

# Development of a novel bedside algorithm for differential diagnosis of vertigo

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## **HINTS to diagnose stroke in the acute vestibular syndrome: three-step bedside oculomotor examination more sensitive than early MRI diffusion-weighted imaging.**

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#### **Abstract**

**BACKGROUND AND PURPOSE:** Acute vestibular syndrome (AVS) is often due to vestibular neuritis but can result from vertebrobasilar strokes. Misdiagnosis of posterior fossa infarcts in emergency care settings is frequent. Bedside oculomotor findings may reliably identify stroke in AVS, but prospective studies have been lacking.

**METHODS:** The authors conducted a prospective, cross-sectional study at an academic hospital. Consecutive patients with AVS (vertigo, nystagmus, nausea/vomiting, head-motion intolerance, unsteady gait) with  $\geq 1$  stroke risk factor underwent structured examination, including horizontal head impulse test of vestibulo-ocular reflex function, observation of nystagmus in different gaze positions, and prism cross-cover test of ocular alignment. All underwent neuroimaging and admission (generally  $< 72$  hours after symptom onset). Strokes were diagnosed by MRI or CT. Peripheral lesions were diagnosed by normal MRI and clinical follow-up.

**RESULTS:** One hundred one high-risk patients with AVS included 25 peripheral and 76 central lesions (69 ischemic strokes, 4 hemorrhages, 3 other). The presence of normal horizontal head impulse test, direction-changing nystagmus in eccentric gaze, or skew deviation (vertical ocular misalignment) was 100% sensitive and 96% specific for stroke. Skew was present in 17% and associated with brainstem lesions (4% peripheral, 4% pure cerebellar, 30% brainstem involvement;  $\chi^2(2)$ ,  $P=0.003$ ). Skew correctly predicted lateral pontine stroke in 2 of 3 cases in which an abnormal horizontal head impulse test erroneously suggested peripheral localization. Initial MRI diffusion-weighted imaging was falsely negative in 12% (all  $< 48$  hours after symptom onset).

**CONCLUSIONS:** Skew predicts brainstem involvement in AVS and can identify stroke when an abnormal horizontal head impulse test falsely suggests a peripheral lesion. A 3-step bedside oculomotor examination (HINTS: Head-Impulse-Nystagmus-Test-of-Skew) appears more sensitive for stroke than early MRI in AVS.

Abstract

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J Emerg Med. 2016 Apr;50(4):617-28. doi: 10.1016/j.jemermed.2015.10.040. Epub 2016 Feb 16.

## Using the Physical Examination to Diagnose Patients with Acute Dizziness and Vertigo.

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### Author information

#### Abstract

**BACKGROUND:** Emergency department (ED) patients who present with acute dizziness or vertigo can be challenging to diagnose. Roughly half have general medical disorders that are usually apparent from the context, associated symptoms, or initial laboratory tests. The rest include a mix of common inner ear disorders and uncommon neurologic ones, particularly vertebrobasilar strokes or posterior fossa mass lesions. In these latter cases, misdiagnosis can lead to serious adverse consequences for patients.

**OBJECTIVE:** Our aim was to assist emergency physicians to use the physical examination effectively to make a specific diagnosis in patients with acute dizziness or vertigo.

**DISCUSSION:** Recent evidence indicates that the physical examination can help physicians accurately discriminate between benign inner ear conditions and dangerous central ones, enabling correct management of peripheral vestibular disease and avoiding dangerous misdiagnoses of central ones. Patients with the acute vestibular syndrome mostly have vestibular neuritis, but some have stroke. Data suggest that focused eye movement examinations, at least when performed by specialists, are more sensitive for detecting early stroke than brain imaging, including diffusion-weighted magnetic resonance imaging. Patients with the triggered episodic vestibular syndrome mostly have benign paroxysmal positional vertigo (BPPV), but some have posterior fossa mass lesions. Specific positional tests to provoke nystagmus can confirm a BPPV diagnosis at the bedside, enabling immediate curative therapy, or indicate the need for imaging.

**CONCLUSIONS:** Emergency physicians can effectively use the physical examination to make a specific diagnosis in patients with acute dizziness or vertigo. They must understand the limitations of brain imaging. This may reduce misdiagnosis of serious central causes of dizziness, including posterior circulation stroke and posterior fossa mass lesions, and improve resource utilization.

