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Acute Vestibular Syndrome

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ABSTRACT

PURPOSE OF REVIEW: This article provides a practical approach to acute vestibular syndrome while highlighting recent research advances.

RECENT FINDINGS: Acute vestibular syndrome is defined as sudden-onset, continuous vertigo lasting longer than 24 hours with associated nausea and vomiting, all of which are worsened with head movement. Acute vestibular syndrome is provoked by a variety of central and peripheral causes, the most common of which are vestibular neuritis and acute stroke (posterior circulation). A clinical approach focusing on timing, associated history, and ocular motor findings can improve diagnostic accuracy and is more sensitive and specific than early neuroimaging. Because of the shared neurovascular supply, both peripheral and central vestibular disorders can manifest overlapping signs previously considered solely peripheral or central, including vertical skew, nystagmus, abnormal vestibular ocular reflex, hearing loss, and gait instability. Although acute vestibular syndrome is typically benign, stroke should be considered in every person with acute vestibular syndrome because it can act as a harbinger of stroke or impending cerebellar herniation. Treatment is focused on physical therapy because the evidence is minimal for the long-term use of medication.

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Dr Steenerson discusses the
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treatment of peripheral
vestibular disorders.

SUMMARY: The diagnosis of acute vestibular syndrome first requires the elimination of common medical causes for dizziness. Next, underlying pathology must be determined by distinguishing between the most common causes of acute vestibular syndrome: central and peripheral vestibular disorders. Central vestibular disorders are most often the result of ischemic stroke affecting the cerebellar arteries. Peripheral vestibular disorders are assumed to be caused mostly by inflammatory sources, but ischemia of the peripheral vestibular apparatus may be underappreciated. By using the HINTS Plus (Head Impulse test, Nystagmus, Test of Skew with *Plus* referring to hearing loss assessment) examination in addition to a comprehensive neurologic examination, strokes are unlikely to be missed. For nearly all acute vestibular disorders, vestibular physical therapy contributes to recovery.

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INTRODUCTION

Originally coined by Hotson and Baloh¹ in 1998, *acute vestibular syndrome* describes the sudden onset of continuous vertigo lasting longer than 24 hours and associated with nausea, head motion intolerance, and unstable balance.¹ Although vertigo and nausea are the driving symptoms of acute vestibular syndrome, patients often describe additional spatial disorientation and gait instability that may be confused with nonvestibular sources of dizziness ranging from hyponatremia to gastroenteritis. When acute vestibular syndrome is strictly defined as sudden-onset, continuous vertigo and common medical causes for dizziness such as arrhythmia, hypotension, and toxic or metabolic derangements have been ruled out, key examination findings can help determine the cause. The most common causes are inflammatory events of the peripheral labyrinth followed in frequency by ischemic events of the posterior cerebral circulation.²

Previous work has focused heavily on bedside ocular motor testing protocols because of their high specificity and sensitivity for differentiating central from peripheral causes. Properly performed, clinical examination using HINTS (Head Impulse test, Nystagmus, Test of Skew) is more sensitive in detecting small strokes causing isolated acute vertigo than is early MRI diffusion-weighted imaging.³

Acute care clinicians should maintain a high level of suspicion for posterior circulation stroke because its presentation may perfectly overlap the much more common clinical picture of vestibular neuritis. Posterior circulation strokes that are small and cause isolated acute vertigo tend to allow for a good recovery, but they are important to recognize because they represent a forewarning of vertebrobasilar disease and a larger stroke to follow that might be preventable. Posterior circulation strokes that are larger and involve the cerebellum are essential to recognize because they can lead to life-threatening edema. Life-threatening posterior circulation strokes more commonly involve multiple neurologic deficits on presentation including ataxia, dysarthria, hemianopsia, diplopia, Horner syndrome, or hemisensory deficits.

Some factors serve as obstacles to full recognition of posterior circulation stroke as the cause of acute vertigo. Posterior circulation stroke may be missed because of emergency department algorithms' bias toward anterior circulation stroke.⁴ The National Institutes of Health Stroke Scale neglects many debilitating aspects of posterior circulation stroke, including vertigo, and can fail to detect posterior circulation stroke entirely.⁵ Many stroke centers, therefore, have other protocols to account for acute vertigo and possible stroke. Furthermore, posterior circulation stroke comprises only 15% to 20% of all strokes, and only 20% to 25% of posterior circulation stroke causes acute dizziness, limiting clinician experience and compounding uncertainty. Perhaps in part because of these factors, neuroimaging is overused in acute care settings despite evidence showing its limitations in the first 24 to 48 hours of symptoms.^{6,7}

By understanding the methodology behind the existing protocols, simplifying their interpretation, and updating their accuracy of use with the most recent research, providers can improve their diagnostic accuracy in patients presenting with acute vertigo.

More than 3 million emergency department visits per year are for dizziness,⁸ and about 1 in 5 of those are because of acute vestibular syndrome.⁹ Like other

KEY POINTS

- Acute vestibular syndrome describes the sudden onset of continuous vertigo lasting longer than 24 hours and associated with nausea, head motion intolerance, and unstable balance.
- Nausea, vomiting, and unsteadiness are symptoms of acute vestibular syndrome that are common to several causes, so additional measures are needed to narrow the diagnostic possibilities.
- The posterior circulation (vertebral arteries, posterior inferior cerebellar artery, anterior inferior cerebellar artery, and less often superior cerebellar artery) supplies the brainstem and cerebellar regions causing stroke that might present with acute vestibular syndrome.
- Cerebellar strokes that can present with vertigo, nystagmus, and imbalance if left unrecognized and untreated could lead to brain edema that can rarely lead to herniation and death.
- CT may miss posterior fossa strokes because of considerable bony artifact from the skull, and MRI may be diffusion negative up to the first 48 hours of symptoms.
- Strictly defined acute vestibular syndrome is most commonly due to acute unilateral vestibulopathy (vestibular neuritis or ischemic labyrinthopathy). If all types of acute dizziness are included, about one-third are due to vestibular causes.

acute syndromes seen in the emergency setting, the number of cases of acute vestibular syndrome continues to increase over time; however, it is considerably outpaced by rates of defensive neuroimaging,⁸ perhaps reflecting the misconception that CT or MRI can definitively rule out posterior circulation stroke. In a population-based study by Kerber and colleagues,¹⁰ of patients presenting with any dizziness, 3.2% (53 of 1666) of cases were attributed to stroke; of patients presenting with isolated dizziness, only 0.7% (9 of 1297) of cases could be attributed to acute stroke.

