Guidelines for Reasonable and appropriate care in the emergency department 3 (GRACE-3): Acute dizziness in the emergency department

Abstract

This third Guideline for Reasonable and Appropriate Care in the Emergency Department (GRACE-3) from the Society for Academic Emergency Medicine is on the topic: Adult patients with acute dizziness in the Emergency Department (ED). The multidisciplinary guideline panel applied the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach to assess the certainty of evidence and strength of recommendations regarding five questions for adult ED patients with acute dizziness of less than two weeks' duration. The intended population is adults presenting to the ED with acute dizziness. The panel derived the following evidence-based recommendations: To help distinguish central from peripheral causes in patients with the acute vestibular syndrome: 1) use HINTS in patients with nystagmus, 2) use finger rub to further aid in excluding stroke in patients with nystagmus, 3) use severity of gait unsteadiness in patients without nystagmus, 4) do NOT use brain CT, 5) do NOT use routine MRI as a first-line test, and 6) use MRI as a confirmatory test in patients with central or equivocal HINTS exams. In patients with the spontaneous episodic vestibular syndrome: 7) search for symptoms or signs of ischemia in the posterior cerebral circulation, 8) do NOT use CT, and 9) use CTA or MRA if there is concern for TIA. In patients with the triggered episodic vestibular syndrome, 10) use the Dix-Hallpike test to diagnose posterior canal BPPV, 11) do NOT use CT, and 12) do NOT use MRI routinely, unless atypical clinical features are present. In patients diagnosed with vestibular neuritis, 13) consider short-term steroids as a treatment option. In patients diagnosed with posterior canal BPPV, 14) treat with the Epley maneuver. We also suggest that 15) emergency clinicians be trained in bedside physical examination techniques for patients with the acute vestibular syndrome (HINTS) and the transient episodic vestibular syndrome (Dix-Hallpike test and Epley maneuver).

AT A GLANCE SUMMARY

In emergency department (ED) patients with new dizziness, vertigo, or unsteadiness without an obvious medical or neurological cause, the first step is to determine which presenting syndrome the patient has, based on the timing and triggers of symptoms.

(a) Acute Vestibular Syndrome: monophasic, continuous, and persistent dizziness

(b) Spontaneous Episodic Vestibular Syndrome: one or more discrete episodes of untriggered, spontaneous dizziness

(c) Triggered episodic Vestibular Syndrome: one or more discrete episodes of triggered, positional dizziness.

The specific recommendations are based on these timing and trigger categories.

Syndrome or specific diagnosis	**Recommendation**
Acute vestibular syndrome (AVS)	**FOR**: Diagnosis using HINTS test for vestibular neuritis versus stroke by an appropriately trained clinician. · If exam confirms vestibular neuritis, then treat accordingly; no imaging required. · If exam suggests stroke/central cause, obtain confirmatory MRI-DWI and/or consult neurology. **NEXT BEST**: MRI-DWI if no one qualified in HINTS diagnosis. **AGAINST**: CT with or without CTA/CTP.
Spontaneous episodic vestibular syndrome (s-EVS)	**FOR**: Diagnosis using history-taking. · If history suggests a benign cause (vestibular migraine or Menière disease), refer to vestibular specialist. · If history suggests TIA, manage as TIA; obtain vascular imaging (CTA or MRA) and/or consult neurology. **AGAINST**: Routine neuroimaging in those at low risk of TIA.
Triggered (positional) episodic vestibular syndrome (t-EVS)	**FOR**: Diagnosis using Dix-Hallpike test for posterior canal BPPV by an appropriately trained clinician. · If exam confirms pc-BPPV, then treat accordingly; no imaging required if patient responds to repositioning. · If exam suggests a central mimic or treatment fails, obtain MRI-DWI and/or consult neurology. **NEXT BEST**: Urgent (<72hrs) outpatient referral for diagnosis to an appropriately trained specialist.

	AGAINST: CT with or without CTA/CTP.
Vestibular neuritis	**FOR**: Shared decision-making weighing risks and benefits of short-term steroid treatment for vestibular neuritis among patients presenting within three days of symptom onset.
BPPV	**FOR**: Bedside Epley canalith repositioning maneuver for posterior canal BPPV (diagnosed using the Dix-Hallpike test) in the ED by an appropriately trained clinician. **NEXT BEST**: Urgent outpatient referral for treatment <72 hours by an appropriately trained specialist. **AGAINST**: Outpatient meclizine treatment.
Training	**FOR**: We suggest that emergency clinicians receive training in bedside physical examination techniques for patients with the AVS (HINTS) and diagnostic and therapeutic maneuvers for BPPV (Dix-Hallpike test and Epley maneuver)

Ideally, refer discharged patients both to an appropriate specialist (e.g., otorhinolaryngologist, neurologist, or other specialist with advanced vestibular training) as well as to their primary care physician for further evaluation and treatment. In some clinical settings, a physical therapist with vestibular expertise may be the most qualified clinician available locally or within a reasonable time frame, so may be the best referral choice. Refer all patients diagnosed with vestibular neuritis for vestibular physical therapy whether or not steroids are used, and, if an outpatient vestibular suppressant regimen (e.g., meclizine) is needed, it should be administered only short term (i.e., no longer than 3-5 days) (a sample discharge instruction sheet is included in included Appendix S9).

For patients with suspected BPPV whose Dix-Hallpike test shows horizontal nystagmus or no nystagmus (instead of the expected upbeat-torsional nystagmus), consider the diagnosis of horizontal canal BPPV. The preferred diagnostic maneuver is the supine roll test, and the therapeutic maneuver is either the Lempert (barbecue) roll or Gufoni maneuver. Although some ED clinicians are appropriately trained to diagnose and treat horizontal canal BPPV (and differentiate it from dangerous central mimics), the majority of the committee felt that incorporating this into a formal recommendation was unrealistic.

Box 1 – Recommendations
Diagnosis of the acute vestibular syndrome

1. In adult ED patients with acute vestibular syndrome with nystagmus, we recommend routine use of the 3-component head impulse, nystagmus, test of skew (HINTS) exam for clinicians trained in its use* to distinguish between central (stroke) and peripheral (inner ear, usually vestibular neuritis) diagnoses. (Strong recommendation, FOR) [High certainty of evidence]

2. In adult ED patients with acute vestibular syndrome with nystagmus, we suggest assessing hearing at the bedside by finger rub to identify new unilateral hearing loss as an additional criterion to aid in the identification of stroke, even if the 3-component HINTS exam result suggests a peripheral vestibular diagnosis. (Conditional recommendation, FOR) [Moderate certainty of evidence]

3. In adult ED patients with acute vestibular syndrome without nystagmus, we suggest assessing severity of gait unsteadiness to help distinguish between central (stroke) and peripheral (inner ear, usually vestibular neuritis) diagnoses. (Conditional recommendation, FOR) [Moderate certainty of evidence]

4. In adult ED patients with acute vestibular syndrome, we recommend against routine use of non-contrast computed tomography of the brain (CT) or (CT angiography [CTA]) to help distinguish between central (stroke) and peripheral (inner ear, usually vestibular neuritis) diagnoses. (Strong recommendation, AGAINST, see Implementation Considerations) [High certainty of evidence]

5. In adult ED patients with acute vestibular syndrome, we recommend against routine use of magnetic resonance imaging of the brain (MRI) or cerebral vasculature (MRI angiography [MRA]) as the first-line diagnostic test to help distinguish between central (stroke) and peripheral (inner ear, usually vestibular neuritis) diagnoses. (Strong recommendation, AGAINST, see Implementation Considerations) [High certainty of evidence]

6. In adult ED patients with acute vestibular syndrome and central or equivocal HINTS results, we recommend use of stroke protocol MRI (with diffusion-weighted images [DWI] and MRA) to further help distinguish between central (stroke) and peripheral (inner ear, usually vestibular neuritis) diagnoses. (Strong recommendation FOR, see Implementation Considerations regarding timing of MRI) [High certainty of evidence]

Diagnosis of the spontaneous episodic vestibular syndrome

7. In adult ED patients with spontaneous episodic vestibular syndrome, we recommend routine use of a detailed history and physical exam with emphasis on cranial nerves

including visual fields, eye movements, limb coordination, and gait assessment to help distinguish between central (TIA) and peripheral (vestibular migraine, Menière disease) diagnoses. [Ungraded good practice statement]

8. In adult ED patients with spontaneous episodic vestibular syndrome, we recommend against routine use of CT to help distinguish between central (TIA) and peripheral (vestibular migraine, Menière disease) diagnoses. (Strong recommendation, AGAINST) [Moderate certainty of evidence]

9. In adult ED patients with spontaneous episodic vestibular syndrome and concern for TIA, we suggest use of CTA or MRA to rule out posterior circulation vascular pathology (Conditional recommendation, FOR) [Moderate certainty of evidence]

Diagnosis of the triggered episodic vestibular syndrome

10. In adult ED patients with triggered episodic vestibular syndrome, we recommend routine use of the Dix-Hallpike test to diagnose posterior canal BPPV (Strong recommendation, FOR) [Moderate certainty of evidence]

11. In adult ED patients with triggered episodic vestibular syndrome, we recommend against routine use of CT or CTA (Strong recommendation, AGAINST) [Moderate certainty of evidence]

12. In adult ED patients with triggered episodic vestibular syndrome diagnosed with typical posterior canal BPPV by a positive Dix-Hallpike test with the characteristic nystagmus, we suggest against routine use of MRI or MRA (Conditional recommendation, AGAINST) [Moderate certainty of evidence]

Treatment of acute vestibular neuritis

13. In adult ED patients with a clinical diagnosis of vestibular neuritis, we suggest shared decision-making with patients to weigh risks and benefits of short-term steroid treatment for those presenting within three days of symptom onset. (Conditional recommendation, FOR) [Very low certainty of evidence]

Treatment of posterior canal BPPV

14. In adult ED patients with posterior canal BPPV diagnosed by a positive Dix-Hallpike test, we recommend the Epley† canalith repositioning maneuver be performed at the time of diagnosis. (Strong recommendation, FOR) [Moderate certainty of evidence]

Training emergency clinicians to perform bedside eye movement examinations

15. We suggest that all ED clinicians be trained* in the performance and interpretation of the HINTS exam and bedside maneuvers to diagnose and treat posterior canal BPPV,

since untrained ED physicians do not reliably apply or accurately interpret results of this bedside eye movement examination. [Ungraded Good Practice Statement]

* The specifics of training emergency clinicians in the use of these eye movement examination techniques have not been fully defined. As of September 2022, there is no generally agreed upon mechanism for training or certification in these skills. Routine training mechanisms should be developed and implemented as part of emergency medicine residency programs, continuing medical education courses, or other similar educational vehicles. Until such training opportunities are routinely available to emergency clinicians, it is unrealistic to expect that all emergency clinicians will be able to acquire the skills necessary to safely implement these examination techniques without expert backup (e.g., using video-oculography to verify the accuracy of bedside findings or obtain a specialty teleconsultation).

† The original Epley canalith repositioning maneuver included applying a vibratory stimulus over the mastoid bone during the procedure.(1) This aspect of the Epley maneuver does not appear to increase efficacy,(2) so the current standard maneuver (i.e., without vibration) is technically the "modified Epley maneuver." However, most clinicians use the term "Epley maneuver" to describe the modified maneuver, so is used that way here.

General note: These recommendations do NOT apply to dizzy patients who have obvious general medical causes for their symptoms (e.g., a cardiac dysrhythmia or medication side-effect) or to dizzy patients with an obvious stroke or other central nervous system pathology (e.g., patients with hemiplegia, visual field cut, altered mental status). For patients with general medical causes, the approach will depend on the cause, and, for stroke patients, institutional stroke protocols should be followed. The three presenting syndromes outlined above are based on timing and triggers of the dizziness (see diagnostic algorithm).

INTRODUCTION

Acute dizziness is a common emergency department (ED) presentation, accounting for 2.1-3.6% of visits per year,(3-7) with an estimated annual cost approximating $10 billion in the United States, a large proportion of which is related to imaging.(8) Resource use and ED length of stay for these patients are higher than in patients with other chief complaints.(3, 6) Use of neuroimaging in the ED, especially non-contrast computed tomography of the head (CT) is rising over time,(6, 9) while the proportion of diagnostically useful studies is decreasing.(10)

The traditional diagnostic paradigm, developed 50 years ago, based on symptom quality (asking the patient, "what do you mean by dizzy"?), suggests that the differential diagnosis and clinical evaluation be based on the patient's description of dizziness (vertigo, lightheadedness, imbalance or disequilibrium, or "other").(11) This paradigm was never properly validated, has significant methodological flaws and does not reliably predict underlying causes.(12, 13)

Newer evidence shows that patients' dizziness descriptors (e.g., "vertigo" versus "lightheadedness" or "imbalance", and others) often change when reassessed minutes later and that many patients simultaneously endorse multiple descriptors, undercutting the logic of a symptom quality-based paradigm.(14, 15) We therefore use the general term "dizziness" throughout the manuscript except where otherwise specified (such as when referring to formal international consensus definitions or to publications that specify those words in their inclusion criteria). Accumulating evidence and expert opinion published over the last 15 years suggest that a diagnostic paradigm based on the timing and triggers of the dizziness (rather than symptom quality or descriptor) is a more diagnostically useful way to approach patients with acute dizziness.(13-20)

Using a timing and triggers paradigm, acutely dizzy patients present in one of three patterns (Figure 1). These categories drive the differential diagnosis, the diagnostic testing and the interpretation of many of these tests. International consensus definitions for three specific vestibular syndromes relevant in the ED have been incorporated into the International Classification of Vestibular Disorders and the International Classification of Diseases 11th Revision (ICD-11).(21) Abridged, slightly modified definitions are provided below:

<u>Acute vestibular syndrome (AVS)</u>
A clinical syndrome of acute-onset continuous vertigo, dizziness, or unsteadiness lasting days to weeks and generally including features suggestive of new, ongoing vestibular system dysfunction (e.g., nausea and vomiting, nystagmus, and postural instability). In the ED, they are symptomatic even at rest, and exacerbation by head movement or position change is typical.

