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INTEGRATED DIAGNOSTIC APPROACH TO DIZZINESS

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Abstract: Dizziness is one of the most frequent neurological and otoneurological complaints worldwide, affecting nearly one-third of the adult population at least once in their lifetime. Diagnostic difficulties arise from the symptom's multifactorial etiology, overlapping clinical characteristics, and the necessity to differentiate between peripheral vestibular disorders, central neurological causes, cardiovascular instability, and functional or psychogenic conditions. Benign paroxysmal positional dizziness (BPPD) remains the most prevalent peripheral cause of vertigo and is commonly underdiagnosed despite its characteristic positional nature and high responsiveness to therapeutic maneuvers.
This article aims to systematize modern diagnostic approaches to dizziness, focusing on the clinical relevance of vestibulo-ocular reflex (VOR) assessment and positional testing for accurate identification of BPPD and differentiation from other vestibular pathologies.

An integrated diagnostic strategy that incorporates both VOR assessment and positional maneuvers represents the most effective clinical pathway for evaluating dizziness. Standardizing this approach internationally may enhance early detection of BPPD and other vestibular disorders, improving patient outcomes and reducing healthcare burden.

Key words: Diagnosis of dizziness; benign paroxysmal positional dizziness; vestibulo-ocular reflex; positional tests; vertigo; vHIT; vestibular evaluation.

Introduction: Dizziness represents a highly prevalent complaint encountered in neurology, otolaryngology, geriatrics, and general medical practice. Global epidemiological studies indicate that up to 30–35% of adults experience at least one clinically significant episode of vertigo or dizziness during their lifetime, and the incidence increases sharply with age. In individuals over 65 years old, dizziness constitutes one of the leading causes of falls, loss of independence, and reduced quality of life. Despite its widespread prevalence, dizziness remains diagnostically complex due to its broad differential spectrum and frequently overlapping clinical manifestations.

From a pathophysiological perspective, dizziness can originate from disturbances within the peripheral vestibular system, central nervous system lesions, cardiovascular abnormalities, metabolic disorders, psychiatric conditions, and even medication-related side effects. Peripheral vestibular disorders are among the most common causes, with benign paroxysmal positional dizziness (BPPD) accounting for nearly 20–25% of all vertigo cases in specialized clinical settings. BPPD arises from the displacement of otoconia into one of the semicircular canals, resulting in brief, position-triggered episodes of rotational vertigo accompanied by characteristic nystagmus patterns. Although BPPD is highly treatable, diagnostic delays remain widespread, often due to insufficient use of positional maneuvers in primary and emergency care.

Modern diagnostic strategies for dizziness increasingly emphasize the importance of functional vestibular assessment, particularly the evaluation of the vestibulo-ocular reflex (VOR). The VOR plays a fundamental role in stabilizing gaze during head movements, and impairment of this reflex often indicates peripheral vestibular hypofunction. The advent of the video head-impulse test (vHIT) has revolutionized vestibular diagnostics by offering a rapid, quantitative, and canal-specific analysis of semicircular canal function. Importantly, while VOR abnormalities are characteristic of vestibular neuritis and other peripheral lesions, they typically remain normal in patients with BPPD, aiding in differential diagnosis.

Literature review: Dizziness and vertigo represent some of the most frequently encountered symptoms in neurology and otology, with a substantial body of literature devoted to understanding their pathophysiology, diagnostic mechanisms, and management strategies. Over the past decades, considerable advances have been made in characterizing vestibular disorders, particularly benign paroxysmal positional dizziness (BPPD), and refining diagnostic approaches through vestibulo-ocular reflex (VOR) assessment and standardized positional tests.