Although it is important in the acute setting to frame the initial workup of acute dizziness in the dichotomy of determining “stroke” or “not stroke,” the other causes of acute dizziness must be considered. A comprehensive study looking at all causes of acute dizziness in patients presenting to the emergency department found otovestibular causes account for approximately one-third, and neurologic causes (including stroke) account for 11%. Other causes are delineated in **TABLE 5-1**.¹¹ Of otovestibular causes, the most likely are acute unilateral vestibulopathy, migraine, benign paroxysmal positional vertigo (BPPV), and Ménière disease.¹¹

When acute vestibular syndrome is held to the strict syndrome criteria of longer than 24 hours of the illusion of movement, imbalance, nystagmus, nausea, and vomiting, 10% of all causes of acute dizziness can be attributed to acute vestibular syndrome according to one single-center study.¹² The vast majority of strictly defined cases are due to acute unilateral vestibulopathy (vestibular neuritis or ischemic labyrinthopathy) and a smaller fraction are due to posterior circulation stroke.^{13,14} The remaining few can be attributed to a first-ever vestibular migraine attack and possibly Ménière disease, although strict criteria for Ménière disease limit attacks to 12 hours.¹² Other otovestibular causes are easily distinguishable from true acute vestibular syndrome and are discussed in further detail.

TABLE 5-1

Rate of Various Etiologies for Dizziness in the Acute Care Setting^{a,b}

Dizziness source	Rate, %
Otovestibular	32.9
Cardiovascular	11.5
Neurologic (stroke)	11.2 (4)
Metabolic	11
Poisoning	10.6
Psychiatric	7.2
Gastrointestinal	7

^a Data from Newman-Toker DE, et al, Mayo Clin Proc.¹¹

^b Notably, acute dizziness was not further delineated into a true acute vestibular syndrome, which is narrowly defined as spontaneous, continuous vertigo lasting longer than 24 hours. Other large-scale, population-based studies have found acute vestibular syndrome as the cause of 19% of dizziness cases in the acute care setting.⁹

APPROACH TO THE PATIENT WITH ACUTE DIZZINESS

As already discussed, various medical causes can result in a patient with acute dizziness. Understanding the key differentiators of medical causes of acute dizziness can help quickly rule out their role in acute vestibular syndrome. By emphasizing the core characteristics of acute vestibular syndrome in history-taking, including quality, timing, triggers, and associated symptoms, the interviewer can more reliably identify true acute vestibular syndrome. Finally, key examination techniques narrow the causes of true acute vestibular syndrome to central and peripheral etiologies.

Cardiac and Metabolic Causes of Acute Dizziness

Orthostatic hypotension, defined as a greater than 20-mm Hg drop in systolic blood pressure in a normotensive patient on standing, can cause global cerebral hypoperfusion, generating dizziness that can be exacerbated by orthostatic positional changes. Rarely, hypotension in the setting of asymmetric posterior circulation vascular supply may cause relative hypoperfusion of select areas of the vestibulocerebellum and/or peripheral vestibular end organs, resulting in vestibular asymmetry and, thus, brief vertigo¹⁵; however, spinning vertigo is certainly not the most common description of dizziness from orthostatic hypotension. Overall, it is rare and unlikely for hypotension to present with sustained vertigo as seen in acute vestibular syndrome.¹⁶

Arrhythmia often has a sudden, unpredictable onset with rapid recovery. Neurally mediated syncope generally occurs while standing and has a prodrome. Structural heart defects, heart failure, or aortic stenosis can all cause dizziness. Lack of chest pain, palpitations, shortness of breath with a normal physical examination devoid of murmur or fluid overload in the setting of normal orthostatic blood pressure measurements and normal electrocardiogram (ECG) are reassuring that a cardiovascular cause is not the source of acute dizziness.

Toxic and metabolic abnormalities can be quickly considered by reviewing basic serum electrolyte levels, glucose, thyroid function, and a drug screen, if needed, for acute dizziness. All of these conditions can present with acute dizziness, but none of them causes sustained vertigo for longer than 24 hours with nausea and vomiting worsened by head motion. Among metabolic causes, Wernicke encephalopathy can be the exception. It can lead to neuronal and/or neuropil destruction and endothelial swelling affecting the mammillary bodies, periaqueductal gray matter, thalamus, inferior olives, and cerebellum and may present with acute vertigo, ataxia, nausea, and vomiting although often with other neurologic findings such as gaze paresis.

Medications, Toxins, and Substances That Cause Acute Dizziness

Nearly any medication can cause a predictable or idiosyncratic side effect of dizziness. Antihypertensives that are newly prescribed or recently increased can cause various forms of light-headedness, orthostasis, and fatigue. Psychoactive medications are prone to causing dizziness, especially at initiation or dose increases. Certain medications may be associated with vertigo, imbalance, or eye movement abnormalities. Antiepileptic medications, such as phenytoin, carbamazepine, and primidone, can cause dizziness but rarely vertigo. Phenytoin, however, may cause a central-pattern nystagmus (gaze-evoked nystagmus), vertigo, and ataxia, particularly at toxic levels. Aminoglycosides, particularly gentamicin, which is vestibulotoxic, can cause acute vestibular