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**KEYWORDS:** BPPV; dizziness; misdiagnosis; physical examination; posterior circulation stroke; vertigo

- >3% of all emergency department (ED) visits.
- Can be difficult to diagnose.
- Most of them have benign vestibular problems or general medical causes
- Some have posterior circulation stroke and other serious central nervous system (CNS) causes

- One of the most serious misdiagnoses that can occur in patients with dizziness is missed posterior circulation stroke.
- Many symptoms of vertebrobasilar ischemia are nonspecific (e.g., headache, dizziness, vomiting)

- Misconceptions
- Symptoms that worsen with movement confirm a peripheral vestibular process
- A normal brain computed tomography (CT) scan is reassuring in excluding ischemic stroke
- The sensitivity of brain CT for posterior circulation acute ischemic stroke is low (7%–42%)

- CT is an excellent test for an intracerebral hemorrhage
- But intracerebral hemorrhage that mimics a benign dizziness presentation is rare.

- Magnetic resonance imaging (MRI) is the gold standard for diagnosing acute ischemic stroke
- Early MRI has important limitations in diagnosing acute ischemic stroke
- The physical examination is highly sensitive in these patients.

- What do you mean dizzy?
- Vertigo? Lightheadedness? Disequilibrium?  
Slipping? etc

- They changes their type of dizziness
- When we ask the same question 10 min later  
~50% of them changes their answer
- So the word used by the patient is unimportant  
(e.g., *vertigo* vs. *lightheadedness*, or other terms)
- But patients are far more consistent with their reporting of timing and triggers of symptoms.

- The specific word that the patient endorses is not diagnostically meaningful
- A new paradigm based on the timing and triggers of dizziness is more helpful
- Understanding these clinical groups is key to the use of the physical examination

- Taking a history should be focus on
  - the duration
  - episodic or constant nature of the symptom
  - triggers if it is episodic
  - other factors associated symptoms
  - epidemiological context

# Timing-and-Trigger-Based Vestibular Syndromes in Acute Dizziness

<b>Vestibular Syndrome</b>	<b>Common Benign Cause</b>	<b>Dangerous Cause(s)</b>
<b><i>Acute vestibular syndrome</i></b>	Vestibular neuritis	Stroke
<b><i>Triggered episodic vestibular syndrome</i></b>	BPPV	Posterior fossa tumor
<b><i>Spontaneous episodic vestibular syndrome</i></b>	Vestibular migraine	TIA Cardiac dysrhythmia

# Acute Vestibular Syndrome

- Monophasic acute dizziness that begins abruptly or very rapidly and persists continuously for days.
- Feel less symptomatic when not moving, they are still dizzy at rest.
- Their dizziness may be exacerbated (i.e., from an abnormal baseline) by movement but it is not triggered (i.e., from a normal baseline) by movement.

# Triggered Episodic Vestibular Syndrome (t-EVS)

- Repetitive episodes of dizziness that are triggered by some event
- They are completely asymptomatic at rest and will develop dizziness (usually lasting < 1 min) that is reliably triggered by a specific head movement or postural shift (i.e., standing or sitting up).

# Spontaneous Episodic Vestibular Syndrome (s-EVS)

- Multiple episodes of dizziness (usually lasting many minutes to many hours) that comes on without any clear identifiable trigger, even if there appear to be contextual predisposing factors (e.g., sleep deprivation, stress, or hormonal changes)
- Between episodes, they are completely asymptomatic.

# Acute Vestibular Syndrome

- Acute vestibular syndrome (AVS) is acute, rapid-onset, persistent dizziness with a monophasic course that resolves over days to weeks
- The most common causes of the AVS are vestibular neuritis and posterior circulation stroke

# Acute Vestibular Syndrome

- The next most common is multiple sclerosis, which is not immediately life threatening
- Less common causes of AVS (medical and other neurological conditions) will be suggested by the clinical context, vital signs, and basic laboratory testing
- Therefore, we will focus on the major differential diagnosis here—vestibular neuritis vs. stroke

# Acute Vestibular Syndrome

- A general neurological physical examination needs to be done
- Cranial nerve, cerebellar, and gait testing are particularly important (finger-to-nose and heel-to-shin, facial motor and sensory symmetry, dysarthria, and gait testing)
- In patients with posterior circulation strokes, approximately 30%–60% will have one of these findings