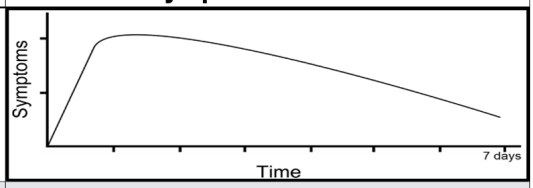
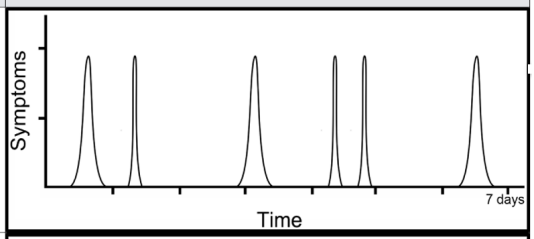
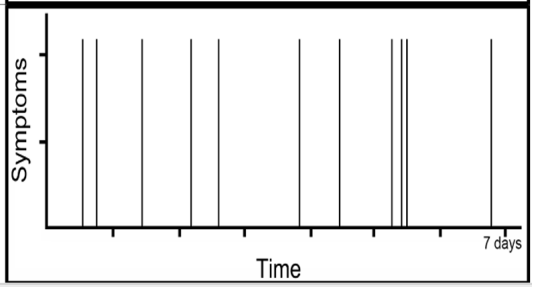
<u>Spontaneous episodic vestibular syndrome (s-EVS)</u>
A clinical syndrome of transient vertigo, dizziness, or unsteadiness usually lasting minutes to hours and generally including features suggestive of temporary, short-lived vestibular system dysfunction (e.g., nausea and vomiting, nystagmus, and postural instability) during attacks. There is usually a history of recurrent attacks but patients may initially present after a first attack. There are no clear triggers for these attacks, although symptoms will often be exacerbated by head movement or position change during an attack. In the ED, these patients are generally asymptomatic at rest (if symptoms persist, one would approach as an AVS).

<u>Triggered episodic vestibular syndrome (t-EVS)</u>
A clinical syndrome of transient vertigo, dizziness, or unsteadiness lasting seconds to minutes and generally including features suggestive of temporary, short-lived vestibular system dysfunction (e.g., nausea, nystagmus, and postural instability). There is usually a history of recurrent attacks but patients may initially present after a first attack. There are clear triggers for these attacks, most often movement of the head (including during postural shifts, as when standing or lying). In the ED, these patients are generally asymptomatic at rest, but symptoms can readily be provoked at the bedside by reproducing the patient's trigger.

<u>"Isolated" vertigo, dizziness, or unsteadiness</u>

Vestibular syndromes may be characterized as “isolated” when the only associated symptoms or signs are non-localizing ones that routinely accompany vestibular pathology (especially malaise, nausea or vomiting, nystagmus and postural instability). The presence of new focal neurological symptoms or signs (e.g., lateralizing weakness or numbness, dysarthria, diplopia, Horner’s syndrome, or limb ataxia) accompanying the vestibular symptoms would make the syndrome “non-isolated” (as would other general medical symptoms such as chest pain or dyspnea). The presence of new hearing symptoms (e.g., tinnitus or hearing loss) in an otherwise isolated vestibular syndrome is called an isolated audio-vestibular syndrome.

Figure 1 – Clinical presentation patterns of patients with acute dizziness based on timing and triggers

Clinical Presentation	Description	Graphic representation of symptoms over time&
Acute vestibular syndrome^	A clinical syndrome of acute-onset continuous vertigo, dizziness, or unsteadiness* lasting days to weeks and generally including features suggestive of new, ongoing vestibular system dysfunction (e.g., nausea and vomiting, nystagmus and postural instability. In the ED, they are symptomatic even when at rest.	
Episodic vestibular syndrome^	A clinical syndrome of multiple, recurrent attacks of vertigo, dizziness, or unsteadiness, which many be spontaneous or triggered. If the patient presents during a first attack and is actively symptomatic, approach as the acute vestibular syndrome.	
Spontaneous episodic vestibular syndrome^	A clinical syndrome of transient vertigo, dizziness, or unsteadiness usually lasting minutes to hours and generally including nausea and vomiting, postural instability and nystagmus. There are usually multiple recurrent attacks with repeated spells but may initially present after a first attack. There is no clear trigger of these attacks. In the ED, these patients are generally asymptomatic at rest	
Triggered episodic vestibular syndrome^	A clinical syndrome of brief transient vertigo, dizziness, or unsteadiness lasting seconds to minutes and generally including nausea and vomiting, postural instability. There are usually multiple recurrent attacks with repeated spells but some patients may initially present after a first attack. These attacks have a clear trigger, usually movement of the head or standing up. In the ED, these patients are generally asymptomatic at rest but the symptoms can be triggered at the bedside.	

* – the word endorsed by the patient does not have etiologic significance

& – the number of episodes depicted in the graphic is arbitrary; there is no specific number required, but a first prolonged episode of dizziness can sometimes mimic an acute vestibular syndrome

^ – the word ‘vestibular’ refers to the nature of the symptom and can be due to pathology originating in either the central or the peripheral vestibular structures (and may be due to underlying medical etiologies such as orthostatic hypotension or cardiac dysrhythmias)

The differential diagnosis of dizziness is broad. Each timing and triggers category suggests a narrowed differential diagnosis (Table 1). In some early-presenting patients, the episodic nature may not yet be apparent and some patients with benign paroxysmal positional vertigo (BPPV) describe a vague but persistent dizziness or lightheadedness between episodes.

Table 1 – Differential diagnosis of acute dizziness based on the timing and triggers category *

Vestibular syndrome	Common benign (non-life threatening) causes	Key dangerous (potentially life-threatening) mimics	Important less common causes
AVS (~30%)	● Vestibular neuritis^	● Posterior circulation ischemic stroke	● Posterior fossa hemorrhage ● Wernicke syndrome ● Labyrinthitis (vestibular neuritis-like vestibulopathy with new, accompanying ipsilateral hearing loss; may be viral or bacterial) ● Multiple sclerosis ● Drug or medication toxicity
s-EVS (~40%)	● Vestibular migraine	● Posterior circulation TIA	● Cardiac dysrhythmia ● Pulmonary embolism ● Panic attack ● Menière disease
t-EVS (~30%)	● BPPV ● Orthostatic hypotension caused by non-life-threatening medical conditions	● CPPV from structural central lesions (e.g., posterior fossa mass lesion, stroke) ● Orthostatic hypotension caused by potentially life-threatening medical conditions	● Posterior circulation TIA from rotational vertebral artery syndrome ● Carotid sinus syndrome ● Postural orthostatic tachycardia syndrome (POTS)

Abbreviations: AVS = acute vestibular syndrome, s-EVS = spontaneous episodic vestibular syndrome, t-EVS = triggered episodic vestibular syndrome, BPPV = benign paroxysmal positional vertigo, CPPV = central paroxysmal positional vertigo, TIA = transient ischemic attack

* - This list is not meant to be encyclopedic but rather focuses on the more common or important treatable uncommon causes of acute dizziness. The proportion of patients in each timing-trigger category refers to dizziness of presumed neuro-vestibular cause (i.e., not due to an obvious medical illness), which is about half of all acute dizziness.
^ – Vestibular neuritis is sometimes referred to as acute unilateral peripheral vestibulopathy. It is a presumed viral or post-viral condition (unlike labyrinthitis, which may be bacterial).

Roughly half of ED patients with dizziness have various general medical conditions, 33% have otological or peripheral vestibular causes and 11% have neurological etiologies (of which a third are cerebrovascular).(6)

When seeing an acutely dizzy patient in the ED, it is important to avoid anchoring and cognitive bias.(22) There are numerous general medical conditions that can present with dizziness; however, emergency clinicians' normal workflow will usually identify these causes. Co-chief complaints such as dizziness ***plus*** new dyspnea, chest or abdominal pain, diarrhea, dysuria, or fever each suggest other potential diagnoses. A history of a new medication might cause either side effects or drug-drug interactions resulting in dizziness. Vital sign assessment provides other clues. Fever, significant tachycardia or bradycardia, an irregular pulse, hypoxia or tachypnea, hypotension, hypertension (with the caveat that ischemic stroke can be associated with compensatory hypertension) should always be explained and should alert clinicians to search for a general medical explanation. Physical exam findings such as dry mucous membranes, jugular venous distention, a new heart murmur, rales or wheezing, significant abdominal tenderness or an acute rash would be clues of various general medical conditions.

In studies of ED patients with acute dizziness, only 3.2-6% were found to have serious central causes, mostly ischemic stroke.(3, 23, 24) Among the subset of dizzy patients with AVS, the most common causes are vestibular neuritis (also referred to as acute unilateral peripheral vestibulopathy) and posterior circulation ischemic stroke; labyrinthitis is an uncommon peripheral cause.(25-32) Approximately 10-25% of cases of AVS are due to stroke, the vast majority of which are ischemic, rather than hemorrhagic.(5, 31) In a study of over 5500 ED patients with dizziness, 27% had a CT scan done and 3% had an magnetic resonance imaging (MRI), presumably in an attempt to avoid missing a stroke.(33) Importantly, the sensitivity of CT for early-presenting acute ischemic stroke has been shown to be as low as 10%.(34)

This low prevalence of stroke among all comers with acute dizziness, coupled with the very low sensitivity of CT for ischemic stroke underscores the limited diagnostic utility of CT for patients presenting with dizziness.(4, 5, 35-41) Although CT is far more sensitive for intracerebral hemorrhage (ICH), this is an uncommon cause of patients presenting with ***isolated*** dizziness.(42) In this study of 595 ICH cases, only 13 (2.2%) presented with dizziness and a NIHSS of <2. All 13 patients had focal or global neurological symptoms or signs. Viewed from the opposite perspective, a pooled analysis of 126 AVS patients reported that five (4%) had ICH as a cause.(31) Only two of those five patients had isolated dizziness.

In practice, CT is used far more frequently than MRI in the ED to attempt to diagnose or exclude stroke,(33) but the results are rarely helpful.(9, 35) This represents an important knowledge gap amongst emergency clinicians.(43) Patients with dizziness diagnosed with a benign diagnosis and then discharged from the ED after a negative CT at the index visit were 2.3 times more likely to return with a stroke within 30 days compared to patients who did not have a CT, suggesting that physicians correctly risk stratified for stroke but then relied on CT (the wrong test) to exclude it.(44) It is clear that some of these patients suffer serious morbidity and mortality from this misdiagnosis,(45) but the proportion of misdiagnosed patients who are

harmed (due to extension of the initial stroke, developing a second stroke, or complications from posterior fossa edema) has not been systematically studied.

It is worth noting that a decision to order a CT scan (despite its low accuracy) has multiple potential influences.(46) Evidence from ED clinician surveys suggests that individuals who rely on the traditional dizziness "type" schema for diagnosis are more likely to also rely on CT to rule out stroke, reinforcing that this may partially be a knowledge gap.(43) However, the decision to order neuroimaging is likely also driven by other factors such as overreliance on technology relative to bedside examination,(47) a culture of blame,(48) medicolegal fears,(46, 49) or patient preferences.(46, 50)

Although MRI is far more sensitive than CT for acute ischemic stroke,(34) it, too, has limitations. A meta-analysis found that MRI with diffusion-weighted imaging (DWI) missed 6.8% of ischemic strokes (within the first 72 hours) and MRI-DWI negative strokes were five times more common in posterior circulation events.(51) In patients specifically presenting with an AVS, early DWI-MRI (within 48 hours of symptom onset) misses 10-22% of strokes.(28, 52-54) and 50% of small volume posterior fossa strokes, half of which are due to large vessel disease.(54)

Thus, dizziness is common, a non-trivial minority of cases are caused by ischemic stroke for which CT, the common "go to" test in the ED, has poor diagnostic sensitivity. While neuroimaging has its limitations in the diagnostic evaluation of acutely dizzy patients, the bedside exam can be very helpful. In the hands of neuro-otologists, the physical examination can accurately distinguish peripheral from central causes of AVS.(25, 28, 30) However, many EDs do not have access to these sub-specialists, even via telemedicine. Although systematic reviews and single institution experience report that emergency clinicians in routine practice do not use these tools, use them in the wrong patients, or perform or interpret the testing incorrectly,(55-57) accumulating evidence also shows that emergency clinicians can successfully learn and apply these techniques.(58-60)

A critical message of this guideline is that a training program that demonstrates durable skill acquisition needs to be developed and disseminated at scale so that emergency clinicians can become more proficient and more confident in performing these bedside ocular motor tests. This curriculum will likely need to combine didactic learning with generous use of video examples. It is also possible that this could be aided by more routine use of video-oculography (VOG) (see Conclusion and research needs section for Question one).

Evidence also shows that emergency clinicians are not using best practices to treat patients with BPPV with bedside canalith repositioning maneuvers such as the Epley maneuver, recommended by two different BPPV guidelines, one by the American Academy of Neurology (Level A recommendation) and the other by the American Academy of Otolaryngology - Head and Neck Surgery (Strong recommendation).(61, 62) Not recognizing or properly treating these benign conditions can result in unnecessary resource utilization, falls, injuries, lost work, medication side effects, increased recurrent rate and diminished effectiveness of delayed therapeutic maneuvers.(61, 63-70) Although less serious than missing a stroke diagnosis, the

number of patients affected is far larger. Confidently diagnosing BPPV essentially rules out a stroke, just as seeing an intrauterine pregnancy on ultrasound in a patient with first trimester vaginal bleeding excludes an ectopic pregnancy (barring two simultaneous diagnoses in the first case and a heterotopic pregnancy in the second).

In ED patients with acute dizziness, it is the characteristics (not simply the presence or absence) of nystagmus that can be extremely helpful in making a confident diagnosis and yet studies show that emergency clinicians harbor misconceptions about how nystagmus informs the diagnostic process.(14, 56-58) Collectively, these studies show that when nystagmus is documented by frontline providers, the descriptions of the nystagmus are often inconsistent with the recorded diagnoses, suggesting that either the clinician was misinterpreting the type of nystagmus, or they were misinterpreting its diagnostic significance, for example diagnosing BPPV in a patient with spontaneous nystagmus. Furthermore, a recently completed clinical trial (AVERT NCT02483429) found nystagmus descriptions by ED clinicians frequently did not match eye movements recorded in the ED by portable VOG (*Newman-Toker, unpublished*). The details of nystagmus can be extremely helpful both in making a specific diagnosis of peripheral vestibular causes and distinguishing peripheral from central ones (Table 2).

Table 2 – Common nystagmus patterns useful for diagnosis of acutely dizzy patients

Nystagmus pattern	Nystagmus characteristics	Common causes
Peripheral vestibular		
Positional	· Transient (lasts < 30s) upbeat-torsional nystagmus triggered by the Dix-Hallpike test · Transient (lasts < 90s) horizontal nystagmus triggered by the supine roll test and beating toward the lowermost ear (“geotropic”)	· Posterior canal BPPV · Horizontal canal BPPV
Persistent	· Horizontal spontaneous* (present on primary gaze) nystagmus that is unidirectional (never changes direction with different gaze positions or positional tests [“direction-fixed”])	· Vestibular neuritis *(but can be seen in stroke^)*
Central vestibular		

Positional	· Non-fatiguing positional nystagmus (especially downbeating or horizontal nystagmus beating away from the lowermost ear [“apogeotropic”])	· CPPV *(but can be seen in rare BPPV variants^)*
Persistent	· Dominantly vertical (upbeating or downbeating), or dominantly/purely torsional spontaneous* nystagmus · Gaze-evoked (direction changing) horizontal nystagmus (persistent left-beating nystagmus on leftward gaze and persistent right-beating nystagmus on rightward gaze)†	· Stroke, Wernicke syndrome, multiple sclerosis (or other structural central lesions) and medication side-effects (e.g., anticonvulsants) or acute intoxication (e.g., alcohol)

*“Spontaneous nystagmus” refers to nystagmus that is present on routine testing when the patient opens their eyes and looks straight ahead (also known as “primary gaze”). “Positional nystagmus” refers to nystagmus that is not present when the head is held still but is elicited on specific positional movements of the head (e.g., the Dix-Hallpike test).