KEY POINTS

- Orthostatic hypotension and other cardiac causes of dizziness can classically cause near-syncope and possibly brief bouts of vertigo but rarely sustained vertigo as is classic for acute vestibular syndrome.
- Vitamin B₁ deficiency causing Wernicke encephalopathy can rarely present as acute vestibular syndrome, although often with additional neurologic findings.
- Phenytoin toxicity may present with acute vertigo, nausea, ataxia, and gaze-evoked nystagmus.
- Acute intoxication with alcohol, phencyclidine, opiates, marijuana, and barbiturates can cause nystagmus and vertigo.
- Vertigo is a disorder of motion perception and encompasses false spinning sensations (spinning vertigo) and other false sensations such as swaying, tilting, bobbing, bouncing, or sliding (nonspinning vertigo).
- Spontaneous vertigo classic to acute vestibular syndrome continues even when the patient is motionless but worsens with any kind of head movement; in contrast, the vertigo of benign paroxysmal positional vertigo ensues after only certain provocative head maneuvers that evoke vertigo lasting less than 1 minute rather than continuously for 24 hours.
- Recurrent attacks that are new and increasing may rarely be a sign of stuttering transient ischemic attack of the posterior circulation.

syndrome. Toxins such as organophosphates and carbon monoxide have been associated with acute vestibulocochlear symptoms.¹⁷ Substances including alcohol, phencyclidine, opiates, marijuana, and barbiturates can cause nystagmus and vertigo.¹⁸

After a comprehensive review of toxic-metabolic and medical causes of acute dizziness, the diagnosis of acute vestibular syndrome can be more reliably focused by targeted questions (TABLE 5-2).^{6,19}

Is There Spontaneous Movement?

According to the International Classification of Vestibular Disorders,² vertigo encompasses false spinning sensations (spinning vertigo) and other false sensations such as swaying, tilting, bobbing, bouncing, or sliding (nonspinning vertigo). By highlighting a sensation of false motion or movement, vertigo can be more accurately identified. Spontaneous vertigo is vertigo that occurs without an obvious trigger and may be exacerbated by movements (especially head movements). Spontaneous vertigo is the defining feature of strictly defined acute vestibular syndrome.

Is the Movement Continuous?

Vertigo worsens during head movement, so when a patient's vertigo worsens with position changes, it does not necessarily mean a diagnosis of BPPV is assured unless characteristic nystagmus induced by canal-plane-specific positioning is present, for example, with the Dix-Hallpike test. An important distinction for the interviewer is determining if dizziness is exquisitely triggered by position change or if it is primarily spontaneous and constant and only aggravated by movement. Classic BPPV is triggered by certain head positioning; however, a minority of patients describe constant underlying dizziness between positional attacks, which can lead to confusion.

Is This the First-Ever Attack?

Patients with a long history of recurrent dizziness attacks are less likely to have a serious cause of their dizziness. Recurrent attacks that are new and increasing may rarely be a sign of stuttering transient ischemic attack (TIA) of the posterior

TABLE 5-2

Targeted Questions in the History That Can Help Narrow the Differential Diagnosis for Acute Vestibular Syndrome Causes^a

Question	Target
Is there spontaneous movement?	Determines if a false sense of motion (vertigo) is the driving symptom
Is the movement continuous?	Noncontinuous vertigo should raise suspicion this is not acute vestibular syndrome
Is this the first-ever attack?	Recurrent attacks should point toward episodic vestibular syndrome causes instead of acute vestibular syndrome; rarely represent stuttering transient ischemic attacks

^a Data from Kerber KA and Newman-Toker DE, *Neurol Clin*⁶ and Young AS, et al, *Handbook of Clinical Neurology*.¹⁹

circulation. More commonly, stereotyped recurrent dizziness attacks are classified as *episodic vestibular syndrome* and generate a different category of differential diagnoses from acute vestibular syndrome, including vestibular migraine, Ménière disease, and BPPV. Although vestibular neuritis can recur, the lifetime recurrence rate is only 2%, so it is unlikely to explain multiple recurrent vertigo attacks.

EXAMINATION TECHNIQUES

When the above questions are satisfactorily assessed and have confirmed sudden-onset, continuous, spontaneous vertigo, certain examination techniques help narrow the short list of differential diagnoses of acute vestibular syndrome. The classic distinction of peripheral versus central causes is an excellent starting framework. Peripheral causes resulting from acute vestibular syndrome are referred to as *acute unilateral vestibulopathy* and typically result from two main pathologies that affect the vestibulocochlear nerve and vestibular end organs: vestibular neuritis (labyrinthitis if hearing is also involved) and ischemic labyrinthopathy. Central causes refer to mainly posterior circulation stroke but can, of course, involve any lesions along the central vestibular circuitry.

The original HINTS examination (Head Impulse test, Nystagmus, Test of Skew) is the earliest collection of physical examination findings developed to reliably differentiate a central cause, such as stroke, from a peripheral cause, such as vestibular neuritis (FIGURE 5-1).^{20,21} This collection refers to the following:

- ◆ **Head impulse:** A bedside head impulse test with a catch-up saccade during rapid acceleration of the head to one side is a sign of peripheral vestibular loss on the side of the turn associated with the catch-up saccade.
- ◆ **Nystagmus:** Nystagmus that is spontaneous, horizontal, and unidirectional that attenuates with visual fixation is another peripheral sign. Using fixation blocking techniques such as a bright penlight to blind the patient's ability to fixate or bedside Frenzel goggles improves detection of (peripheral-pattern) nystagmus.
- ◆ **Test of skew:** A lack of vertical misalignment, or skew, is reassuring for peripheral pathology.

Any other findings should raise concern for a central cause, and stroke workup should be performed. For central causes, HINTS is 96.8% sensitive and 98.5% specific compared with 14.3% falsely negative MRI in the first 48 hours.²² HINTS

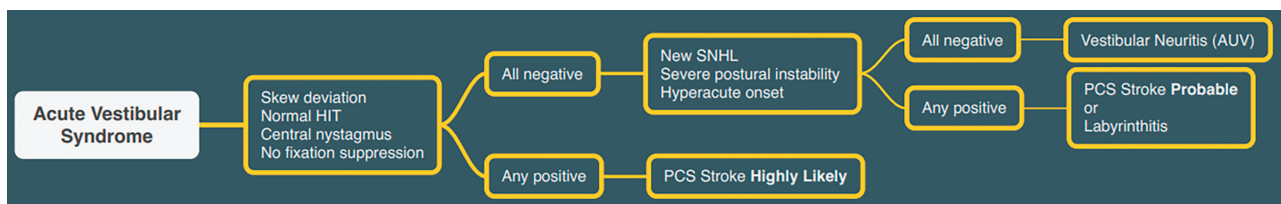


FIGURE 5-1

Adapted algorithm for the approach to acute vestibular syndrome. The algorithm focuses on the strict definition of acute vestibular syndrome as acute, continuous vertigo lasting longer than 24 hours followed by HINTS (Head Impulse test, Nystagmus, Test of Skew) examination plus additional useful differentiators including sensorineural hearing loss (SNHL) evaluation, truncal ataxia assessment, and timing.⁴⁹