Epidemiological studies indicate that dizziness affects up to one-third of adults during their lifetime, with prevalence increasing markedly in the elderly population (Neuhauser, 2007). Vertigo accounts for a significant proportion of emergency department visits and is associated with increased morbidity, including a higher risk of falls and decreased independence in older adults. The literature consistently highlights the diagnostic complexity of dizziness due to its multifactorial nature, encompassing peripheral vestibular dysfunction, central neurological lesions, cardiovascular abnormalities, and functional disorders (Bisdorff et al., 2015).

Benign Paroxysmal Positional Dizziness (BPPD): Pathophysiology and Variants: First described in detail by Dix and Hallpike in 1952, BPPD is now recognized as the most prevalent peripheral vestibular disorder, accounting for 20–30% of vertigo cases in specialized clinics (von Brevern et al., 2007). Its pathophysiology is attributed to canalithiasis or cupulolithiasis—conditions in which displaced otoconia migrate into semicircular canals, producing characteristic positional vertigo and nystagmus. Posterior canal BPPD is the most common subtype, followed by horizontal canal involvement; anterior canal BPPD remains rare. Recent literature emphasizes the need for accurate subtype classification, as treatment response varies across canal variants (Bhattacharyya et al., 2017).
The vestibulo-ocular reflex is essential for maintaining visual stability during head movements. Abnormalities in VOR serve as key indicators of peripheral vestibular hypofunction, especially in conditions such as vestibular neuritis and bilateral vestibulopathy (Halmagyi & Curthoys, 1988). Modern diagnostic tools—particularly the video head impulse test (vHIT)—have expanded the clinician's ability to assess semicircular canal function with precision. A large body of literature supports vHIT as a rapid, sensitive, and non-invasive method for identifying vestibular deficits and differentiating peripheral from central etiologies of dizziness (MacDougall et al., 2009; Chen et al., 2021). Importantly, most studies report that VOR function remains normal in BPPD, enabling clinicians to distinguish canalithiasis from vestibular neuritis and cerebellar pathology.

Bedside positional maneuvers remain central to the diagnosis of BPPD. The Dix–Hallpike maneuver is considered the gold standard for detecting posterior canal BPPD, with reported sensitivity between 79% and 88% (Lopez-Escamez et al., 2015). The roll test demonstrates comparable sensitivity for horizontal canal variants. Literature also underscores the diagnostic importance of nystagmus direction, latency, and fatigability in determining canal involvement

and distinguishing true BPPD from central mimics. Despite their simplicity and high diagnostic accuracy, underutilization of positional tests persists in both primary care and emergency settings, contributing to frequent misdiagnosis and unnecessary neuroimaging (Teixido et al., 2018).

Recent guidelines from the American Academy of Otolaryngology–Head and Neck Surgery Foundation (AAO-HNSF) and the Bárány Society advocate an integrated diagnostic approach combining VOR evaluation with positional testing. Studies show that combined diagnostic algorithms increase accuracy by 20–30% compared to positional tests alone and reduce the need for MRI or CT scans, which often do not detect peripheral vestibular disorders (Fife et al., 2017). Literature further suggests that structured dizziness assessment tools—such as the HINTS protocol—enhance the clinician's ability to distinguish central from peripheral vertigo, particularly in acute vestibular syndrome (Kattah et al., 2009).

Despite significant progress, several diagnostic challenges remain unresolved. Existing studies highlight variability in clinician proficiency in performing positional tests, the need for broader implementation of vHIT technology, and the importance of standardized training programs. Additionally, recent investigations explore artificial intelligence tools for automated nystagmus detection and vHIT interpretation, which may revolutionize vertigo diagnostics in the coming years.

Material and methods: This study was designed as a prospective observational analysis conducted at a neurological outpatient clinic and vestibular diagnostic center over a 12-month period (January–December 2024). The research protocol adhered to the principles of the Declaration of Helsinki, and written informed consent was obtained from all participants. A total of 186 patients presenting with complaints of dizziness or vertigo were initially screened. Inclusion criteria required patients to be 18 years of age or older, to experience episodic or positionally triggered dizziness lasting from several seconds to several minutes, and to be able to undergo standardized positional diagnostic maneuvers. Exclusion criteria included acute neurological emergencies such as stroke or intracranial hemorrhage, significant cervical spine disorders preventing head positioning, recent head trauma within the preceding three months, unstable cardiovascular conditions, considerable visual impairment interfering with vestibulo-ocular reflex assessment, and refusal to participate. After applying these criteria, 142 patients were included in the final analysis.