^ - Some findings are ambiguous (i.e., can be seen in both peripheral and central causes). Spontaneous horizontal unidirectional (“direction-fixed”) nystagmus is typical of vestibular neuritis but can also be seen with strokes. Non-fatiguing positional nystagmus that is horizontal and beats away from the lowermost ear (“apogeotropic”) can be seen in CPPV but also with an uncommon BPPV variant (horizontal canal cupulolithiasis).

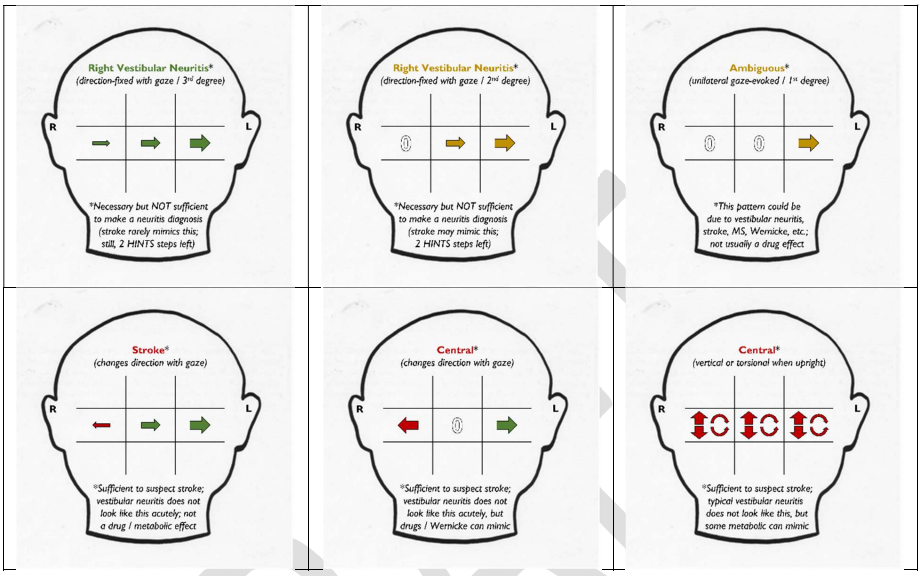
† **Pathologic gaze-evoked nystagmus** must be differentiated from physiologic end-gaze nystagmus (sometimes called “end-point nystagmus”). The physiologic (normal) form is (a) present only on extreme lateral gaze, (b) of low amplitude, and (c) non-sustained (i.e., lasts just a few beats). While an occasional “normal” individual will have more prominent physiologic end-gaze nystagmus, it must generally be assumed in a patient with acute dizziness that sustained gaze-evoked nystagmus is pathologic, rather than physiologic, until proven otherwise.

Figure 2 – Graphic representation of nystagmus patterns (Note: 2nd similar figure for positional nystagmus is coming)

Nystagmus Patterns *for SAEM GRACE3 Guideline*

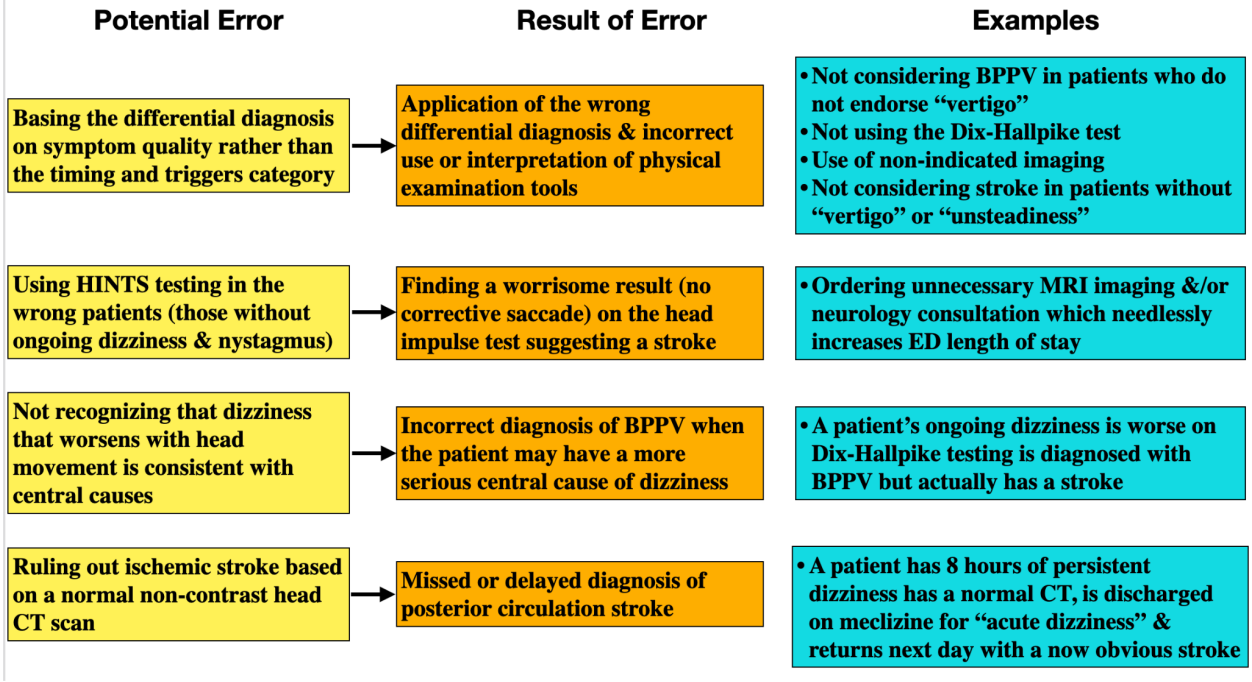
Nystagmus Patterns 2021-12-09

The Acute Vestibular Syndrome (AVS)



Thus, use of a flawed symptom quality paradigm, knowledge gaps related to bedside diagnostic and therapeutic maneuvers, limitations of brain imaging, and inconsistent availability of ED MRI all contribute to non-evidence-based management.(13) It is not surprising that emergency clinicians consistently select dizziness and vertigo as a high priority for a clinical decision rule for adult patients.(71, 72) It also helps explain the high misdiagnosis rate in patients with acute dizziness, with one study showing that emergency clinicians missed over a third of strokes presenting with dizziness.(23) Figure 2 illustrates some of the factors related to misdiagnosis.

Figure 2 – Common errors in the diagnosis of adult ED patients with acute dizziness



The objective of this guideline is to provide an evidence-based framework intended to support patients, clinicians and other health-care professionals in their decisions about the evaluation and management of adult ED patients with acute dizziness who do not have an obvious central cause with frank neurological findings or an obvious general medical one. To maximize the impact of this guideline, and because the diagnosis and treatment of acute dizziness is such a visual subject, members of the committee have created a multimedia educational smart phone App that is hosted by Johns Hopkins to help close the current knowledge gaps.

SCOPE AND PURPOSE

The target audience includes practicing ED clinicians (physicians and advanced practice providers) responsible for the evaluation and management of adult patients presenting with acute dizziness in community and academic settings, as well as healthcare systems and

hospitals responsible for care pathways in this patient population. Since there are no current guidelines regarding the overall diagnosis and management of patients presenting with acute dizziness, the Society for Academic Emergency Medicine (SAEM) formed the Guidelines for Reasonable and Appropriate Care in the Emergency Department (GRACE-3) Writing Team to collect and analyze the evidence for ED care of the acutely dizzy ED patient to create this guideline.

METHODS

Group Composition

The GRACE-3 Writing Team included emergency clinicians from geographically diverse hospitals in the U.S., Canada, South America, and Europe, including those with research methodology expertise (all of whom are also practicing clinicians) and content expertise in the diagnosis and treatment of acute dizziness as well as three patient representatives. Of the 18 members five were female. The panel also included a board-certified neuro-otologist, and an oto-neurologist with advanced specialization in acute dizziness. The SAEM supported the development of this guideline.

Group Interaction and Processes

From March 2021 until August 2022, the GRACE-3 writing group met monthly using virtual conferencing. Committee members were selected based on their content expertise, as well as for gender, geographical and specialty diversity. Three patient representatives who had prior experience with advocacy in this space were also selected. Four subcommittees (three for the diagnostic questions [AVS, s-EVS, t-EVS] and two for the therapy questions [steroids for vestibular neuritis and the Epley maneuver for posterior canal BPPV]) met at various intervals but no less than once per month to refine priority questions, discuss specific topics, review literature searches, and synthesize existing evidence to develop the GRACE-3 recommendations.

The group applied the Grading of Recommendations Assessment Development and Evaluation (GRADE) framework to assess literature identified through a systematic review process and to generate clinical recommendations.(73-76) In brief, GRADE methodology for guideline development is a stepwise process that includes: a) development of systematic reviews of priority questions; b) assessment of certainty in the evidence at the outcome level by explicit consideration of the eight GRADE criteria (risk of bias, inconsistency, indirectness, imprecision, publication bias, effect size magnitude, dose response, and opposing biases and confounders); c) development of recommendations using the GRADE Evidence-to-Decision (EtD) framework, which includes consideration of the certainty (quality) of evidence, the balance of benefits and potential harms, equity considerations including the values and preferences of stakeholders including patients and clinicians, resource utilization including cost and feasibility, and acceptability of recommendations to stakeholders. Recommendations are assigned direction (for, against, or either) and strength (strong versus conditional/weak [the latter used interchangeably in GRADE]).(77)

We used the direct costs for procedures and tests derived from Medicare data. We recognize that there are many indirect costs including the costs of training physicians/clinicians to learn new bedside evaluation and treatment techniques, time lost from work in patients with a diagnostic delay, those related to a subsequent stroke in patients who initially presented with a posterior circulation TIA, or costs related to falls and injuries due to untreated benign vestibular problems and others. However, due to the inherent difficulties in assigning specific numeric values, we used only the direct costs in our assessments of "cost-effectiveness".

Training

The methodologists all received GRADE training, and all writing group members were encouraged to watch online video content describing the GRADE methodology and its application to GRACE-3. (https://www.saem.org/publications/academic-emergency-medicine/grace)

Declaration and management of competing interests

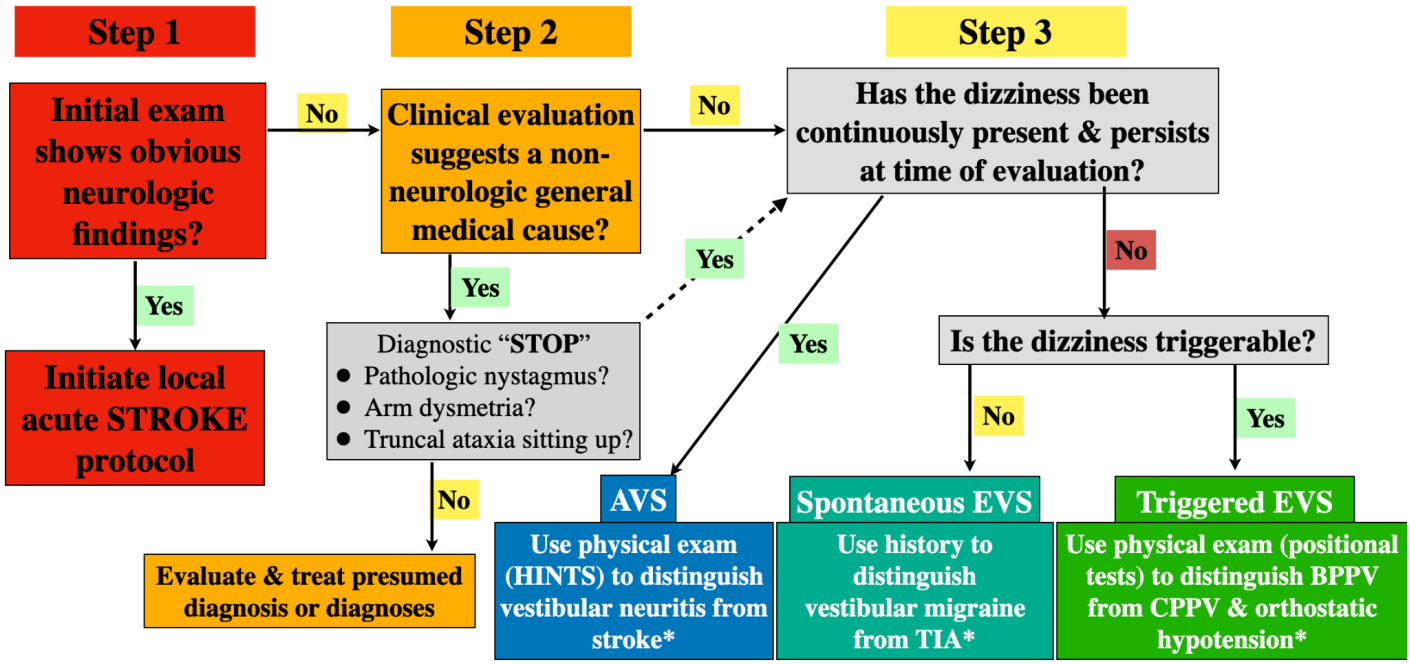
All group members disclosed conflicts of interest using SAEM's standard methods. All members were able to participate as a voting member with the following disclosures and management (see details at end of document).

Definitions of the intended patient population

The GRACE-3 writing group deliberated extensively about the population of interest for this clinical practice guideline and focused on definitions of the various acute presentations of adult ED patients with dizziness or vertigo (AVS, s-EVS and t-EVS) as discussed above and depicted in Figure 1. Using these diagnostic categories is key in creating meaningful questions and in crafting the recommendations, because the evidence, the differential diagnosis and clinical approach and the diagnostic test characteristics differ based on these presentations. Note that the use of the word "vestibular" does not denote a peripheral cause; pathology affecting either central or peripheral vestibular structures can cause dizziness.

A diagnostic algorithm may help to conceptualize and direct the clinical approach to these patients (Figure 3). The first step is meant to rapidly identify patients whose dizziness is not isolated and who may be candidates for reperfusion or other time-sensitive treatments. Step two is intended to identify the roughly 50% of acutely dizzy patients with general medical causes. The final step poses questions to identify the patient's timing and triggers category, the target population for this guideline.