AUV = acute unilateral vestibulopathy; HIT = head impulse test; PCS = posterior circulation stroke. Modified with permission from Venhovens J, et al, *J Neurol*.²⁰ © 2016 Springer-Verlag.

outperforms MRI and the ABCD² (age, blood pressure, clinical features, duration, presence of diabetes) score in the acute care setting.²² The ABCD² score is a risk-stratification tool with points ranging from 0 to 7 used to identify patients at high risk of stroke that includes an age of 60 or older (1 point), blood pressure 140/90 mm Hg or higher (1 point), unilateral weakness (2 points) or impaired speech (1 point), symptom duration of 10 to 59 minutes (1 point) or longer than or equal to 60 minutes (2 points), and presence of diabetes (1 point). The higher the score, the greater the risk of stroke.

Although HINTS has been in academic use for more than 10 years, it has limitations in its practical use. Many providers in acute care settings lack the confidence to use their own examination and interpretation of eye movements to make a critical decision about whether a patient has had a stroke and tend to fall back on neuroimaging.²³ This means the utility of HINTS is strongly influenced by the level of expertise of the person performing it.²⁴ The uncertainty arises from a few sources but most commonly results from a lack of practice. This may improve in time. Stroke teams are increasingly using HINTS regularly because patients with isolated vertigo will not be recognized by the National Institutes of Health Stroke Scale as having a possible stroke. Some interesting innovations are being explored to circumvent this. Portable video-oculography has been shown to improve the accuracy of ocular motor assessments both in person and telemedically.²⁵ Although not evidence based, using slow-motion recording on smartphones can, in this author's experience, help capture difficult-to-interpret catch-up saccades on bedside head impulse testing.

HINTS Plus is the same as HINTS but with the addition of audiometry (TABLE 5-3²⁶). New-onset hearing loss with acute vestibular syndrome was identified as an additional predictor of stroke based on a 2013 population-based study; its addition increased sensitivity for stroke detection to 99%.²² With this added value, hearing should be assessed in every patient with acute vestibular syndrome. Although formal audiometry is not feasible in most emergency department settings, bedside testing with the finger-rub test or smartphone-based applications can help identify some patients. If a hearing assessment cannot be obtained in the emergency setting, an outpatient

TABLE 5-3

Classic HINTS Plus (Head Impulse Test, Nystagmus, Test of Skew With Audiometry) Examination Findings in Central and Peripheral Causes for Acute Vestibular Syndrome^a

	Head impulse test	Nystagmus	Test of skew	Plus hearing loss
Central	No corrective saccade	Direction-changing, pure vertical, pure torsional or vertical-torsional, nonfatiguing	Abnormal vertical ocular alignment	Present (anterior inferior cerebellar artery), absent (posterior inferior cerebellar artery)
Peripheral	Corrective saccade with head turn toward side of lesion	Unidirectional, horizontal-torsional, attenuates with fixation point	Absent or rarely time-limited vertical ocular alignment	Absent (vestibular neuritis), present (labyrinthitis)

^a Data from Kattah JC, et al, Stroke³; Kung NH, et al, J Neuroophthalmol²¹; and Kattah JC, J Neurol Phys Ther.²⁶

audiogram can be arranged to aid in risk stratification and secondary prevention after all acute care decisions have been made.

Another study examining refining of acute vestibular syndrome examination techniques added ataxia and truncal instability ratings to HINTS and found ataxia grade 2 to 3 added to overall sensitivity, resulting in a perfect 100% sensitivity.²⁷ Truncal ataxia, measured by using independent observers, was scored as grade 1, mild to moderate imbalance with walking independently; grade 2, severe imbalance with standing, but cannot walk without support; grade 3, falling at an upright posture (TABLE 5-4). The ataxia rating alone had a sensitivity of 92.9% and was easier to perform reliably compared with HINTS.²⁷ Another group found that adding the ABCD² score also improved stroke detection: ABCD² score of less than 4 (low risk) had a stroke frequency of 1% (5 of 512 patients) compared with 8.1% (32 of 395 patients) in the high-risk group (ABCD² score \geq 4).²⁸ HINTS Plus combined with ataxia and vascular risk factor assessment such as the ABCD² score can reduce the risk of missing stroke diagnosis to near nil.²⁴ An algorithmic approach using these concepts is shown in FIGURE 5-1.

ACUTE STROKE

If the HINTS Plus examination demonstrates a central pattern consisting of no catch-up saccade on head impulse testing, central pattern nystagmus (direction-changing, vertical, unaffected by fixation), vertical skew deviation, and/or new, sudden asymmetric hearing loss, stroke is likely. If high-grade truncal ataxia is present, stroke is nearly certain. The two most common types of stroke stem from the posterior inferior cerebellar artery (PICA) and anterior inferior cerebellar artery (AICA) territories with ischemic stroke outnumbering hemorrhagic stroke 8:1.²⁴ The presence of acute unilateral hearing loss with acute vestibular syndrome suggests that a lateral pontine stroke in the distribution of AICA is somewhat more probable. Head or neck pain with sudden-onset vertigo should prompt evaluation for vertebral dissection (CASE 5-1).

PICA territory strokes are the most common in acute vestibular syndrome and most affect the cerebellum followed by the medulla, pons, and thalamus.²⁴ Because the PICA supplies the posterior inferior cerebellum (including the nodulus, uvula, and flocculus) and ipsilateral pontomedullary vestibular nucleus, the main symptoms and signs of a PICA territory infarction may consist only of

Truncal Ataxia Gradations Used to Distinguish Peripheral Versus Central Causes of Acute Vestibular Syndrome^a

TABLE 5-4

Ataxia grade	Definition
1	Mild to moderate imbalance with walking independently
2	Severe imbalance with standing, but cannot walk without support
3	Falling at upright posture

^a In a study evaluating acute vestibular syndrome presentations of posterior circulation stroke, all patients at grade 3 had stroke, and all at grade 1 had peripheral causes.²⁷

CASE 5-1

A 33-year-old right-handed man presented to the emergency department for evaluation of new-onset continuous dizziness. He described the sudden onset of room-spinning vertigo shortly after beginning skiing that morning. He became so dizzy that he could no longer ski. He had no vascular risk factors but did have dull head and neck pain.