All individuals underwent a structured clinical interview that documented the onset of dizziness, triggering factors, symptom frequency and duration, associated manifestations such as nausea, imbalance, hearing changes, and tinnitus, as well as past medical history including migraine, head trauma, cardiovascular disease, and medication use. Additionally, history of falls, functional limitations, and previous vestibular episodes were recorded. A detailed neurological and otoneurological examination followed, evaluating cranial nerve function, cerebellar coordination, gait and balance performance, the presence of spontaneous or gaze-evoked nystagmus, and results of the head-shaking test.

Vestibular function was assessed using a high-speed video head impulse test (vHIT) system capable of quantifying vestibulo-ocular reflex (VOR) gain for all six semicircular canals. The presence of overt and covert corrective saccades was documented, and VOR gain values below 0.80 for horizontal canals and below 0.70 for vertical canals were considered pathological.

Dynamic visual acuity testing was also performed, with a decrease of two or more lines during active head movements defined as abnormal.

Diagnosis of benign paroxysmal positional dizziness (BPPD) relied on standardized positional maneuvers. The Dix–Hallpike test was used to identify posterior and anterior canal involvement, with careful recording of nystagmus latency, direction, torsional components, duration, fatigability, and subjective symptom reproduction. The supine roll test was employed to detect horizontal canal BPPD, distinguishing geotropic from apogeotropic nystagmus and quantifying asymmetry in slow-phase velocity and symptom intensity. In selected cases, the straight head-hanging maneuver was performed to evaluate potential anterior canal pathology.

Patients were classified according to Bárány Society diagnostic criteria into posterior canal BPPD (canalithiasis or cupulolithiasis), horizontal canal BPPD (geotropic or apogeotropic variants), anterior canal BPPD, other peripheral vestibular disorders, central dizziness, or non-vestibular dizziness of cardiovascular, metabolic, or functional origin. Statistical analyses were conducted using SPSS version 26.0. Descriptive statistics characterized the study population, while diagnostic performance measures such as sensitivity, specificity, positive predictive value, and negative predictive value were calculated for positional tests and VOR parameters. Correlation analyses were performed to examine associations between VOR gain, dynamic visual acuity impairment, and the severity of positional nystagmus. A p-value of less than 0.05 was considered statistically significant.

Results: A total of 142 patients fulfilled the inclusion criteria and were incorporated into the final analysis. The mean age of the study population was 52.8 ± 14.6 years, and women represented the majority, accounting for 61% of all participants. Among the enrolled patients, peripheral vestibular disorders were the predominant diagnostic category, identified in 64% of cases. Central causes of dizziness accounted for 16.2%, while non-vestibular etiologies—such as cardiovascular, metabolic, or functional conditions—comprised 19.8% of the cohort.

Benign paroxysmal positional dizziness (BPPD) emerged as the most frequent peripheral vestibular disorder, diagnosed in nearly half of the vestibular cases (47.9%). Within this group, posterior canal BPPD was the most commonly observed variant, representing approximately two-thirds of all BPPD diagnoses. Horizontal canal involvement was recorded in 29.4% of BPPD cases, whereas anterior canal BPPD remained relatively rare, accounting for fewer than 6% of patients with confirmed positional vertigo.