Figure 3 – Diagnostic Algorithm for Approaching Adult ED Patients with Acute Dizziness



AVS: acute vestibular syndrome, EVS episodic vestibular syndrome
For each vestibular syndrome, only the most common diagnoses are listed

* - for each vestibular syndrome, only the most important and common benign and central causes are listed

Selection of questions

The GRACE-3 writing group discussed the target population and considered the management challenges presented, while attempting to maintain the perspectives of treating clinicians, health systems, and patients. The GRACE-3 writing group generated a series of potential questions related to diagnosis, treatment, and disposition.

Because of the wide range of medical conditions that can present as acute dizziness (e.g., cardiac dysrhythmia, anemia, medication side effects, dehydration and many others), the GRACE-3 writing group considered including these general medical causes in the search, but instead chose to focus on the subset of ED dizzy patients ***without*** an obvious medical or neurological cause. We specifically for literature that defined the three clinical syndromes previously specified, acknowledging that these distinctions are often lacking in the existing literature.

An important consideration for the GRACE-3 Writing Team was the feasibility of the guideline for emergency clinicians and patients in various practice settings. The GRACE-3 Writing Team openly discussed divergent intellectual biases amongst members of the group and attempted to account for them in crafting the recommendations. For example, disagreements about level of detail to include or use of jargon were resolved by group discussion followed by an open vote, with the final decision driven by the majority. The committee recognized that many emergency clinicians are unfamiliar with some of the diagnostic and therapeutic maneuvers that are useful in patients with acute dizziness, and therefore we included an important recommendation for clinician training. We included an algorithm to help clinicians better conceptualize the diagnostic flow of these patients. We also proposed language for emergency clinicians to use for discharge instructions (Appendix S9).

After several months of discussion, all GRACE-3 writing group members, including three patient representatives, had the opportunity to submit candidate questions and outcomes of interest, using the standard PICO (Population, Intervention, Comparison, Outcomes) format.(78) Candidate questions shared features such as patient-oriented benefits (improved diagnosis, symptom reduction, reduced radiation risk, and cost) and impact on health system and societal resource utilization (more rational use of imaging, more accurate diagnosis and targeted treatment). The writing group chose to limit the questions to five based on available time and resources and prior experience from GRACE-1(79) and GRACE-2.(80) Box 2 details the final five key priority questions selected by the GRACE-3 writing group. Our questions were compound, resulting in multiple recommendations per question.

Box 2 – PICO questions for GRACE-3

QUESTION 1 – Should adult ED patients presenting with acute, continuous prolonged dizziness/vertigo (the acute vestibular syndrome [AVS]) undergo neuroimaging to diagnose stroke in the ED, or should they be diagnosed through bedside examination without neuroimaging? If yes to neuroimaging, what type of imaging? If no to neuroimaging, what type of bedside examination?

QUESTION 2 – Should adult ED patients presenting with spontaneous episodes of dizziness/vertigo (the s-EVS) undergo neuroimaging to diagnose TIA in the ED, or should they be diagnosed through bedside examination without neuroimaging? If yes to neuroimaging, what type of imaging? If no to neuroimaging, what type of bedside examination?

QUESTION 3 – Should adult ED patients presenting with triggered episodes of dizziness/vertigo (the t-EVS) undergo neuroimaging to diagnose stroke in the ED, or should they be diagnosed through bedside examination without neuroimaging? If yes to neuroimaging, what type of imaging? If no to neuroimaging, what type of bedside examination?

QUESTION 4 – Should adult ED patients diagnosed with vestibular neuritis be treated with steroids?

QUESTION 5 - Should adult ED patients diagnosed with posterior canal BPPV be treated with a canal repositioning maneuver (e.g., the Epley maneuver)?

Abbreviations: ED: emergency department; AVS: acute vestibular syndrome; s-EVS: spontaneous episodic vestibular syndrome; t-EVS: TIA: transient ischemic attack; transient episodic vestibular syndrome; BPPV: benign paroxysmal positional vertigo

Selection of outcomes of interest

Each subcommittee selected outcomes of interest from those judged to be of greatest importance by the writing group including the three patient representatives. For the three diagnostic questions, the outcomes related to accurate diagnosis. For the fourth and fifth questions on therapy, the outcomes focused on symptom relief and other markers of improvement.

Evidence synthesis and development of clinical recommendations

Systematic reviews

Each of the GRACE-3 subcommittees focused on its specific PICO questions. For the first three questions related to diagnostic accuracy, the Mayo Clinic Evidence Based Practice Center performed a comprehensive systematic review. With input from study investigators, who were physicians, medical reference librarians created and performed a comprehensive search strategy using search terms submitted by the writing group. Controlled vocabulary supplemented with keywords was used to search for neuroimaging and physical exam tests for adult ED patients with dizziness/vertigo. The databases were searched between 2000 to September 30, 2021 without any language restrictions. Databases included Ovid Medline (1946+, including Epub, ahead-of-print, in-process, and other non-indexed citations), Ovid Embase (1974+), Ovid EBM Reviews and Web of Science Core Collection (1975+), Ovid Cochrane Central Register of Controlled Trials, Ovid Cochrane Database of Systematic Reviews, and Scopus (1970+). All steps of the systematic review were done in duplicate including study selection, risk of bias assessment and data extraction. Full manuscripts of the systematic review performed for this guideline are published separately.(81, 82)

For the question related to steroid use in vestibular neuritis, the GRACE-3 subcommittee performed an umbrella review (systematic review of systematic reviews).(83) Of the 149 titles retrieved, five systematic reviews were selected for quality assessment. Two were found to be of high methodological quality.(84, 85)

For the question on the use of the Epley maneuver for treatment of posterior canal BPPV (pc-BPPV), we performed another umbrella review. Of the 2228 abstracts reviewed in duplicate, we found 70 manuscripts for full-text review. We sought systematic reviews of randomized controlled trials (RCTs) that evaluated the effects of Epley maneuver (intervention of interest) as compared to placebo or sham procedure (comparison) in adult patients diagnosed with pc-BPPV (population). Seven systematic reviews were included in the qualitative synthesis, and

one systematic review was of high methodological quality and was included in the quantitative assessment.(86)

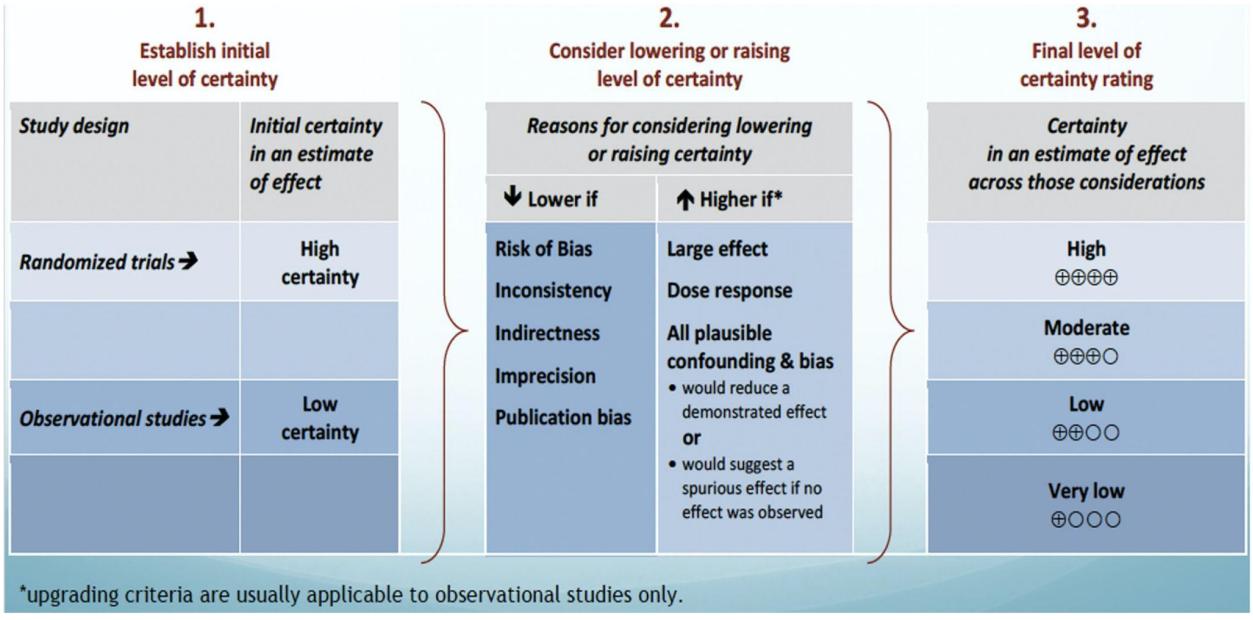
The full search strategies for the five PICO questions are available in **Appendix S1, S2 and S3**.

The individual subcommittee evidence synthesis documents were then circulated among the group in January 2022 for review and commentary.

Certainty of evidence

After synthesizing the available evidence in systematic reviews, certainty of evidence was assessed using GRADE.(87, 88) The GRADE methodology provides a transparent approach to evaluate the certainty of evidence at the outcome level based on eight criteria including risk of bias (methodological flaws),(89, 90) inconsistency (heterogeneity across studies),(91, 92) indirectness (studies conducted in populations other than the intended ED population),(90, 93) imprecision (wide confidence intervals resulting from underpowered studies/studies with small sample sizes), publication bias, effect size magnitude, dose-response effects, and opposing bias/confounders.(92, 94) A level of certainty in the evidence is assigned to each effect estimate evaluated (**Figure 4**). The GRADEpro Guideline Development Tool (https://gradepro.org/) was used to generate summary tables and Evidence to Decision Frameworks. Ultimately, an overall certainty in the evidence was determined to accompany each recommendation.

Figure 4 – Rating the certainty in the evidence using the GRADE methodology



*Reproduced with permission by the U.S. GRADE Network

Evidence-to-Decision framework

The GRACE-3 writing group met virtually to discuss the evidence synthesis and recommendations using the GRADE EtD framework.(73-76, 95) For each PICO question, the

group responsible for that question carried out extensive, structured group discussions (with input from at least one methodologist per group) of each EtD framework criteria including certainty of evidence, balance of benefits and harms (desirable and undesirable effects of the intervention, balance of effects), values, resources, acceptability, feasibility, and equity.(74)

Following discussion of all EtD framework criteria, the GRACE-3 writing group developed recommendations for each PICO question with a direction (for, against, or either) and a strength (strong, or conditional/weak) (**Table 2**). Each recommendation also received an overall certainty of evidence level. Recommendations for which no evidence was found were assessed by indirect evidence and consensus. When applicable, we created "Ungraded good practice statements" when recommending best practices related to history or physical exam as there aren't studies comparing "good history/physical exam" versus "poor history/physical exam". Good practice statements represent situations in which a large body of indirect evidence strongly supports the net benefit of the recommended action.(96, 97) **Box 1** includes the recommendations of GRACE-3.

Use of indirect evidence

GRADE methodology allows the use of indirect evidence.(90, 93) Lacking GRADE-specific recommendations to define "indirect evidence" or distinguish it from "direct evidence", the GRACE-3 writing group decided *a priori* that "direct evidence" would match each element of the PICO question for AVS, t-EVS, and s-EVS, respectively.(98) If any element of the published research differed from the PICO question, that manuscript was considered "indirect evidence". The systematic reviews conducted to inform this guideline included studies of undifferentiated dizziness populations, as well as studies that used the same categories (AVS, s-EVS and t-EVS). Directness or indirectness of the evidence are denoted in each question. In the GRADE approach, concerns for indirectness downgrades the certainty in the evidence, limiting the strength of conclusions and recommendations that are drawn.(90, 93)

Indirect evidence was especially important for GRACE-3 since much of the research in this area was not done in the ED or interventions that were done in the ED were not always performed by emergency clinicians. Although indirect evidence typically leads to downgrading of the certainty of evidence, the committee extensively debated how to best incorporate it. This is because some of the diagnostic maneuvers, for example, the HINTS exam and the Dix-Hallpike test (Dix-Hallpike test), are heavily rooted in pathophysiology that is the same no matter ***who*** is performing these maneuvers as long as that individual is ***trained in how*** to perform them correctly. This impacted our recommendations including the recommendation for training. Another example relates to the sensitivity of CT for stroke in patients with the AVS, in which a substantial body of indirect evidence aligns in the same direction as the more limited direct evidence, leading to a high level of certainty of evidence for the recommendation.

QUESTION 1 - Should adult ED patients presenting with acute, continuous prolonged dizziness/vertigo (the AVS) undergo neuroimaging to diagnose stroke in the ED, or should they

be diagnosed through bedside examination without neuroimaging? If yes to neuroimaging, what type of imaging? If no to neuroimaging, what type of bedside examination? [Evidence to decision frameworks in Appendix S4]

1. In adult ED patients with acute vestibular syndrome with nystagmus, we recommend routine use of the 3-component head impulse, nystagmus, test of skew (HINTS) exam for clinicians trained in its use* to distinguish between central (stroke) and peripheral (inner ear, usually vestibular neuritis) diagnoses. (Strong recommendation, FOR) [High certainty of evidence]

2. In adult ED patients with acute vestibular syndrome with nystagmus, we suggest assessing hearing at the bedside by finger rub to identify new unilateral hearing loss as an additional criterion to aid in the identification of stroke, even if the 3-component HINTS exam result suggests a peripheral vestibular diagnosis. (Conditional recommendation, FOR) [Moderate certainty of evidence]

3. In adult ED patients with acute vestibular syndrome without nystagmus, we suggest assessing severity of gait unsteadiness to help distinguish between central (stroke) and peripheral (inner ear, usually vestibular neuritis) diagnoses. (Conditional recommendation, FOR) [Moderate certainty of evidence]

4. In adult ED patients with acute vestibular syndrome, we recommend against routine use of non-contrast computed tomography of the brain (CT) or (CT angiography [CTA]) to help distinguish between central (stroke) and peripheral (inner ear, usually vestibular neuritis) diagnoses. (Strong recommendation, AGAINST, see Implementation Considerations) [High certainty of evidence]

5. In adult ED patients with acute vestibular syndrome, we recommend against routine use of magnetic resonance imaging of the brain (MRI) or cerebral vasculature (MRI angiography [MRA]) as the first-line diagnostic test to help distinguish between central (stroke) and peripheral (inner ear, usually vestibular neuritis) diagnoses. (Strong recommendation, AGAINST, see Implementation Considerations) [High certainty of evidence]

6. In adult ED patients with acute vestibular syndrome and central or equivocal HINTS results, we recommend use of stroke protocol MRI (with diffusion-weighted images [DWI] and MRA) to further help distinguish between central (stroke) and peripheral (inner ear, usually vestibular neuritis) diagnoses. (Strong recommendation FOR, see Implementation Considerations regarding timing of MRI) [High certainty of evidence]

Summary of evidence

The key differential diagnosis in AVS is between stroke (central) and vestibular neuritis (peripheral). Patients with AVS generally remain symptomatic at the time of ED assessment, so

physical exam has the potential to aid diagnosis, and structural neuroimaging has the potential to "rule out" stroke. The systematic review found direct evidence of diagnostic accuracy for both physical exam elements (general neurological exam, HINTS, and gait/limb ataxia) and neuroimaging (CT, CTA, and MRI) in the evaluation of adult ED patients with AVS.(81, 82) This evidence supports a strong recommendation for use of HINTS followed by MRI-DWI to confirm stroke when eye signs appear central and MRI-DWI to confirm stroke when eye findings are completely normal but the patient is unable to stand independently. Conversely, it also supports a strong recommendation for diagnosis of vestibular neuritis without neuroimaging when HINTS eye signs are all peripheral-appearing, hearing loss is absent, and patients can stand unaided.