His vital signs and neurologic examination were normal except for gait instability and truncal ataxia such that he could no longer walk unassisted. HINTS Plus (Head Impulse test, Nystagmus, Test of Skew with hearing assessment) revealed absent catch-up saccade on head impulse testing, gaze-evoked nystagmus, vertical skew deviation, and normal hearing on the finger-rub test. The emergency department physician ordered vascular imaging, which showed a right vertebral dissection and a posterior inferior cerebellar artery (PICA) territory infarct.

COMMENT

This patient's postural and ocular motor examination findings are quite concerning for central vestibular pathology, particularly cerebellar. Although lacking conventional vascular risk factors, vascular risk factors that can lead to stroke presenting as acute vestibular syndrome in young people are more likely related to trauma, increasing the risk of dissection. PICA territory strokes are more common in younger patients, of which dissections are common causes.

CASE 5-2

A 75-year-old man presented to his primary care physician for evaluation of sudden-onset continuous dizziness. He had no vascular risk factors except for age. On further questioning, he described spontaneous vertigo attacks that began in the past 1 to 2 weeks and were getting progressively longer.

His examination revealed catch-up saccade on head impulse testing to the right and peripheral-pattern nystagmus that was spontaneously left-beating and attenuated with fixation. He was able to ambulate but required assistance. Bedside finger-rub testing demonstrated asymmetric right hearing loss. His primary care physician recommended immediate emergency evaluation. Central imaging revealed anterior inferior cerebellar artery territory ischemia with intracranial atherosclerosis.

COMMENT

This case demonstrates that new vertigo that abruptly begins and quickly intensifies is concerning for stuttering transient ischemic attack. It also highlights that, by the original HINTS (Head Impulse test, Nystagmus, Test of Skew) evaluation, he may have been incorrectly diagnosed with a peripheral cause of acute unilateral vestibulopathy and sent home. HINTS Plus (HINTS with audiometry) demonstrated hearing loss that helped stratify the cause of symptoms correctly as a posterior circulation stroke.

vertigo and truncal ataxia without the other classic cerebellar signs of gaze-evoked nystagmus or dysmetria.²⁹

Because the internal auditory artery off of the AICA supplies the peripheral vestibular and auditory structures in addition to the AICA supply of the lateral pons, middle cerebellar peduncle, and anterior and inferior cerebellum, strokes in this distribution can affect peripheral or central vestibular structures or both. Although labyrinthine ischemia cannot be detected on MRI, the possibility should be considered in a patient with a peripheral-pattern acute vestibular syndrome and considerable vascular risk factors.

Rarely, AICA infarction can affect only the vestibular root entry zone and seventh cranial nerve fascicle, resulting in isolated vertigo and lower motor neuron-pattern facial nerve palsy. The concept of isolated root entry zone, cerebellum, or vestibular nucleus infarct causing peripheral-pattern symptoms is captured in the terms *vestibular pseudoneuritis* and *pseudolabyrinthitis*³⁰ (CASE 5-2). A collection of longitudinal studies suggests that patients who present to the emergency department with acute vestibular syndrome have a higher relative risk of stroke during the following year.³¹ Although the rate of stroke remained low, the increased relative risk may indicate missed early stroke or TIA presenting as acute vestibular syndrome. Other studies have found less significant associations,³² but the importance of carefully ruling out posterior circulation stroke nonetheless remains as smaller strokes may serve as harbingers of more disabling, larger strokes to come. Acute vestibular syndrome without clearly identified stroke may still benefit from vascular risk factor optimization and a time-limited course of aspirin because of the known association of acute vestibular syndrome with ischemic labyrinthopathy and/or a punctate central ischemic event and a higher likelihood of stroke in the subsequent 90 days.

ACUTE UNILATERAL VESTIBULOPATHY

If the HINTS Plus and ataxia examination reveal a peripheral pattern, does that mean it must be vestibular neuritis? The answer is not necessarily. Vestibular neuritis has become a catch-all term for the more accurate descriptor: acute unilateral vestibulopathy. Acute unilateral vestibulopathy indicates a peripheral asymmetry in vestibular function, disrupting normal vestibular tone. Of acute unilateral vestibulopathy causes, vestibular neuritis is likely the most common.¹⁴ Vestibular neuritis refers to inflammation of the vestibulocochlear nerve, which thus results in acute unilateral vestibulopathy. Vestibular neuritis is classically understood to derive from a viral infection. Association with a viral prodrome such as upper respiratory infections is not always present, and the absence of a previous upper respiratory infection should not exclude vestibular neuritis as a cause. Some evidence supports herpes simplex virus type 1 involvement because herpes simplex virus DNA has been detected in as many as 60%³³ or as few as 18%³⁴ of sampled vestibular ganglia of patients with vestibular neuritis. Additionally, histopathologic studies of vestibular neuritis show similar pathology to what is seen in herpes zoster oticus, linking viral etiologies.¹⁴ However, herpes simplex virus type 1 is very common in the general population, and, because of the inability to assay in live, symptomatic individuals, causation cannot yet be proven. Because of the prevalence of neurotropic viruses in the general population and relative rarity of acute unilateral vestibulopathy, acute unilateral vestibulopathy may

KEY POINTS

- In patients with acute vertigo, nystagmus may be obvious with the naked eye, but when it is not, removal of fixation by some means (eg, Frenzel goggles, Fresnel lenses, magnifying sheet, bright penlight, or fundoscopy) improves detection of more subtle nystagmus.
- Although ideally hearing should be assessed in every patient with suspected acute vestibular syndrome, emergency settings are rarely equipped for formal audiometry. Bedside testing with hearing test smartphone applications or finger-rub testing followed by an eventual outpatient formal audiogram can provide valuable vascular risk factor information.
- Grading truncal ataxia in acute vestibular syndrome patients can increase anterior inferior cerebellar artery stroke detection sensitivity to 100%.
- If the HINTS Plus (Head Impulse test, Nystagmus, Test of Skew plus hearing loss assessment) examination demonstrates a central pattern consisting of no catch-up saccade on head impulse testing, central pattern nystagmus (direction-changing, vertical, unaffected by fixation), vertical skew deviation, and/or new, sudden asymmetric hearing loss, stroke is likely.

just as likely derive from demyelination, ischemia, or autoimmune or other inflammatory conditions preferentially affecting cranial nerves. Indeed, a lack of significant response to antivirals³⁵ may be a surrogate sign of involvement of other etiologies beyond viral neuritis.