# Acute Vestibular Syndrome

- In patients with normal general neurological examinations, specific bedside eye movement testing is very useful.
- The HINTS study was published in 2009
- They showed that the physical examination identified all of the stroke patients

- These three tests in the HINTS
  - Horizontal head impulse test (HIT)
  - Testing for nystagmus
  - Skew deviation

HINTS Eye Findings in AVS	Peripheral	Central
Nystagmus	Dominantly horizontal, direction-fixed, beating away from the affected side	Often mimics peripheral; if direction-changing horizontal or dominantly vertical or torional, then central
Head impulse	Unilaterally abnormal VOR toward the affected side	Usually bilaterally normal VOR
Test of skew	Normal vertical eye alignment (no skew deviation)	Often mimics peripheral; if skew deviation is present, then central

# Acute Vestibular Syndrome

- The first step is testing for nystagmus.
- There are different forms of nystagmus, the most common of which is jerk nystagmus, in which the eyes slowly drift off target and then snap back to the target
- If the eyes drift rightward, then the fast component beats toward the patient's left, this is called "left-beating" nystagmus.

# Acute Vestibular Syndrome

- Horizontal nystagmus (right-beating or left-beating)
- Vertical nystagmus (up-beating or down-beating)
- Torsional movements

# Acute Vestibular Syndrome

- First examine for spontaneous nystagmus, and then test for gaze-evoked nystagmus.
- For spontaneous nystagmus, carefully observe the patient's eyes while they are looking straight ahead in neutral (primary) gaze.
- Observe for jerk-like deflections and note the direction in which the fast phase beats (horizontal, vertical, or torsional)

# Acute Vestibular Syndrome

- Next, test for gaze-evoked nystagmus by asking the patient to follow one's finger or another object placed about 25 cm away from the patient's face.
- Move the object to the right and left and up and down.
- Note the presence of nystagmus in each direction of gaze and note the direction of its rapid phase.

- If the direction of the rapid phase is the same (right-beating) this is called "*direction-fixed*" *nystagmus* (more often suggesting a peripheral process)
- If the direction of the fast component changes (e.g., right-beating on rightward gaze and left-beating on leftward gaze), this is called "*direction-changing*" *nystagmus* (almost always indicating a central process).
- The change in the direction of the fast phase is the important finding.

# Acute Vestibular Syndrome

- The presence or absence of nystagmus is not diagnostic, but the characteristics of the nystagmus (e.g., vector, direction, change in different gaze positions, or with different viewing conditions) is.
- All patients with vestibular neuritis should have nystagmus in the first few days of the illness.
- However, the vast majority of patients with cerebellar stroke who present with dizziness or vertigo also have nystagmus.

- The next component of the HINTS is the HIT, a test of the vestibulo-ocular reflex (VOR)
- The test should be performed several times, very quickly toward each ear using a lateral to center motion, over a very short distance (no more than 20°)

- The presence of a corrective saccade (fast eye movement) is a "positive" test and a positive test (abnormal VOR) generally indicates a peripheral process, usually vestibular neuritis.
- The absence of a corrective saccade in AVS is consistent with a stroke (a normal bedside finding predicts a dangerous disease)

- The third component of HINTS is testing for skew deviation (not very sensitive (30%), but is very specific (98%) for a brainstem lesion)
- To test for skew deviation, the examiner uses the "alternate cover" test.
- With the patient looking directly at the examiner's nose, the physician alternately covers the right eye, then the left eye, and continues alternating back and forth.

- In patients with skew deviation, each time the covered eye is uncovered, there will be a slight vertical correction (on one side you will see an upward correction and on the other you will see a downward correction).
- A normal response is => no vertical correction
- An abnormal response is suspicious for stroke in a patient presenting with AVS.

1. Is the patient unable to sit or stand without assistance?
2. Does the patient have any new finding on a targeted general neurological examination?
3. Does the patient have worrisome spontaneous or gaze-evoked nystagmus (predominantly vertical or torsional, or direction-changing horizontal)?
4. Does the patient have a negative HIT (no corrective saccade on either side)?
5. Does the patient have skew deviation (vertical eye misalignment)?

- If the answer to any of these five questions is "yes," then the patient needs an evaluation for stroke.
- If the answer to all five questions is "no," then the patient almost certainly has a peripheral cause for the AVS.
- None of the five tests can be used individually to exclude stroke because none has 100% sensitivity.