Direct and indirect evidence

General neurological exam

The systematic review that focused on the clinical exam(81) identified articles with data related to the general neurological exam,(99-103) cranial nerve testing,(104-106) limb weakness,(28, 104, 105, 107-109) dysarthria assessment,(105, 107) presence of spontaneous nystagmus,(60, 103, 106, 110) truncal or gait ataxia,(28, 99, 100, 104, 111-113) tandem gait assessment,(104, 111) limb ataxia,(28, 99) any cerebellar sign (unspecified dysmetria, finger-to-nose, heel-to-shin and rapid alternating movement),(104, 105, 107, 111) and hearing loss.(104, 107, 112) Nearly all of the studies were judged to have moderate to high risk of bias. For the most part, these studies reported a low sensitivity but high specificity for stroke or other central cause if the findings were present, which is expected given that if a central finding is present, the causative pathology is central.

The two studies (n=444) that reported diagnostic test accuracy when performed by emergency clinicians (although the specific elements of the exams performed were not specified and the number of patients were low, total n=444) reported sensitivities ranging from 37.5-72.7%, and specificities 66.7-100%.(103, 104) Additionally, it is important to note that indirect evidence demonstrates that some patients with acute ischemic posterior circulation strokes have a NIHSS of zero.(114) A recently completed clinical trial (AVERT NCT02483429) found that, among 130 ED patients randomized with dizziness and either pathologic nystagmus or pathologic ataxia, there were 14 strokes (9 ischemic strokes, 4 TIAs, and 1 hemorrhage) – these all had NIHSS scores of zero (minimum) to 4 (maximum), with an interquartile range of zero to 1.(115)

Spontaneous nystagmus

The ***presence*** of spontaneous nystagmus *(*6 studies, 621 patients) had a sensitivity of 52.3% (95% CI 29.8%-74.0%, moderate certainty) and specificity of 42.0% (95% CI 15.5%-74.1%, moderate certainty).(60, 103, 106, 109, 110, 116) Of the 5 studies that reported the specialty of the examiner, emergency clinicians performed the exams in 4 (n=531). In the largest study, in which emergency clinicians used Frenzel lenses, which had a low risk of bias (n=342), the sensitivity for a central cause was 45.0 and the specificity was 77.6.(60) Because nearly all patients with vestibular neuritis have spontaneous nystagmus and about half of patients with cerebellar stroke do, the mere presence of spontaneous nystagmus (without further characterizing the type), is not helpful in distinguishing central from peripheral causes.(18, 26)

Type of nystagmus

In patients with an AVS, nystagmus that is vertical, torsional or gaze-evoked direction-changing (i.e., right-beating on rightward gaze and left-beating on leftward gaze) indicates a central cause. The systematic review identified 16 studies (n=1366) reporting data on the ***type*** of nystagmus(25, 28, 53, 104, 107, 112, 116-125). In a pooled analysis of the 16 studies, sensitivity of nystagmus type was 50.7% (95% CI 41.1%-60.2%, moderate certainty) and specificity was 98.5% (95% CI 91.7%-99.7%, moderate certainty). In a sensitivity analysis including patients with AVS (14 studies), there was a similar sensitivity and specificity.

In the one study in which only emergency clinicians' exams were reported, the sensitivity and specificity were 20.0 and 75.7%.(104) In three studies with a low risk of bias, the specificities were 97%,(123) and 100%.(28, 121) The examiner in each of these three studies were neurologists or neurology subspecialists.

Test of skew

Test of skew, in which the examiner uses the alternate cover test to detect vertical skew deviation is a finding that strongly suggests a central cause of a patient's dizziness. The systematic review identified 15 studies (14 of which were restricted to an AVS presentation) that evaluated this finding.(25, 28, 53, 104, 106, 107, 112, 116-119, 122, 125-127) A pooled analysis showed a sensitivity of 23.4% (95% CI 15.0-35.6%, moderate certainty) and a specificity of 97.6% (95% CI 96.1-98.6%, moderate certainty).(81) The one study that reported on exams done by emergency clinicians found a lower sensitivity (0%) but an unchanged specificity (98.6%).(104)

Gait & truncal ataxia assessment

Ten studies (1,810 patients) reported data on gait assessment and truncal ataxia. Increasing severity of truncal ataxia had an increasing specificity for central etiology.(28, 58, 99, 100, 104, 111-113, 117, 118) Pooled sensitivity was 69.7% (43.3%-87.9%, low certainty) and specificity 83.7% (52.1%-96.0%, low certainty). In the three studies that reported an emergency clinician performing the exam, the sensitivity was 74.2% (95% CI 55.9%, 86.7%) and specificity was 82.2% (95%CI 57.1%, 94.1%).(81) When evaluating the 5 studies in an AVS population, pooled estimates did not significantly differ.(81) A study of 114 patients with an AVS (judged to have moderate risk of bias because gait assessment was done by neurology residents) graded the severity of gait unsteadiness (see Table 3).(117) They found that Grade 2 or 3 ataxia was 93% sensitive and 61% specific for stroke, while Grade 3 ataxia was 67% sensitive and 100% specific for stroke.(117) Additional indirect evidence found that in a study of 92 consecutive patients with posterior circulation strokes, 88 (95.6%) had gait ataxia, further supporting the importance of gait assessment.(128)

Table 3 – Assessment of gait unsteadiness

Severity of gait unsteadiness	Definition	Positive predictive value of ataxia grade for stroke(117)

Grade 0	normal	0% (n=0/5) with no unsteadiness had stroke
Grade 1	mild to moderate imbalance with walking independently	7% (n=3/42) with Grade 1 unsteadiness had stroke
Grade 2	severe imbalance when standing or cannot walk without support	28% (n=11/39) with Grade 2 unsteadiness had stroke
Grade 3	falling at upright posture/inability to stand unaided	100% (n=28/28) with Grade 3 unsteadiness had stroke

Limb ataxia

The systematic review identified four studies (n=1135) reporting the presence of limb ataxia findings, defined as finger-to-nose testing (two), unspecified dysmetria (one) and combination of dysmetria and/or dysdiadochokinesia (one).(103, 104, 107, 111) The pooled sensitivity for limb ataxia was 24.6% (95% CI 15.6-36.5%, moderate certainty) and specificity was 978% (95% CI 94.4-99.2%, moderate certainty). In the one study done by emergency clinicians, the sensitivities/specificities for finger-to-nose, heel-to-shin and rapid alternating movements were 25%/99.5%, 0%/100% and 0%/99.7%, respectively.(104)

A more recent mono-center Japanese study not included in the systematic review reported on two cohorts (one retrospective and one prospective).(129) Emergency medicine residents performed the exams for finger-to-nose testing. The study included 357 patients (both cohorts combined) with isolated dizziness, of which 31 had a final diagnosis of a cerebrovascular cause of symptoms. Abnormal finger-to-nose testing was strongly associated with a central cause (OR 25.3, 95% CI 7.3-88.2, p<0.001).(129)

HINTS and HINTS plus exam

The HINTS (head impulse, nystagmus, test of skew) exam is a combination of three bedside ocular motor tests (Table 4) first described in 2009. When performed by vestibular experts, the diagnostic accuracy of the HINTS exam is high (98% sensitivity and >92% specificity.(28, 30, 117, 121) A limitation is that some these studies enrolled patients with at least 1 stroke risk factor (rather than an all-comer AVS population), which could impact the results.(28, 121) The head impulse test component should only be used in patients with ongoing dizziness who also have nystagmus. Use in other dizzy patients results in increased and unnecessary neuroimaging. For example, if a patient with anemia as a cause had persistent dizziness without nystagmus, the clinical findings (bilaterally normal head impulse tests) would falsely suggest stroke.

Fourteen studies including 1,781 patients evaluated HINTS.(53, 55, 58, 105, 107, 117-123, 125, 130) Pooled sensitivity was 92.9% (95% CI 79.1%-97.9%, high certainty) and specificity was 83.4% (95% CI 69.6%-91.7%, moderate certainty). In the 10 studies of patients with AVS, sensitivity was 93.1% (95% CI 86.2%-96.7%).(81) Two studies evaluated HINTS performed by ED providers. Dmitriew et al did not identify any central cases, thus sensitivity could not be calculated; specificity was 64.3% in an AVS population and 96.4% in a mixed population.(55) In Gerlier et al, emergency clinicians were provided with 4 hours of individual lectures and 2 hours

of workshop training. Sensitivity for stroke identification was 97.9% and specificity 64.5% in a mixed population (i.e., not restricted to AVS).(58)

In 2013, "HINTS plus" was introduced (Table 4), which is simply the addition of a fourth exam component – bedside test of hearing by finger rub. New unilateral hearing loss helps identify patients with anterior inferior cerebellar artery (AICA) territory stroke, a vascular distribution that accounts for nearly all of the false positive HINTS cases (HINTS tests as peripheral but the cause is really central).(121) This occurs because the AICA territory usually supplies blood to the inner ear via the labyrinthine artery, so AICA infarction often involves a combined peripheral (labyrinthine and cochlear infarction) and central (lateral pontine and cerebellar - site of the vestibular nerve entry zone) stroke. In other words, HINTS may look peripheral in AICA-territory strokes because the lesion is peripheral, but the cause of that peripheral involvement is a central, cerebrovascular one.

Five studies (342 patients) utilized the HINTS Plus with pooled sensitivity of 99.0% (95% CI 73.6%-100%, high certainty) and specificity of 84.8% (95% CI 70.1%-93.0%, high certainty).(100, 118, 119, 121, 122) No studies reported the HINTS plus performed by emergency clinicians.

The systematic review identified seven studies (n=955) evaluating hearing loss (apart from HINTS plus) and found a pooled sensitivity of 4.3% (95% CI 1.1%, 15.5%, high certainty) and specificity of 95.0% (95% CI 85.2%, 98.4%, high certainty).(104, 107, 112, 118, 119, 122, 131) The two studies in which the hearing test was administered by emergency clinicians also found sensitivities of 97% (all AVS patients,(104) and 91.8% (vestibular syndrome unspecified).(131) Collectively, these findings underscore the fact that in patients presenting with dizziness plus acute ipsilateral hearing loss, stroke is far more common than labyrinthitis.

It is clear that when applied in routine practice by emergency clinicians without special training, HINTS testing is inaccurate, partly due to use in the wrong patients and partly due to issues with its interpretation.(55, 132) On the other hand, emergency clinicians trained in the proper application and use of HINTS in a mixed population of ED patients with dizziness were found to have 97.9% sensitivity and 64.5% specificity for stroke with a 99.4% negative predictive value.(58) The training in this study was six hours (four of lectures and two of workshop) and was repeated seven months later. The training included not only the HINTS exam but also the maneuvers for diagnosing and treating both posterior canal BPPV (pc-BPPV) and horizontal canal BPPV (hc-BPPV).(58) Another study of trained emergency clinicians found similar excellent results for components of the HINTS exam (details described below in STANDING section).(60)

In patients with a clear-cut AVS, one would not normally use the Dix-Hallpike test. However, early in the course of BPPV, before its episodic nature has become clear, some patients describe waxing and waning symptoms, superficially mimicking an AVS. In such patients, assuming there is ***NO*** spontaneous or direction-changing gaze-evoked nystagmus, it is reasonable to use the Dix-Hallpike test.(133) In this situation, it is important to strictly interpret the Dix-Hallpike test results – a positive being defined as reproduction of symptoms ***PLUS***

transient, crescendo-decrescendo, upbeat-torsional nystagmus with torsion towards the affected ear and only during ipsilateral Dix-Hallpike test.

Table 4 – Components of the HINTS and HINTS + examinations(28, 121)

HINTS exam component	Usual finding^ in vestibular neuritis	Usual finding^ in stroke	Considerations
Head impulse test	Presence of a corrective saccade when head is rotated rapidly towards the affected side (opposite the fast phase of nystagmus)	Bilateral absence of a corrective saccade	Can be falsely reassuring in patients with AICA or labyrinthine infarcts. Has only been validated in AVS patients with nystagmus.
Nystagmus testing	Unidirectional horizontal (sometimes with a slight torsional component) nystagmus, always beating to same side with gaze or positional testing	Pure vertical, torsional or direction-changing horizontal, gaze-evoked nystagmus (beats right when looking right and beats left when looking left)	Central cases can mimic the nystagmus of vestibular neuritis closely. It is especially true that cases with unilateral gaze-evoked nystagmus and none looking straight or to the other side could be peripheral or central.
Test of skew	Vertical repositioning absent	Vertical repositioning present	Horizontal shifts of the eyes with alternate cover testing are common in the general population and should not be considered to be "skew" deviation as a sign of stroke. Rarely, a severe vestibular neuritis will have a clinically visible skew.
HINTS plus			
Hearing test by finger rub*	Hearing intact	New unilateral hearing loss	Helps to identify AICA or labyrinthine infarcts.

