional testing, purely vertical spontaneous nystagmus, and positive VOR cancellation testing (saccadic intrusions or jumpy eye movements).<sup>7,9</sup> Bilateral positive head impulse testing can be seen in both peripheral vestibular disorders and central disorders, and its importance as a potential red flag is dependent on the clinical presentation of the patient and their medical history. An example of a red flag bilateral positive head impulse test is in a patient with acute vestibular syndrome (AVS),<sup>9</sup> presenting with spontaneous nystagmus.

Acute vestibular syndrome is the result of an acute unilateral peripheral or central vestibular lesion that causes a sudden asymmetry<sup>10</sup> and presents commonly with a cohort of symptoms including vertigo, nausea/vomiting, and gait unsteadiness.<sup>10</sup> However, differentiating AVS from a posterior circulation stroke can be challenging because of the overlap in clinical presentation and discrepancy in early diagnostic testing. Early computed tomography testing cannot rule out acute ischemia; although the National Institutes of Health Stroke Scale (NIHSS) does not include AVS,<sup>10</sup> the HINTS (HI: Head Impulse, N: Nystagmus, TS: Test of Skew) protocol is a cluster of clinical tests used to better differentiate the

presence of posterior circulation stroke in AVS. HINTS has been shown to be more sensitive than magnetic resonance imaging<sup>11</sup> and outperforms common stroke screening components for stroke in acute continuous vertigo and dizziness.<sup>12</sup> A positive HINTS test suggests posterior stroke in AVS when any of the following 3 signs are present: normal head impulse, gaze direction nystagmus, or eye skew deviation.<sup>11</sup> In addition, the acronym INFARCT summarizes the application of HINTS, in which IN: Impulse normal, FA: Fast Alternates (referring to nystagmus fast phase), and RCT: Refixation on Cover Test (skew deviation)<sup>9,12</sup> in which refixation on alternate cover test (skew deviation) correlates with a positive HINTS examination and need for further imaging.

Presence of a positive head impulse test bilaterally is a central finding per the HINTS criteria and further medical workup/imaging should be recommended. By contrast, in a patient who does not present with AVS and who has a known history of intravenous aminoglycoside use, a positive head impulse test bilaterally would likely be indicative of bilateral vestibular hypofunction in the setting of ototoxicity.

There are few red flag signs during positional testing for BPPV because nonurgent neurologic conditions such as vestibular migraine or BPPV variants (such as anterior canal or short arm posterior canal) can cause more purely vertical nystagmus patterns. Because of the positioning of the neck during typical BPPV positional tests, it is important to monitor for transient neurologic changes in speech, sensation, strength, or vision during testing that would be consistent with vertebrobasilar insufficiency.

Vestibular testing described for the purposes of this article is performed in room light, that is, without removing visual fixation through the use of Fresnel lenses or video infrared goggles. The reason for this is that many novice vestibular clinicians or clinicians who do not primarily work with a vestibular population usually do not have access to the necessary equipment. Room light vestibular examination is valid and supported in the literature, including the bedside head impulse test. Schubert et al<sup>13</sup> showed a 71% and 84% sensitivity for the head thrust test for unilateral vestibular hypofunction and bilateral vestibular hypofunction, respectively, and a specificity of 82%. In the case of AVS presenting with spontaneous nystagmus where appropriate application of HINTS protocol is paramount, the ability to remove fixation is strongly encouraged. There are other cases where the removal of visual fixation is either necessary or beneficial to vestibular differential diagnosis, and a more complete review can be found in “Nystagmus goggles: how to use them, what you find, and what it means” by Halmagyi et al.<sup>14</sup>

Suggestive testing includes use of the modified clinical test of sensory interaction on balance (mCTSIB) for determining the vestibular system's contribution to balance deficits and a version of dynamic visual acuity for identifying functional gaze stability impairments. Functional testing should include standardized measures such as the Functional Gait Assessment or the Dynamic Gait Index; however, it may be necessary to select an alternative functional measure for deconditioned patients

due to comorbidities or environmental restrictions. The Vestibular EDGE<sup>15,16</sup> task force has provided recommendations for outcome measures based on acuity, and these recommendations can be used to assist in selecting an appropriate standardized measure.