# Triggered Episodic Vestibular Syndrome

- Patients with the t-EVS are the second group in whom physical examination has an especially important impact.
- The most common causes are BPPV and orthostatic hypotension.

- Patients usually describe brief episodes of dizziness that are triggered by head movement. The common trigger of rolling over in bed can lead to patients being awakened from sleep by dizziness.
- Patients with BPPV have normal hearing and do not have other neurological findings.

- The classic history is one of episodes of dizziness that are abruptly triggered by head movement and resolve in less than a minute upon stopping head motion
- Some patients overestimate the duration because they trigger back-to-back episodes

- There are different diagnostic and physical maneuvers for each semicircular canal

Positional Tests in t-EVS	BPPV (Posterior)	BPPV (Horizontal)	Central
Dix- Hallpike	Upbeat-torsional 5-30 s No spontaneous reversal	None	Variable direction (downbeat or horizontal;almost never upbeat) Often >90 s No spontaneous reversal
Supine roll test	None	Pure horizontal 30-90 s Spontaneous reversal typical	Variable direction (downbeat or horizontal;almost never upbeat) Often >90 s No spontaneous reversal

- The posterior canal is the most frequently affected due to its anatomy
- Therefore, this canal is generally tested first with the Dix-Hallpike maneuver
- Each side is tested independently
- The patient should be asymptomatic at the start of the test

- In typical cases, symptoms and nystagmus should begin after a few seconds of latency and resolve in  $< 30$  s.
- The expected nystagmus should be mixed upbeat torsional.
- The positive side identifies the affected posterior canal (right ear down = right posterior canal),
- EPs can diagnose and treat BPPV with a curative canalith repositioning procedure

- An AVS patient (symptomatic at baseline) examined using the Dix-Hallpike test will almost have increased symptoms and increased intensity nystagmus (exacerbated). These patients will feel worse with any head movement.
- If the Dix-Hallpike test induces symptoms and nystagmus from a t-EVS patient with a history of brief, recurrent spells triggered by specific head movements (no symptoms at baseline), this is generally diagnostic of BPPV.

- The same nystagmus has opposite meaning in these two vestibular syndromes.
- In t-EVS, a burst of upbeat-torsional nystagmus triggered by the Dix-Hallpike position means BPPV.
- In the AVS, upbeat torsional nystagmus (the same finding) is a central sign, usually due to brainstem stroke.

- If patients whose histories suggest BPPV have negative Dix-Hallpike tests then specifically testing the horizontal (=lateral) canal is indicated using the supine head roll test
- Nystagmus will beat horizontally and will generally be more severe and prolonged than the posterior canal variant (about 60 s).
- The side provoking more intense nystagmus is typically the affected side that will guide the repositioning maneuver.

- In a patient whose history suggests BPPV, if there are atypical examination features or if a physician cannot see typical findings that resolve after the appropriate canalith repositioning procedure (Epley maneuver), specialist consultation is probably the safest action.

## Bedside diagnosis for patients with t-EVS

(NB: By definition, patients with t-EVS are 100% asymptomatic at rest, and develop dizziness that is only triggered by movement)

1. Not likely to be orthostatic hypotension



2. Positive positional testing (specific nystagmus identified) for posterior or horizontal semi-circular canal BPPV



3. Immediate and clear therapeutic response to canalith repositioning maneuver(s)



Safe to Go

# Spontaneous Episodic Vestibular Syndrome

- Most patients with the s-EVS will be asymptomatic at the time of presentation because the primary symptoms from an episode usually resolve within a few hours.
- Because the findings are not triggered, physical examination is less useful in this situation because the examination is usually totally normal.
- Common causes of the s-EVS include vestibular migraine and Menière's disease, but TIA is the serious cause not to be missed.

- The most common cause of s-EVS is vestibular migraine.
- If the patient has had recurrent, stereotyped episodes for years that are associated with typical migraine features (e.g., photophobia, visual aura) and predisposing factors (e.g., menstrual periods), the diagnosis is usually not difficult.

- Some of these patients may have physical findings that are suggestive of a CNS process (if they are symptomatic at the time of presentation).
- The type the nystagmus is variable and could be horizontal (direction-fixed or direction-changing), vertical, or torsional.

- In patients without a well-established history of vestibular migraine who are presenting with persistent symptoms and physical findings consistent with a central problem, it is safest to proceed as if the patient has an AVS with central features.

- Thank you for listening