* Hearing testing is not part of the original 3-component HINTS exam but was added later and is referred to as HINTS plus (HINTS +) to add sensitivity for strokes.
^ None of the component tests is 100% sensitive as a stand-alone test. The head impulse test has the highest sensitivity, but all four benign findings (direction-fixed nystagmus, unilateral corrective saccade opposite the side of the fast phase of nystagmus, no skew, no hearing loss) must be present to confidently diagnose vestibular neuritis in AVS.
Abbreviations: HINTS = Head Impulse Nystagmus Test of Skew, AICA = anterior inferior cerebellar artery, AVS = acute vestibular syndrome

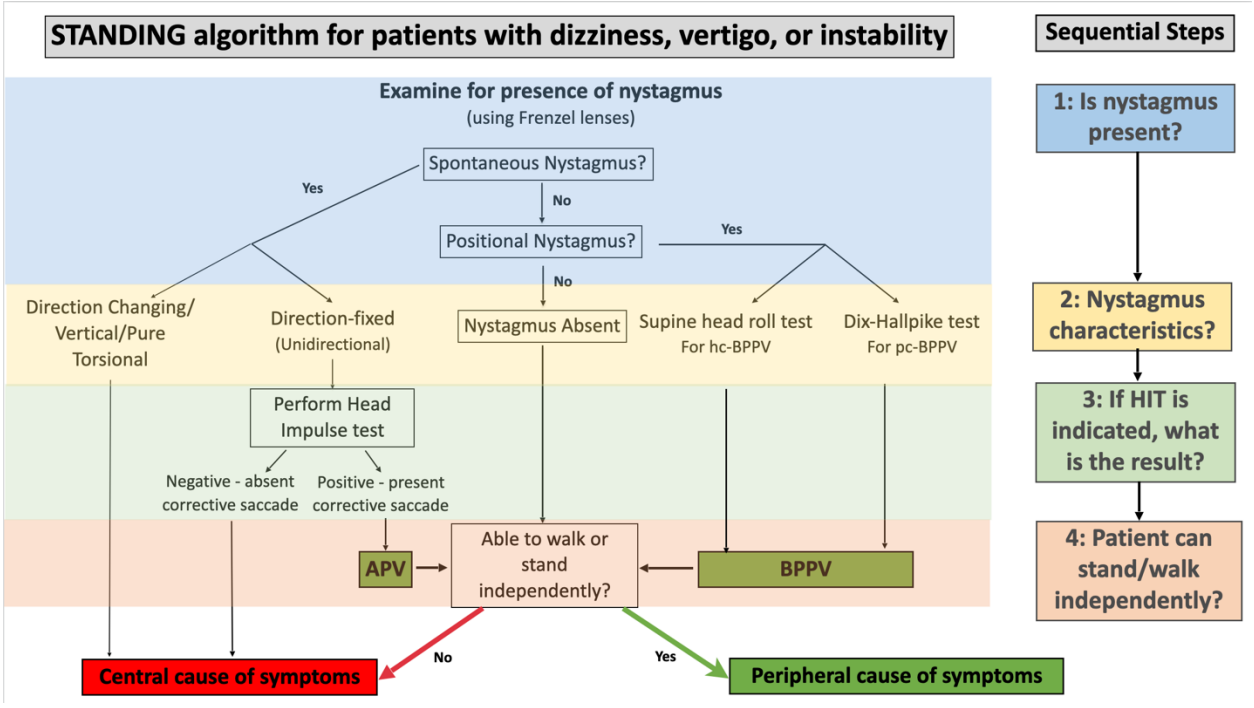
STANDING algorithm

The systematic review identified three articles (750 patients) that studied the STANDING algorithm (Figure 4).(58-60) This algorithm was developed by emergency clinicians and the interventions were performed by trained emergency clinicians. The training in this study included a six-hour workshop, four hours of lecture and a two-hour demonstration on normal volunteers followed by 10 proctored examinations on ED patients. Again, the training included not only the HINTS exam but also diagnostic and therapeutic maneuvers for pc- and hc-BPPV.(60)

The 4-step STANDING is more inclusive than HINTS in that positional nystagmus testing is part of the initial assessment of nystagmus so its use is not restricted to patients with an AVS. Step one (blue in Figure 4) is to define the presence or absence of nystagmus and step 2 (yellow) is to assess the characteristics of the nystagmus. Step three (green) is to perform the head impulse test in those patients with spontaneous nystagmus. The final step (orange) is to assess gait unsteadiness.(134) The sensitivity for identifying a central cause of the dizziness (mostly strokes) ranged from 93.4-100% and the specificities from 71.8-94.3%.(58, 60, 134)

The STANDING algorithm skips the step of deliberately classifying the patient as AVS, s-EVS, or t-EVS, and jumps straight to an algorithmic combination of HINTS, gait ataxia severity testing, and positional testing (minus consideration of skew deviation ['TS' in HINTS] or hearing ['plus' in HINTS plus]). Because our PICO questions were structured around AVS, s-EVS, and t-EVS, STANDING was not ultimately included in the final recommendations, although its overall structure is similar to the recommendations made for physical diagnosis when combined across syndromes.

Figure 5 – STANDING Algorithm(134)



Abbreviations: BPPV = benign paroxysmal positional vertigo, pc-BPPV = posterior canal BPPV, hc-BPPV = horizontal canal BPPV, APV = acute peripheral vestibulopathy (usually vestibular neuritis), HIT = head impulse test. Figure adapted from reference #(60).

CT scan

Because of its availability, speed for time-sensitive decisions and familiarity, CT is commonly used in the ED as the initial neuroimaging modality for patients with neurologic presentations. The systematic review identified six studies (771 patients) reporting on CT sensitivity in adult ED patients with acute dizziness.(36, 102, 109, 131, 135, 136) None of these studies specified vestibular syndromes but rather reported on a mix of ED patients with acute vertigo or dizziness. The reference standard used was MRI in four studies and clinical follow-up in two studies. Three studies evaluated the outcome of stroke, with sensitivity ranging from 6.7% to 75.0% and specificity ranging from 77.3% to 99.0%.(82) Three studies evaluated the outcome of all central causes, with sensitivity ranging from 21.4% to 43.4% and specificity ranging from 90% to 100%. In the meta-analysis, pooled sensitivity was 28.5% (95% CI 14.4%–48.5%), specificity of 98.9% (95% CI 93.4%–99.8%), positive likelihood ratio (LR) of 26.2 (95% CI 5.6–123.4), and negative LR of 0.72 (95% CI 0.58–0.91).(82) Sensitivity analysis of the four studies that used MRI as the reference standard had similar sensitivity and specificity. Not all the studies systematically obtained both CT and MRI in all patients with dizziness to search for strokes; MRIs as the reference standard in some studies were obtained because of clinical suspicion of stroke. This necessarily biases results towards larger, more obvious strokes and favors CT sensitivity. Thus, the pooled estimate of sensitivity for CT here is almost certainly a ceiling, rather than a floor estimate.

Although the systematic reviewers graded the pooled estimates of sensitivity and specificity for CT to have moderate level of certainty due to concerns for risk of bias, the guideline panel decided, after vigorous debate, to not downgrade given the body of both direct and indirect evidence all showing that CT is very inaccurate in identifying posterior ischemic strokes among patients with AVS. Therefore, the guideline panel's judgment of certainty of evidence for CT being an inaccurate test in this situation was deemed as high. In patients with AVS, if we apply the average pretest probability of stroke at 25%,(31) a negative CT will only decrease the posttest probability to 19.4%, which is far above the threshold that emergency clinicians have indicated as acceptable when "ruling out" stroke among patients presenting with acute dizziness (< 0.5% posttest probability of stroke).(137) Table 5 illustrates the impact of different diagnostic modalities on the posttest probability of stroke among adult ED patients with the AVS and shows poor performance of CT, better performance of elements of the neurological exam and gait, very good performance of MRI and excellent test characteristics of the HINTS plus exam.

Table 5. Pretest and post-test probabilities of stroke using different tests in adult ED patients with the acute vestibular syndrome. Estimates of diagnostic accuracy were extracted from published systematic reviews(81, 82)

Post-Test Probability of Stroke Following a Negative Test (Arranged by increasing level of test sensitivity – left to right)					
Pretest probability of stroke (vascular risk profile)	**CT** **Sens 28.5%** **Spec 98.9%** **NLR 0.72**	**General neuro examination** **Sens 46.8%** **Spec 92.8%** **NLR 0.57**	**Truncal/gait ataxia** **Sens 69.7%** **Sped 83.7%** **NLR 0.36**	**MRI** **Sens 79.8%** **Spec 98.8%** **NLR 0.20**	**HINTS plus Battery** **Sens 99%** **Sped 84.8%** **NLR 0.01**
10% (low)	7.4%	6.3%	3.8%	2.2%	0.1%
25% (average)(31)	19.4%	16.0%	10.7%	6.7%	0.3%
50% (high)	41.9%	36.3%	26.5%	16.7%	1.0%

Abbreviations: CT = non-contrast brain computed tomography; MRI = magnetic resonance imaging (with diffusion-weighted imaging); Sens = sensitivity; Spec = specificity; NLR = negative likelihood ratio; HINTS plus = head impulse, nystagmus, test of skew, and finger rub test for hearing.

As with any stroke, early CT is less sensitive than later CT. In a study of 356 consecutive ED patients with possible stroke, CT had an overall sensitivity of 15% (95% CI 12-23%).(34) Importantly, this study included all strokes, so likely the majority of strokes detected were larger anterior circulation infarcts which would be expected to be more visible on brain imaging. In ED patients with posterior circulation infarct, CT sensitivity for infarction, compared to MRI, ranged from 10%, to 41%.(37, 38) In the study reporting 41%, the average time from symptom onset to imaging was 12 hours.(37) Again, clinical selection of patients who underwent MRI and were therefore eligible for the study makes this an overestimate of CT sensitivity.

Studies analyzing the diagnostic yield of CT in ED patients presenting with dizziness or vertigo, have reported that finding a causative brain lesions ranged from < 1% to 7%.(35, 39, 40) Furthermore, the diagnostic yield of CT in ED patients with dizziness is decreasing over time due to rising rates of CT with stable rates of pathology detectable in the broader ED dizzy population and is associated with longer ED length of stays.(9) Another important adverse effect of a CT is the false reassurance of a negative study.(13, 44)

Furthermore, although CT is an excellent test for acute ICH, ICH rarely presents with isolated dizziness. In one study of 595 patients with ICH, only 13 (2.2%) had dizziness as the primary

chief complaint and a NIHSS of <3.(42) All 13 patients had some other neurological finding on exam.

CT angiography (CTA)
Our systematic review identified a single study (153 patients with undifferentiated dizziness) about CTA which had a low sensitivity for finding a central cause (14%) and a very high specificity (98%).(36) Indirect evidence of CTA is consistent with this finding. In a study of 228 patients (ED and outpatient) with acute dizziness who had a CTA, only three (1.3%) found a lesion that changed management.(138) In addition to providing false reassurance, other costs of CTA include radiation exposure with associated cancer risk, contrast-associated anaphylactoid reactions and nephropathy, and financial costs.

MRI scanning
The systematic review identified five studies of MRI (n=943).(28, 122, 136, 139) One study was in patients with AVS, one in patients with AVS symptoms that had resolved within 24 h, and three studies in undifferentiated dizziness. The reference standard was delayed MRI in three studies and follow-up diagnosis in two. Pooled sensitivity was 79.8% (95% CI 71.4%–86.2%), specificity 98.8% (95% CI 96.2%–100%), and negative LR 0.20 (95% CI 0.14–0.30). There were no false-positive examinations. Certainty in the sensitivity and specificity estimates was high.(82)

This is consistent with other data showing that small posterior circulation infarcts are five times more likely to be DWI-MRI negative than those in the anterior circulation.(51) In patients presenting with an AVS, as compared to the criterion standard of delayed MRI beyond 72 hours from symptom onset, early MRI sensitivity for stroke presenting with acute dizziness is roughly 80-90%.(28, 52, 54, 139) This is also consistent with the data showing that DWI-MRI is time dependent for strokes in any arterial distribution(28) and specifically in the posterior circulation.(140)

Taken together, these data show that MRI scanning, when done within 48 hours of symptom onset is less accurate than the HINTS exam, when performed by either a vestibular specialist or trained emergency physician.

Benefits
If HINTS testing were used by appropriately trained emergency clinicians, accurate diagnosis and treatment would be faster and both less dependent on and more accurate than emergent imaging. Furthermore, more widespread use of HINTS testing would eliminate many very low value CT scans as well as some MRI scans in patients diagnosed with a peripheral cause. The potential benefits of accurate and timely diagnosis of posterior circulation stroke in patients with an AVS include more reperfusion treatment (if indicated), rapid initiation of secondary prevention measures, finding and treating the underlying vascular lesion and monitoring and treating complications from posterior fossa edema.

Patients with ischemic posterior circulation minor strokes may be at higher risk of a subsequent stroke than those with anterior circulation strokes,(141) in part due to the incidence of

vertebral artery stenosis.(142, 143) Regarding reperfusion with intravenous alteplase, there are fewer data specific to patients with posterior circulation strokes compared to those of the anterior circulation; in the International Stroke Trial-3, only 246 of 3035 (8.1%) had posterior circulation strokes and the proportion of those presenting with dizziness or isolated dizziness was not reported.(144) Studies specifically analyzing intravenous thrombolysis in posterior circulation strokes, which both found similar outcomes to those anterior circulation strokes, did not report on the proportion of patients presenting with an AVS.(145, 146) A recent study of thrombolytic therapy that compared vascular territories also demonstrated that overall neurologic outcomes were similar, but also showed that the risk of brain hemorrhage in posterior circulation stroke was half that in anterior circulation stroke, suggesting that the risk-benefit ratio may favor thrombolysis in posterior circulation cases.(147)

Although many patients with minor strokes presenting with the AVS will not be candidates for thrombolysis, most of them are candidates for short-term (21 days) dual antiplatelet treatment with either clopidogrel or ticagrelor plus aspirin (DAPT) begun soon after the qualifying minor stroke or TIA (within 12-72 hours, depending on the study). A pooled analysis of 10,051 patients comparing with clopidogrel plus aspirin to aspirin alone found that DAPT had a reduced risk of major ischemic events at 90 days compared to aspirin monotherapy (hazard ratio 0.70; 95% CI 0.61-0.81, $p<0.001$).(148) A meta-analysis of four randomized clinical trials (n=21,459 patients) of DAPT (with either clopidogrel or ticagrelor) versus aspirin monotherapy started within 24 hours found that the intervention of DAPT reduced the outcome of recurrent ischemic stroke (relative risk 0.76, 95% CI 0.68-0.83, $p<0.001$).(149) Another network meta-analysis comparing DAPT with either clopidogrel plus aspirin with ticagrelor plus aspirin reported essentially identical improvements in both prevention of recurrent stroke or death and decreased risk of functional disability.(150) Use of DAPT in patients with minor stroke has been incorporated into the recommendations of both the American Heart Association and the European Stroke Organization.(151, 152) Because of the increased risk of hemorrhage in patients treated with DAPT, neither clopidogrel nor ticagrelor should be prescribed for more than 21 days.

Early diagnosis will also lead to a more rapid identification of the causative vascular lesion allowing for earlier intervention when appropriate, for example a vertebral dissection or stenosis or a cardioembolic source of clot. Antiplatelet and anticoagulant treatments have been shown to reduce subsequent stroke risk in both dissection and atrial fibrillation.(153, 154)

Finally, early diagnosis will lead to earlier initiation of monitoring for complications of posterior fossa edema, which tends to peak in the days following a cerebellar stroke.(155) Some of these patients will need ventriculostomy for acute hydrocephalus or suboccipital craniectomy for posterior fossa edema causing brainstem compression or near herniation.(156)

Harms and burden

Missing posterior circulation strokes in patients with an AVS has potential adverse outcomes that are the converse of the benefits mentioned in the last paragraph and also include the ability to more quickly manage complications of cerebellar strokes such as cerebral edema.(155) The current diagnostic tools available each have unique harms in addition to cost

and increasing ED length of stay. CT involves ionizing radiation, potentially contrast administration.(157, 158) MRI can cause anxiety and claustrophobia and is often unavailable.(159) The general neurologic exam is not accurate enough to satisfy emergency clinicians' desire for sensitivity for a serious diagnosis.(137)

Without training, inaccuracy of the HINTS exam can increase risk of misdiagnosis. This last point is not trivial. The ideal program for training front-line clinicians how and when to perform HINTS testing and how to interpret the results is not yet developed and will require time and effort to implement at scale. Such a program would include didactic content including generous use of video examples, but also hands-on experience with performing these bedside ocular motor tests (as well as positional maneuvers for diagnosis and treatment of BPPV. The frequency with which this training module would need to be repeated (if any) is not defined.