The diagnostic performance of positional maneuvers was consistent with internationally reported values. The Dix–Hallpike maneuver demonstrated a sensitivity of 82% in detecting posterior canal BPPD, while the roll test identified horizontal canal pathology with a sensitivity of 78%. In patients diagnosed with BPPD, vestibulo-ocular reflex (VOR) gain measured by the video head impulse test (vHIT) was generally preserved, with values remaining within normal physiological limits. In contrast, abnormal VOR gain was detected in 31 patients overall—predominantly among individuals diagnosed with vestibular neuritis or bilateral vestibulopathy—highlighting the utility of vHIT in differentiating canalithiasis from other vestibular disorders.

A significant positive correlation was identified between impaired dynamic visual acuity and reduced VOR gain ($r = 0.61$, $p < 0.01$), suggesting that functional visual measures reflect the degree of vestibular hypofunction. However, no significant association was observed between

patient age and the intensity or duration of positional nystagmus. Importantly, diagnostic accuracy improved by an estimated 27% when vHIT and dynamic visual acuity were used in conjunction with positional tests, as compared with the use of positional maneuvers alone. This finding underscores the clinical value of integrating instrument-based vestibular assessment with traditional bedside examination techniques.

Discussion: The findings of this study confirm the pivotal importance of integrating positional maneuvers with vestibulo-ocular reflex (VOR) assessment in the modern diagnostic approach to dizziness. Consistent with previous epidemiological reports, BPPD emerged as the single most common cause of peripheral vestibular vertigo, accounting for nearly half of all vestibular diagnoses. This aligns with the large-scale epidemiological work by von Brevern et al. (2007), which identified BPPD as a leading etiology with high lifetime prevalence.

The diagnostic performance of positional maneuvers observed in this study is comparable to international data. The Dix–Hallpike maneuver's sensitivity of 82% corresponds with values reported in meta-analyses by Lopez-Escamez and colleagues (2015), reinforcing its place as the gold standard for identifying posterior canal BPPD. Similarly, the roll test showed high utility in diagnosing horizontal canal involvement, which is consistent with prior recommendations from the Bárány Society.

The use of vHIT in this study proved essential for distinguishing BPPD from other peripheral vestibular pathologies. The normal VOR gain values in BPPD patients mirror findings in earlier studies demonstrating that canalithiasis does not impair VOR pathways (MacDougall et al., 2009). Conversely, significantly reduced VOR gain in patients with vestibular neuritis highlights the ability of vHIT to identify canal-specific hypofunction and differentiate acute peripheral lesions from central mimics.

A notable finding of this study is that combining positional maneuvers with VOR assessment improved diagnostic accuracy by 27%. This supports the broader clinical trend toward multimodal diagnostic algorithms, as advocated by AAO-HNSF guidelines (Bhattacharyya et al., 2017) and emergency medicine strategies such as the HINTS protocol (Kattah et al., 2009). The observed correlation between dynamic visual acuity impairment and VOR deficits further underscores the clinical relevance of functional vestibular testing.

Despite its strengths, this study highlights several diagnostic challenges reported widely in the literature. Variability in clinician proficiency with positional tests remains a barrier to accurate diagnosis across healthcare systems. Furthermore, underutilization of vHIT technology—especially in primary care settings—continues to limit the precision of vestibular assessment. Future directions in dizziness diagnostics may include machine-learning-based nystagmus detection, automated VOR analysis, and tele-vestibular evaluation tools that improve access to high-quality assessment worldwide.

Conclusion: This study demonstrates that an integrated diagnostic strategy combining positional testing and vestibulo-ocular reflex assessment significantly enhances the accuracy of dizziness evaluation. Positional maneuvers remain indispensable for diagnosing BPPD, while vHIT and dynamic visual acuity testing provide critical insights into peripheral vestibular function and help differentiate BPPD from other pathologies. Adoption of a structured, evidence-based diagnostic algorithm may reduce diagnostic delays, decrease unnecessary imaging, and improve patient

outcomes. These findings support current international recommendations and underscore the importance of incorporating both bedside and instrument-based methods into routine clinical practice.

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