In contrast, herpes zoster oticus, known by the eponym Ramsay Hunt syndrome,³⁶ is a syndrome associated with facial palsy, vestibulocochlear dysfunction, mouth pain, and vesicular rash over the external auditory canal and concha. Because herpes zoster oticus is a potentially severely disabling and disfiguring syndrome, antiviral treatment is effective and should not be delayed. Famciclovir may be more effective than acyclovir.³⁷ Other infectious causes should be considered in patients with a history of chronic middle ear infections or meningitis because these may progress to bacterial vestibular neuritis or labyrinthitis, in which hearing is affected as well.

Acute unilateral vestibulopathy has similar physical examination findings for most causes. Because of the asymmetry in vestibular tone, patients have

CASE 5-3

A 55-year-old man presented to the emergency department with sudden-onset vertigo for the past 25 hours. He had severe nausea and vomiting and felt considerable exacerbation with head movements. His past medical history was significant for anxiety and depression, and he was recently started on a new medication for anxiety: alprazolam 0.5 mg as needed. He recalled taking the medication the day before onset without difficulty.

His examination revealed spontaneous, horizontal-torsional, right-beating unidirectional nystagmus that attenuated with fixation. Head impulse testing demonstrated catch-up saccade with head accelerated to the left. His hearing was normal. He was able to walk unassisted, although he felt very uncomfortable doing so. The rest of his neurologic examination was normal.

He was discharged with instructions to begin vestibular therapy as soon as possible. At a 3-month follow-up, his symptoms were considerably improved, but he still had a mild sense of head lag with quick movements and prominent brain fog. He continued to take alprazolam daily.

COMMENT

This case demonstrates a classic presentation of acute vestibular syndrome due to acute unilateral vestibulopathy, most likely viral vestibular neuritis. The patient's new medication was not implicated in the onset of dizziness because benzodiazepines are not associated with new-onset, acquired vertigo and nystagmus in adults; in fact, they are potent vestibular suppressants, which may help reduce symptom burden initially. This case highlights two important concepts on recovery from acute vestibular syndrome: (1) previous history of mood disorder is a negative prognosticator for recovery and (2) chronic use of vestibular suppressants contributes to incomplete central compensation.

spontaneous nystagmus with the fast phase beating away from the affected side. It intensifies with gaze in the direction of the fast phase and diminishes or abates with gaze in the direction of the slow phase (known as the *Alexander law*). As central compensation can quickly begin, the spontaneous nystagmus may diminish in some within hours to a few days when patients can visually fixate on their surroundings. The pattern of the nystagmus should mirror the affected parts of the vestibular labyrinth. Because the vestibular nerve has two major divisions (superior and inferior), it is possible to have one or both divisions affected. The superior division is the most commonly affected,³⁸ and, because it innervates the anterior and horizontal canals, spontaneous nystagmus reflects those planes, resulting in horizontal-torsional, unidirectional nystagmus (beating away from the affected side). A similar appearance is seen when both superior and inferior vestibular nerves are affected. In both isolated superior vestibular neuritis and combined superior and inferior vestibular neuritis, head impulse testing results in a catch-up saccade when the head is turned toward the side of hypofunction. If, however, the inferior division is affected in isolation (the least common type), spontaneous downbeating torsional nystagmus may be observed. Isolated inferior vestibular neuritis is rare, accounting for only about 2% of cases.³⁸

Skew deviation is the vertical misalignment of the eyes caused by a supranuclear disorder involving the otolith-ocular pathways. Although vertical skew deviation is usually associated with central lesions of the brainstem or cerebellum, it can rarely occur in peripheral acute unilateral vestibulopathy as part of the ocular tilt reaction (see collections.lib.utah.edu/details?id=1253805 for representative ocular motor findings of acute vestibular syndrome with an ocular tilt reaction due to bacterial labyrinthitis); thus, vertical skew findings must be interpreted with caution. Abnormalities in the pathways, peripheral to central, can manifest as skew deviation. Acute unilateral vestibulopathy is a rare but possible cause of vertical skew³⁹ because of involvement of these same pathways. Skew deviation from peripheral causes is usually mild and short-lived to no more than 1 or 2 days, although this timing does not help with differentiating in the acute care setting.

The classic pattern of HINTS Plus in acute unilateral vestibulopathy is the presence of an abnormal head impulse test with a catch-up saccade and spontaneous unidirectional nystagmus (ie, it does not change direction with changes in the direction of gaze) that attenuates with fixation, increases with gaze in the direction of the fast phase, lessens or abates in the opposite direction (the *Alexander law*), and is devoid of vertical skew deviation on cover-uncover testing.