Decision criteria and additional considerations

The committee felt that the data for the HINTS exam were robust but with the important caveat that most clinicians will need to undergo training for how and when to perform it and how to interpret the results. The current reality is that there is a significant knowledge gap,(55, 57) but also that this gap can be closed with training.(58, 60) A number of issues require clarity. Who will provide it? At what level(s) of the trainees' experience should the training occur? Will emergency medicine residency programs or credentialing organizations embrace it? How much will it cost and who will pay for it? All of these issues remain to be fully defined.

Equity in Healthcare Delivery

As the training issues are resolved, implementation of HINTS by emergency clinicians should improve equity for patients with the AVS by allowing emergency clinicians to more accurately diagnose vestibular neuritis with a bedside exam, thereby making expensive and often unavailable neuroimaging unnecessary. More accurate diagnosis may also reduce some hospitalizations.

Conclusions and research needs

The HINTS exam is the most appropriate, accurate and probably cost-effective tool for appropriately trained emergency clinicians in the assessment of patients with an AVS. Ultimately, cost-effectiveness will depend on the balance between cost of training and the resources saved by its use. It is clear that emergency clinicians can learn to use these techniques effectively.(58, 60) These two studies inform how much training has worked but more research is needed to define ideal training methods, duration, quality assurance and need for periodic updates.

The role for VOG is a fertile area for research. Current VOG devices are similar to a pair of swimming goggles into which sensors are embedded, which record the eye movements of the HINTS exam as well as in positional maneuvers for patients with a t-EVS. The recordings can be interpreted by a remote specialist or a computer. Use of VOG not only helps with diagnosis, but can facilitate and enhance clinician education, calibration (does the VOG confirm what the

clinician thought they saw?), and quality assurance (similar to a point-of-care ultrasound image later reviewed by the ultrasound director).(160) Although routine ED use of VOG may seem far off, it was not that long ago that cardiologists routinely overread all electrocardiograms done in the ED, a skill that is now firmly within the scope of emergency clinicians. Early feasibility studies of VOG in the ED show promise, (53, 161-164) and could become standard over time.

QUESTION 2 – Should adult ED patients presenting with spontaneous episodes of dizziness/vertigo (the s-EVS) undergo neuroimaging to diagnose stroke or TIA in the ED, or should they be diagnosed through bedside examination without neuroimaging? If yes to neuroimaging, what type of imaging? If no to neuroimaging, what type of bedside examination? [Evidence to decision frameworks in Appendix S5]

1. In adult ED patients with spontaneous episodic vestibular syndrome, we recommend routine use of a detailed history and physical exam with emphasis on cranial nerves including visual fields, eye movements, limb coordination, and gait assessment to help distinguish between central (TIA) and peripheral (vestibular migraine, Menière disease) diagnoses. [Ungraded good practice statement]

2. In adult ED patients with spontaneous episodic vestibular syndrome, we recommend against routine use of CT to help distinguish between central (TIA) and peripheral (vestibular migraine, Menière disease) diagnoses. (Strong recommendation, AGAINST) [Moderate certainty of evidence]

3. In adult ED patients with spontaneous episodic vestibular syndrome and concern for TIA, we suggest use of CTA or MRA to rule out posterior circulation vascular pathology (Conditional recommendation, FOR) [Moderate certainty of evidence]

Summary of evidence

The key differential diagnosis in s-EVS is between TIA (central) and vestibular migraine (benign central) or Menière disease (peripheral). Patients with s-EVS are often asymptomatic by the time of ED assessment and, by definition, have symptoms that cannot be triggered/reproduced; as a result, neither physical examination nor structural neuroimaging are likely to be as helpful as in patients with AVS or t-EVS. Clinically, diagnosis usually relies largely on careful history-taking and risk assessment for TIA. The systematic review found limited direct evidence of diagnostic accuracy for some history elements and some neuroimaging (MRI) in the evaluation of adult ED patients with s-EVS. Additional indirect evidence was identified to help support the final guideline recommendations. Direct evidence suggests that routine neuroimaging in unselected s-EVS patients is unlikely to prove cost-effective. However, the aggregated evidence supports as a good clinical practice recommendation for use of focused history-taking to identify suspected TIAs when dizziness is not isolated (i.e., posterior circulation symptoms or

signs are present—sometimes collectively known as the "deadly D's" [diplopia, dysarthria, dysphagia, dysphonia, dysmetria and dysesthesia])(165) or when isolated symptoms are recent (<6 months), lack reassuring features (e.g., clear migraine features like photophobia), and/or vascular risks are high (e.g., $ABCD^2$ score of 4 or higher). Conversely, it also supports diagnosis of vestibular migraine or Menière disease without neuroimaging when symptoms meet international specialty consensus diagnostic criteria.(166, 167) These consensus criteria ensure that symptoms are recurrent and frequently accompanied by specific symptom patterns that are unusual among patients with TIA (e.g., presence of clear migraine headache features with more than half of the isolated vestibular spells).

Direct and indirect evidence

Direct evidence found two recent studies reporting the percentages of s-EVS to be 32.1% (n=136/424) in one study(53) and 16.6% (n=101/610) in the other(102) among ED patients presenting with vertigo or dizziness. Nham et al was a prospective observational study of a convenience sample of 530 ED patients with dizziness.(53) A structured history was taken to capture whether the episode of vertigo was first ever, its duration, its spontaneous or positional nature, presence of aural (tinnitus, fullness or hearing loss), migrainous (headache, visual aura, photo- or phonophobia) or neurological (diplopia, dysarthria, or numbness) symptoms, and presence of vascular risk factors.(53) Of the 136 patients with a s-EVS, any migraine-related symptom correlated with a diagnosis of vestibular migraine (OR 39.7, 95% CI 3.2-490.8) compared to Menière disease and conversely, the presence of unilateral auditory symptoms increased the likelihood of Menière disease (OR 140.3, 95% CI 9.8-2015).(53) Machner et al included 610 patients that presented with vertigo, dizziness and imbalance, (101 with an s-EVS) and evaluated the diagnostic test accuracy of general neurological exam compared to the gold standard of DWI-MRI.(102)

Although neither vestibular migraine nor Menière disease are diagnoses that emergency clinicians need to make in the ED, clinicians should at least be aware of vestibular migraine, as it is the most common cause of the s-EVS.(168) Because vestibular migraine can last a few days, some patients will present while still symptomatic. In those patients, the approach will be the same as for the AVS and the diagnosis is only made in retrospect.(53) Ninety percent of the vestibular migraine patients in that same study had a prior history of migraine; in the other 10%, headache followed a first episode of dizziness.

The most serious cause of the s-EVS is posterior circulation TIA although it is an uncommon cause in ED patients presenting with acute dizziness. One retrospective cohort study of ED patients with dizziness reported a TIA diagnosis in just one percent (9 of 907) of patients.(24) Another population-based study of 1666 adult ED patients with dizziness found that of patients with isolated dizziness, 0.7% were diagnosed with stroke or TIA (the breakdown of the two diagnoses was not reported for isolated dizziness, although the overall cohort had 3.2% attributed to stroke and the ratio of strokes to TIAs was about 2:1).(23) The systematic review identified two studies that addressed posterior circulation TIA in patients with a single episode of dizziness that lasted less than 24 hours.(53, 100) One convenience sample study of ED patients, found that half (16 of 32) of such patients with a single episode of dizziness that had

resolved were diagnosed with a TIA.(53) The other study reported that of 63 such patients, 11 (17%) had strokes and nine (14%) had cerebellar TIA.(100) The fact that they were unable to make any diagnosis in the other 43 (68%) patients, even after neurologic consultation, conventional and perfusion MRI, underscores the degree of diagnostic difficulty in this group.

Regarding posterior circulation TIA, most evidence was indirect, often in studies that combined TIA and minor ischemic stroke (which are essentially different parts of the spectrum of the same cerebrovascular process). Patients presenting to the ED with acute neurological symptoms should undergo a careful neurological physical examination, but it is a normal examination that supports a TIA diagnosis.(169-171) In two different studies comparing emergency physician TIA diagnosis with the "gold standard" of neurologist final diagnosis, between 36-44% of the time, the diagnoses were discordant.(172, 173) However, this gold standard is problematic because another study that compared TIA diagnosis from actual ED cases by three fellowship trained vascular neurologists found considerable discrepancies among the three subjects.(174)

Dizziness is the most common symptom of posterior circulation ischemia,(175, 176) and isolated dizziness is the most common antecedent TIA symptom leading up to a posterior circulation infarction.(177) In one case series of 407 adult patients, 47% reported dizziness.(176) The $ABCD^2$ score is less sensitive for posterior circulation TIA compared to anterior events, which is expected since the "C" in $ABCD^2$ relates to hemispheric symptoms.(178-180) Because the "A" is for age > 60 years, the $ABCD^2$ is also lower in most patients with vertebral dissections, who had a mean age of 42 years in one study (n=302),(181) and 46.5 in another systematic review (n=1972).(182) These patients often lack traditional vascular risk factors. In fact, the $ABCD^2$ score's sensitivity overall was lower for patients less than 60 years of age in one study.(121) Furthermore, duration is yet another component of the $ABCD^2$ score and posterior circulation TIAs tend to be very short,(183, 184) further lowering the score, although one large study reported that half of these events presenting as isolated vertigo lasted longer than 60 minutes.(177)

In a prospective population incidence study of 1141 acute ischemic stroke patients, isolated episodes of dizziness within the 48 hour prior to the stroke were described in 9% of the 275 patients with posterior circulation stroke, compared to less than 1% with anterior circulation stroke (OR 35.8, 95% CI 8-153).(177) In another prospective multi-center study of 447 patients with posterior circulation stroke, brief transient vestibular symptoms were reported in the week prior to the stroke in 33% of patients.(184)

On the other hand, two other studies showed that the presence of isolated episodes of dizziness or vertigo tracked with emergency clinician ***misdiagnosis*** of TIA (compared to the gold standard of the neurologists' diagnosis).(172, 173) This disconnect is likely due to the fact that other causes of episodic dizziness such as vestibular migraine and BPPV are so much more common than TIA that the "noise" (of peripheral causes) drowns out the" signal" (of central ones). Two expert reviews suggest that multiple episodes of isolated dizziness occurring over more than three weeks,(185) or over six months(186) are rarely due to posterior circulation TIA.

In one retrospective review of 339 patients referred to an outpatient stroke clinic, subjects who had fewer than five episodes of vertigo per week were more likely to receive a diagnosis of definite or probable cerebrovascular cause.(187)

In a systematic review of stroke outcomes following posterior versus anterior TIA, in the population-based studies identified, the risk of stroke was higher in patients with posterior events (OR 1.48, 95% CI 1.1-2.0).(141) Therefore identifying these patients is important. We do not recommend using the $ABCD^2$ score because it is inaccurate in predicting acute outcomes in individual TIA patients in general(188, 189) and to identify those due to posterior circulation ischemia in particular.(178-180) However, factoring in risk factors for vertebral artery dissection or stenosis and prior vascular history may be useful with one study finding that an $ABCD^2$ score of ≤ 3 was associated with a low risk for a cerebrovascular cause, although this finding may have been influenced by the fact that MRIs were not obtained on all patients with isolated dizziness.(24)

Neuroimaging

Assessing diagnostic accuracy of neuroimaging for TIA is terminologically complicated and methodologically fraught. The stroke community has shifted from time-based definitions of TIA (i.e., patients whose symptoms resolve in less than 24 hours) to tissue-based definitions of TIA (i.e., patients with a transient episodes of neurological dysfunction "without acute infarction" by imaging).(190) In these modern definitions of TIA and minor stroke, it is no longer possible to "confirm" TIA using neuroimaging… only to confirm "minor stroke in a patient with transient neurological symptoms" or "suspected TIA in a patient with a high-risk vascular lesion on imaging." Nevertheless, it is still possible to draw reasonable inferences based on the low prevalence (pre-test probability) of TIA among those with isolated dizziness combined with the low sensitivity of CT for completed stroke in the posterior fossa. We examined evidence for three types of brain imaging – CT, MRI, and CTA. The relative frequencies of vestibular migraine and posterior circulation TIA make indiscriminate imaging very unlikely to be cost-effective.

CT scan

CT is insensitive for TIA in general, with one study of 322 patients reporting that in 1.2% of patients a non-vascular cause was found (e.g., a subdural hematoma) and in 4%, an infarct was seen.(191) One would expect lower sensitivities for posterior circulation TIA given the intrinsic limitations of bony artifact and smaller lesion size. The data about CT sensitivity for patients with dizziness in general (described in Question 1) showing poor sensitivity even in patients with ongoing dizziness combined with empiric evidence,(191) adds to the certainty that CT is unlikely to be useful to diagnose stroke among patients with the s-EVS.

MRI

The studies assessing MRI in the systematic review did not relate to TIA but to stroke. To some extent, this distinction is artificial since the two exist on the same spectrum of acute ischemic cerebrovascular events. However, since some studies labeled patients with negative DWI MRI as "TIA" rather than "stroke," sensitivity of MRI for posterior circulation TIA presenting as an s-EVS could not be calculated. It is reasonable to perform MRI when a clinical diagnosis of TIA is

suspected, in search of either a minor stroke or a high-risk vascular lesion. However, it would not be cost-effective to use MRI to indiscriminately search for stroke in all s-EVS cases.

Vascular imaging
Our systematic review sought studies evaluating cerebrovascular imaging using ultrasound, CT angiography (CTA) and MR angiography (MRA).(82) The three studies (n=258) that evaluated ultrasound were all related to stroke not TIA. The reference standard was MRI.(118, 131, 192) The sensitivities for ultrasound ranged from 30-53.6%, and specificity 94.9-100% indicating that ultrasound should not be relied upon to diagnose TIA.(82)

The single study identified by our systematic review of CTA in an "all-comer" ED population of 153 patients with isolated dizziness found a very low diagnostic yield for posterior circulation large vessel pathology (14.3%).(36) Indirect evidence also showed that of 228 CTAs done in acutely dizzy patients, only five (2.2%) had clinically relevant findings.(138) The systematic review of neuroimaging did not find any studies directly related to s-EVS.(82)

It is important to realize, however, that, among TIA patients, large vessel disease is an important factor leading to an acute stroke outcome. Both CTA and MRA are very sensitive in identifying vertebral artery stenosis > than 50% and both are better than ultrasound.(193) Furthermore, a large prospective study showed that in 359 patients with posterior circulation minor stroke or TIA, the presence of a vertebrobasilar stenosis (diagnosed mostly by MRA and some by CTA) significantly increased the risk of a second stroke (OR 4.2, 95% CI 2.1-8.6).(194)

Benefits
There are two major benefits to accurate diagnosis in patients with the s-EVS. Correct diagnosis and treatment of TIA can reduce the short-term outcome of stroke by 80% (an important patient-centered and societally relevant outcome),(195, 196) which is durable at five years post index TIA.(197) Starting an anti-platelet agent is an important secondary prevention strategy.(198) In addition, even if emergency clinicians do not diagnose vestibular migraine, they should be aware that it is an extremely common cause of the s-EVS and facilitate outpatient follow-up with a specialist who can make that diagnosis and begin treatment. The included studies did not directly address these benefits.