At the conclusion of the evaluation/examination, the physical therapist should look at the entirety of the data gathered to determine physical therapy diagnosis and treatment plan. In addition to the findings and conclusions from the evaluation, there are several other factors to consider before initiating treatment. These include comorbid cardiopulmonary diagnoses/conditions and their impact on performance or tolerance to treatment, medication effects or side effects and their impact, current evidence for physical therapist treatment of the identified condition, and potential need for referral to other complementary specialties such as otolaryngology, neurology, cardiology, or pulmonology.

In closing, dizziness is a pervasive and sometimes debilitating symptom experienced by many patients. Vestibular dysfunction is a potential cause of reported dizziness and can be successfully managed across the care continuum by physical therapists with vestibular differential diagnosis training. Physical therapy management of vestibular dysfunction in the cardiopulmonary population has the potential to decrease length and impact of symptoms, improve functional and subjective outcomes, and decrease health system costs. Physical therapists should strongly consider investing in continuing education related to these topics to further improve their quality of care.

## REFERENCES

1. Agrawal Y, Carey JP, Della Santina CC, Schubert MC, Minor LB. Disorders of balance and vestibular function in US adults: Data from the national health and nutrition examination survey, 2001–2004. *Arch Intern Med.* 2009;169(10):938-944.
2. McArdle K, Hyon A, Thielman G. Development of a BPPV algorithm for earlier physical therapy consultation in the acute care setting. *J Acute Care Phys Ther.* 2016;7(3):113-125.
3. Lammers K, Kumble S, Sperle C, McCarty J, Steinhorn G. Influence of vestibular diagnosis and management on recommended discharge environment for hospitalized inpatients. *J Acute Care Phys Ther.* 2020; 11(3):151-161.
4. Golan DE. *Principles of Pharmacology: The Pathophysiologic Basis of Drug Therapy.* Baltimore: Lippincott Williams & Wilkins; 2005:856.
5. Rybak LP. Furosemide ototoxicity: Clinical and experimental aspects. *Laryngoscope.* 1985;95(9 pt 2)(suppl 38):1-14.
6. Juhn SK, Rybak LP, Morizono T, Green LP. Pharmacokinetics of furosemide in relation to the alteration of endocochlear potential. *Scand Audiol Suppl.* 1981;14:39-49.
7. Herdman S, Clendaniel R. *Vestibular Rehabilitation (Contemporary Perspectives in Rehabilitation).* 4th ed. Philadelphia, PA: F.A. Davis Company; 2014.
8. Bhattacharyya N, Gubbels SP, Schwartz SR, et al. Clinical practice guideline: Benign paroxysmal positional vertigo (update). *Otolaryngol Head Neck Surg.* 2017;156(suppl 3):S1-S47.
9. Kattah JC. Use of HINTS in the acute vestibular syndrome: an overview. *Stroke Vasc Neurol.* 2018;3(4):190-196.
10. Krishnan K, Bassilious K, Eriksen E, et al. Posterior circulation stroke diagnosis using HINTS in patients presenting with acute vestibular syndrome: A systematic review. *Eur Stroke J.* 2019;4(3): 233-239.

11. Newman-Toker DE, Kattah JC, Talkad AV, Wang DZ, Hsieh Y-H, Newman-Toker DE. HINTS to diagnose stroke in the acute vestibular syndrome—Three-step bedside oculomotor exam more sensitive than early MRI DWI. *Stroke*. 2009;40(11):3504-3510.
12. Newman-Toker DE, Kerber KA, Hsieh Y-H, et al. HINTS outperforms ABCD2 to screen for stroke in acute continuous vertigo and dizziness. *Acad Emerg Med*. 2013;20:987-996.
13. Schubert MC, Tusa RJ, Grine LE, Herdman SJ. Optimizing the sensitivity of the head thrust test for identifying vestibular hypofunction. *Phys Ther*. 2004;84(2):151-158.
14. Halmagyi GM, McGarvie LA, Strupp M. Nystagmus goggles: How to use them, what you find and what it means. *Pract Neurol*. 2020;20:446-450.
15. Scherer M. *Vestibular EDGE. Vestibular Disorders*; 2014. <https://www.neuropt.org/practice-resources/neurology-section-outcome-measures-recommendations/vestibular-disorders>. Accessed July 21, 2022.
16. Hall CD, Herdman SJ, Whitney SL, et al. Vestibular rehabilitation for peripheral vestibular hypofunction: An updated clinical practice guideline from the academy of neurologic physical therapy of the American Physical Therapy Association. *J Neurol Phys Ther*. 2022;46(2):118-177.