Most patients with acute unilateral vestibulopathy will improve with time, but up to 50% of patients have some chronic residual symptoms.⁴⁰ Hypotheses for prolonged and incomplete recovery range from more intuitive theories such as age-related poor central compensation, severity of the degree of vestibular loss,⁴¹ vestibular suppressant use, and physical inactivity to unexpected negative prognosticators such as increased visual dependence, anxiety/depression, fear of bodily sensations, and autonomic arousal (**CASE 5-3**).⁴²

Evidence-based guidelines support the use of vestibular physical therapy in the rehabilitation of acute unilateral vestibulopathy⁴³ with little risk of harm to the patient. Corticosteroids do not appear to change long-term outcomes, but they may hasten recovery.⁴⁴ Function at 12 months after acute unilateral

KEY POINTS

- The internal auditory artery, also known as the labyrinthine artery, supplies the cochlea, saccule, and posterior semicircular canal. Greater than 90% of anterior inferior cerebellar artery infarctions affect hearing and have evidence of peripheral vestibulopathy superimposed on central vestibulopathy.
- Antivirals have not been found to be effective medications and are not recommended in acute vestibular syndrome or acute unilateral vestibulopathy in isolation. Ramsay Hunt syndrome, which may cause acute vestibular syndrome in addition to vesicles around the ear and multiple cranial neuropathies, requires immediate antiviral therapy.
- Peripheral-pattern nystagmus for the majority of patients with acute unilateral vestibulopathy is direction-fixed, horizontal nystagmus that beats away from the affected side. It intensifies with gaze in the direction of the fast phase and diminishes or abates with gaze in the direction of the slow phase (known as the *Alexander law*).
- A catch-up saccade on head impulse testing is an abnormality that indicates ipsilateral peripheral vestibular hypofunction. It is a cortically generated response to the loss of the normal vestibular ocular reflex. A catch-up saccade with a quick turn to the right indicates the right is hypofunctional, and a catch-up saccade with a quick turn to the left indicates the left is hypofunctional.

vestibulopathy is similar despite combined vestibular therapy and steroids or steroids alone. Betahistine and cinnarizine are two vestibular suppressants available outside of the United States about which conflicting studies exist arguing for and against their use in peripheral vestibular disorders. Betahistine does appear to have a favorable safety profile and may be effective, but the quality of evidence is low.⁴⁵ The US Food and Drug Administration (FDA) has not approved betahistine and precludes its distribution across state lines, but it is available for compounding in the United States. Cinnarizine in combination with betahistine may be more effective⁴⁶ than betahistine alone, although quality studies are lacking. Because of concerns for increased risk of parkinsonism from cinnarizine, the FDA has not approved its use,⁴⁷ although its use is prevalent in Europe and Oceania.

CASE 5-4

A 33-year-old right-handed woman presented to the emergency department with new-onset, continuous room-spinning dizziness that came on suddenly while sitting in front of her computer. She had no history of stroke, vascular risk factors, or chronic medical conditions.

Her examination revealed normal vital signs. She had no cranial nerve, motor, sensory, or reflex deficits. Her gait was unstable, and she veered to her left with a near fall and needed minimal gait assistance. Her ocular motor examination performed with fixation was normal. When the penlight was shined in her eyes, a subtle jerk nystagmus was detected, which was horizontal with the fast phase to the patient's right. A head impulse test demonstrated a corrective saccade with head impulse to the left. She had no vertical skew on a cover-uncover test.

She was provided reassurance and discharged home with plans for vestibular therapy. She did well with therapy and was symptom free on follow-up 3 months later. Five months after the initial presentation, she presented to the emergency department again with sudden-onset eye pain. MRI revealed demyelinating plaques of the optic nerve, brainstem, and cerebellum. A lumbar puncture was normal, but serum aquaporin-4 was positive, confirming the diagnosis of neuromyelitis optica spectrum disorder.

COMMENT

This is a rare case of neuromyelitis optica spectrum disorder with a lesion initially in the root entry zone of the vestibulocochlear nerve that appeared compatible with isolated peripheral vestibulopathy. However, with further time, symptom evolution, and neuroimaging, neuromyelitis optica spectrum disorder was suspected and confirmed by serology. This case demonstrates the confusing presentation of root entry zone disease as seemingly peripheral. It also demonstrates the broad differential of acute vestibular syndrome, including various central pathologies, and the importance of long-term follow-up, particularly when other neurologic symptoms evolve.⁵¹

RARE ETIOLOGIES OF ACUTE VESTIBULAR SYNDROME

Situational clues may highlight some of the rare causes of acute vestibular syndrome. Blunt trauma and whiplash have been documented to cause central as well as peripheral vestibulopathy. Lesser recognized blast trauma can also cause acute vestibular syndrome and may have different symptomatology than classic posttraumatic syndromes with more exercise intolerance inducing dizziness.⁴⁸ Demyelinating diseases such as multiple sclerosis⁴⁹ and neuromyelitis optica spectrum disorder⁵⁰ may impact the vestibulocerebellum or vestibulocochlear nerve and its root entry zone (CASE 5-4).

Autoimmune inner ear disease is typically aggressive and bilateral, but this may be the first of a sequential presentation. Other autoimmune disorders such as autoimmune cerebellitis, rhombencephalitis, paraneoplastic syndromes, and anti-GQ1b⁵² syndromes have also been associated with acute vestibular syndrome. Typically, though, these involve more than a singular episode of vertigo and have a somewhat subacute progression and other associated neurologic symptoms. An empiric steroid trial for autoimmune inner ear disease should be considered in patients with aggressive, subacute, fluctuating, bilateral vestibular, and cochlear symptoms. FIGURE 5-2 shows the rare and common differential diagnoses to consider in acute vestibular syndrome.

TRENDS

Although considerable advances in the understanding of acute vestibular syndrome have developed over the past decade, many exciting topics of research are still emerging. New technologies allowing for on-demand interpretation of eye movements may, at some point, play a larger role as the number of neuro-otologists cannot keep up with disease burden; telemedicine and machine learning may help substitute for expertise.²⁵ Devices can focus on interpretation of spontaneous nystagmus as well as head impulse testing to pick up subtleties the untrained, inexperienced, or naked eye may miss. In the direction opposite of technologic advances, a case report found the simple bucket test of the subjective visual vertical may be quite useful in acute vestibular syndrome differentiation,⁵³ but further study is needed. The subjective visual vertical is the patient's ability to perceive true vertical accurately. Defects in subjective visual vertical are associated with otolithic dysfunction. Subjective visual vertical can be tested by simply marking a line in a bucket, offsetting the line from true vertical, and then asking the patient to realign with their perception of vertical. Based on how accurately (in degrees of rotation) the patient aligns with true vertical, subjective visual vertical can be measured.

The video head impulse test is undergoing scrutiny as evidence suggests it can be abnormal in cerebellar (and potentially other central) conditions and may not be a purely peripheral assessment.⁵⁴ Understanding the nuances of central findings is key to accurate assessment of acute vestibular syndrome.

Outside of eye movement evaluations, as previously discussed, truncal ataxia scores may provide another measure for central versus peripheral causes for acute vestibular syndrome. One study has already found that truncal ataxia scoring is an effective screen that requires less expertise for reliable retesting²⁷ and paves the way for an ongoing clinical trial comparing HINTS with STANDING (SponTANeous, Nystagmus, Direction, head Impulse test, standiNG), an algorithm that consists of two ocular motor examinations (head impulse test and detection of nystagmus), detection of ataxia, and practice of

KEY POINTS

- Abnormalities in the pathways, peripheral to central, of the ocular tilt reaction can result in skew deviation; although skew deviation is usually a central finding, it can sometimes be present with acute unilateral vestibular loss.
- HINTS Plus in acute vestibular syndrome due to vestibular neuritis consists of an abnormal head impulse test with a catch-up saccade toward the side affected, spontaneous unidirectional nystagmus with fast phases away from the affected ear, and the absence of skew eye deviation on cover-uncover testing.
- Mood disorders and inactivity can prolong or cause incomplete recovery from symptoms of acute unilateral vestibulopathy.
- Evidence-based guidelines support the use of vestibular physical therapy alone in the treatment of classic acute unilateral vestibulopathy resulting from acute vestibular syndrome.
- Physical and barotrauma can cause central and peripheral vestibular dysfunction.
- An empiric steroid trial for autoimmune inner ear disease should be considered in patients with aggressive, subacute, fluctuating, bilateral vestibular, and cochlear symptoms.

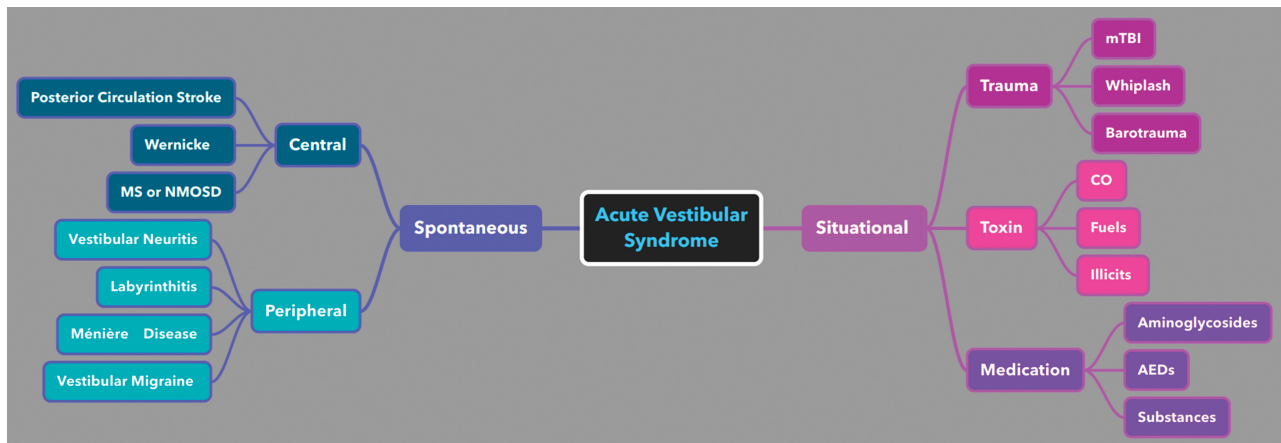


FIGURE 5-2

Schematic to frame differential diagnoses of acute vestibular syndrome.

AEDs = antiepileptic drugs; CO = carbon monoxide; MS = multiple sclerosis; mTBI = mild traumatic brain injury; NMOSD = neuromyelitis optica spectrum disorder.

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release maneuvers. STANDING was proposed in 2015 for diagnosis of the central causes of acute vestibular syndrome in emergencies in a 1-year prospective monocentric study.⁵⁵ The ongoing study seeks to aid in understanding the accuracy of HINTS when nonspecialists perform it, as well as comparing it with STANDING.

Medications as treatment for acute vestibular syndrome, particularly peripheral acute vestibular syndrome, are still controversial. Of medications that are available in the United States, only supportive medications, mostly antiemetic medications and antihistamines, have been studied for symptom management in the first 24 to 48 hours of onset. Few quality trials exist, but evidence suggests that promethazine 25 mg IM or IV, as well as dimenhydrinate 50 mg to 100 mg IV, are more effective and less sedating than IV benzodiazepines.⁵⁶⁻⁵⁸ Outside of the United States, the debate surrounding the utility and safety of betahistine, cinnarizine, and flunarizine continues.

CONCLUSION

Acute vestibular syndrome may seem intimidating because of considerable overlap of symptoms with vestibular and nonvestibular causes, including both serious and benign causes. A commonsense approach followed by targeted HINTS Plus examination and vascular risk factor assessment can help improve diagnostic accuracy. Stroke is common enough and variable enough in presentation to be considered in every patient with acute vestibular syndrome; however, when no acute unilateral hearing loss, central pattern nystagmus, or severe truncal ataxia is present, this is reassuring for a benign acute unilateral vestibulopathy process. Acute unilateral vestibulopathy can stem from etiologies ranging from inflammation to demyelination and improves with time and vestibular physical therapy. When applied systematically, the preceding recommendations can demystify dizziness, improving provider confidence and patient outcomes.

USEFUL WEBSITES AND APPLICATIONS

VESTIBULAR DISORDERS ASSOCIATION

This website serves as a patient education and resource center regarding vestibular disorders. vestibular.org

NEURO-OPHTHALMOLOGY VIRTUAL EDUCATION LIBRARY

This video library features representative videos of ocular motor findings in vestibular disorders including acute vestibular syndrome. novel.utah.edu

aVOR APPLICATION

This application is a teaching, training, and test tool for the vestibulo-ocular reflex (VOR) system and its disorders.

MIMI HEARING TEST APPLICATION

This application provides a hearing test that can be used for the bedside audiometry in HINTS Plus.

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