Harms and burden
The major harm of missing a TIA is that, untreated, 5% of TIA patients have a stroke in the subsequent week following the TIA,(199) and some data suggest that short-term stroke risk is higher in patients with posterior circulation TIA.(141) Potential harms of missed vestibular migraine diagnosis include more ED visits for persistent symptoms, falls and injuries.(200, 201) CT is associated with economic (cost), health (radiation exposure) and logistical (longer ED length of stay) harms without adding much value.(9, 33, 35, 40) Our patient representatives highly valued accurate diagnosis (even for non-TIA diagnoses) based on preventable recurrence, ED visits, and earlier initiation of treatment.

Decision criteria and additional considerations

Consideration of local resources and economic realities may affect the pattern of follow-up. Although it is appropriate to recommend that patients follow-up with their primary care physician, some of these providers may not be aware of diagnoses such as vestibular migraine and referral to a specialist (neurologist, ENT or neuro-otologist/oto-neurologist) may be valuable for some patients. Shared decision-making can only be properly done when information that is important to the patient is shared.(202) This is particularly important when there is equipoise or uncertainty. In a situation where a path of action or intervention is clear, the discussion would be very different. Clinicians should understand the lack of utility of CT scans in this setting.

Conclusions and research needs

There is a dearth of direct evidence about the emergency clinician awareness and diagnosis of vestibular migraine. Improved awareness should help to get the patient the correct follow-up faster. Emergency clinicians' history taking should target features that help to distinguish migraine (multiple episodes over longer time and a history of migraine), or Menière disease (multiple episodes over a longer time with hearing loss) with TIA (fewer episodes with associated Deadly D's" symptoms - diplopia, dysarthria, dysphagia, dysphonia, dysmetria and dysesthesia occurring over a shorter time period). Regarding posterior circulation TIA, better prospective studies of ED patients presenting with the s-EVS may help with identification of those with TIA. Once that diagnosis is made, the management can largely be extrapolated from the management of TIA in general.

QUESTION 3 – Should adult ED patients presenting with triggered episodes of dizziness/vertigo (the t-EVS) undergo neuroimaging to exclude stroke in the ED, or should they be diagnosed through bedside examination without neuroimaging? If yes to neuroimaging, what type of imaging? If no to neuroimaging, what type of bedside examination?
[Evidence to decision frameworks in Appendix S6]

1. In adult ED patients with triggered episodic vestibular syndrome, we recommend routine use of the Dix-Hallpike test to diagnose posterior canal BPPV (Strong recommendation, FOR) [Moderate certainty of evidence]

2. In adult ED patients with triggered episodic vestibular syndrome, we recommend against routine use of CT or CTA (Strong recommendation, AGAINST) [Moderate certainty of evidence]

3. In adult ED patients with triggered episodic vestibular syndrome diagnosed with typical posterior canal BPPV by a positive Dix-Hallpike test with the characteristic nystagmus, we suggest against routine use of MRI or MRA (Conditional recommendation, AGAINST) [Moderate certainty of evidence]

Summary of evidence

The key differential diagnosis in t-EVS is between central paroxysmal positional vertigo (CPPV) (central) and BPPV (peripheral). Patients with t-EVS usually remain symptomatic at the time of ED assessment, and, by definition, have symptoms that can be triggered/reproduced at the bedside. Thus, physical exam has the potential to aid diagnosis, and neuroimaging, if needed, has the potential to "rule out" stroke or other structural causes. The systematic review found evidence of diagnostic accuracy for the physical exam (Dix-Hallpike test) in the evaluation of adult ED patients with t-EVS, but not every study identified in the systematic review met every criterion in the PICO question. Additional indirect evidence was identified to help support the final guideline recommendations. Aggregated evidence supports a strong recommendation for use of the Dix-Hallpike test to diagnose posterior canal BPPV when induced nystagmus is typical. Conversely, it supports a conditional recommendation for use of MRI in cases with atypical nystagmus or lack of response to canalith repositioning treatments.

While orthostatic hypotension is also a cause of t-EVS and has both dangerous and benign causes, Emergency clinicians are quite familiar with diagnosis of orthostatic hypotension. BPPV can sometimes be mistaken for orthostatic hypotension, since some patients with BPPV complain of lightheadedness on arising.(203) However, careful history-taking readily separates those with BPPV, since symptoms in BPPV usually also occur on reclining or when rolling over in bed.(204) Similarly, episodes that occur during sleep strongly suggest the diagnosis of BPPV.(204, 205)

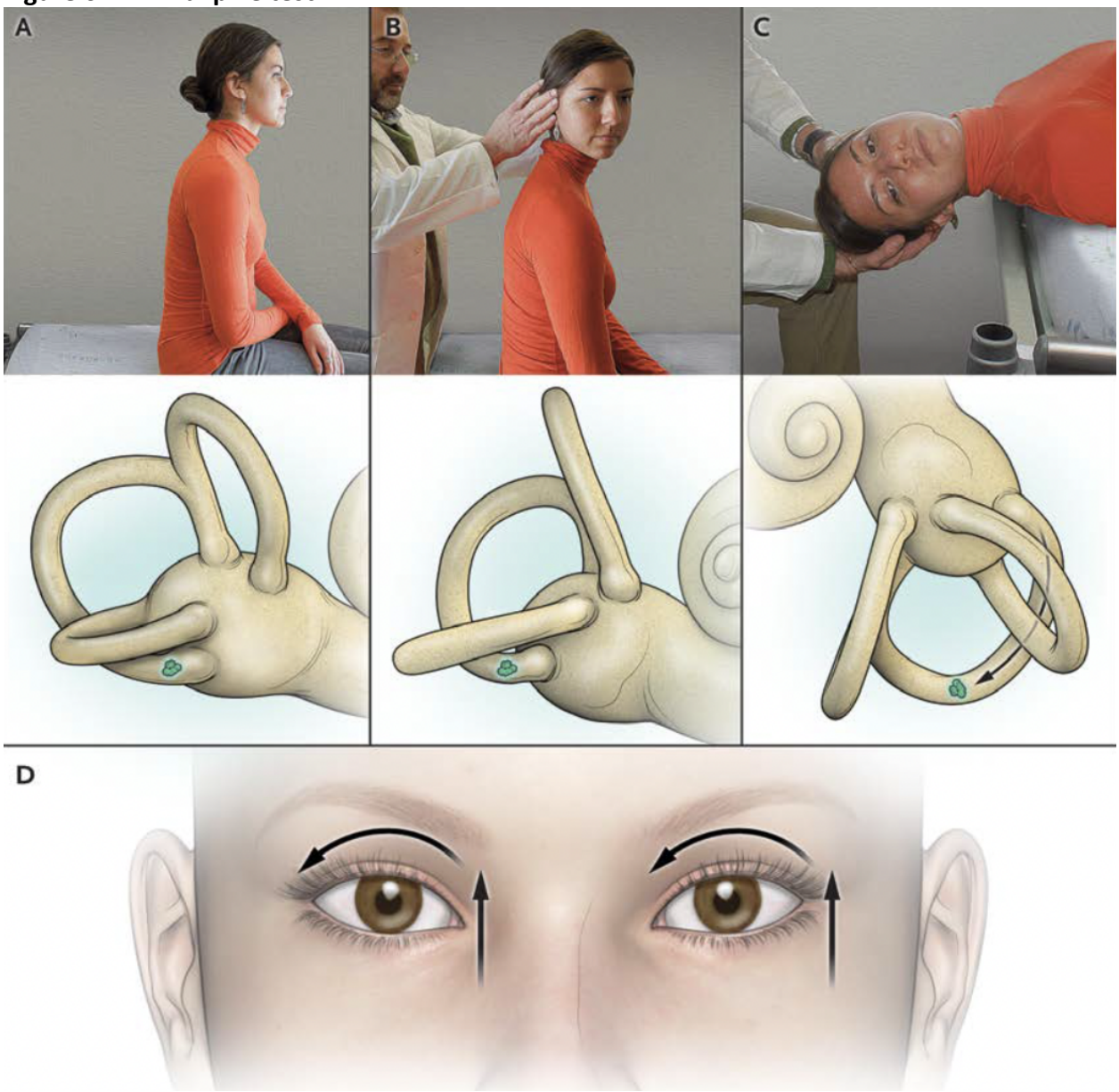
Direct and indirect evidence

Our systematic review identified four studies, of moderate to high risk of bias.(102, 106, 110, 206) In one study all patients with a central etiology had a negative Dix-Hallpike test.(206) One study had 2 patients with positive Dix-Hallpike having both central and peripheral etiology simultaneously.(106) One study had 2 patients with atypical nystagmus on Dix-Hallpike having a central cause.(102) One study had no patients with strokes/central etiology in the cohort that underwent Dix-Hallpike so diagnostic test accuracy was not estimated.(110)

Of critical importance, however, is that 3 of these studies(102, 105, 206) reported that among dizzy ED patients with a central etiology, 100% of them had a negative Dix-Hallpike test. However, in clinical practice, a **positive** Dix-Hallpike test is used to rule in posterior canal BPPV (pc-BPPV) as opposed to a ***negative*** test ruling out a central cause. The Dix-Hallpike test is considered the gold standard diagnostic test for pc-BPPV,(61, 62, 207) so the test's sensitivity for pc-BPPV cannot properly be assessed (i.e., it is essentially 100%, by definition). Routine use of the Dix-Hallpike test by emergency clinicians is very low,(64, 65, 69, 208) and incorrect interpretation of nystagmus findings is common.(163, 209) It is important to note that the Dix-Hallpike test is the preferred test for pc-BPPV and not for other types of BPPV; however some patients with hc-BPPV will have horizontal nystagmus with Dix-Hallpike testing.(133) The Dix-Hallpike test can also be negative in patients with hc-BPPV and in patients with so-called "subjective" BPPV (i.e., positional vestibular symptoms without nystagmus). Since visual fixation can partially suppress nystagmus, apparently "subjective" BPPV will be more common if special goggles (Frenzel lenses or VOG) are not used to block visual fixation.

Indirect evidence shows that emergency clinicians can successfully use the Dix-Hallpike test to diagnose pc-BPPV,(58, 60, 65, 134, 210-212) resulting in decreased imaging, hospitalization and total costs of care,(212) excellent diagnostic accuracy,(58, 60, 134) and increased physician satisfaction with the process of care.(213) Given the frequency of BPPV, the minimal time required to perform the Dix-Hallpike test, and the resultant improved efficiency of care, the committee members, including the patient representatives, felt that emergency clinician adoption of the Dix-Hallpike test was important to improve patient-centered outcomes.

Figure 6 - Dix-Hallpike test



Legend: Shown is a right Dix-Hallpike test. With the patient sitting upright (panel A), the head is turned 45 degrees to the patient's right (panel B). The patient is then moved from the sitting position to the supine position with the head hanging below the top of the examination table at an angle of approximately 20 degrees (panel C). The resulting nystagmus in right pc-BPPV is upbeating and torsional, with the top (12 o'clock) poles of the eyes beating toward the lowermost (right) ear for the torsional component (panel D). A left Dix-Hallpike test is performed similarly, but with a head turn 45 degrees to the left; the resulting nystagmus of left pc-BPPV is also mixed upbeating and torsional, but the torsional component beats towards the left ear (Reproduced with permission of the New England Journal of Medicine @2000.(214)

For this strategy to work, once again, effective training of a large number of clinicians about when and how to do the Dix-Hallpike test and how to interpret the results is required. When done in the correct patients (t-EVS without spontaneous or gaze-evoked nystagmus) a unilaterally positive Dix-Hallpike test, with the characteristic triggered, transient upbeat-torsional nystagmus beating towards the lowermost ear is the gold standard for diagnosing pc-BPPV.(61, 62)

CT scan

The evidence for the diagnostic accuracy and utility of CT is mostly related to patients with an AVS or all suspected neuro-vestibular dizziness, not a t-EVS population, per se. CT scans are used frequently in ED patients eventually diagnosed as BPPV.(20) Overall, the diagnostic yield of CT for important structural causes in dizzy patients is very low.(9, 36, 39, 138) In one study that described specific results in t-EVS patients, none of the 10 CT scans obtained clinically in those with typical BPPV nystagmus revealed clinically important findings; in contrast, 2 of 34 scans obtained in those with atypical or no nystagmus had acute brain lesions (not further described for these particular patients, though).(67, 102) The most recent BPPV-specific Otolaryngology guideline also recommends against routine imaging in the presence of typical nystagmus and adequate therapeutic response to repositioning treatments.(61)

MRI scan

We did not find any direct evidence relating to this question in ED populations and as above, imaging in typical BPPV cases is not recommended.(61, 62) However, there may be clinical clues in patients with a t-EVS that suggest a central mimic of BPPV (i.e., CPPV), in which cases MRI with gadolinium would be the preferred follow-up test (over CT). These clues include atypical nystagmus, especially downbeating or persistent apogeotropic-type horizontal, any other central nervous system findings on exam, or lack of response to canalith repositioning maneuvers.(102, 215-217) This underscores the importance of a careful history and neurological exam as well as supports attempting a canalith repositioning maneuver, since a successful "therapeutic" maneuver helps to clinch the diagnosis.

Many of the causes of CPPV are not acute emergencies. A single retrospective study of 500 patients with a diagnosis of typical BPPV and treated with canalith repositioning maneuvers, reported a 25% incidence of MRI abnormalities (122/472).(218) Two canalith repositioning maneuvers were successful in curing 98.2% (491/500) of the patients. However, all patients

were routinely referred for an outpatient MRI; 472/500 returned for imaging. The authors do not report the lag time between the BPPV visit and the delayed MRI. It is highly unlikely that the MRI findings were responsible for the patients' original presentation since all patients were clinically diagnosed with BPPV and successfully treated by canalith repositioning maneuvers. The relations between other neurological findings (if any) and MRI findings were not reported. Seventy-two percent (88/122) of the MRI findings required no referral and in another 14% (17 patients), a "routine" referral was made. Of the 34 patients referred to a neurosurgeon, fewer than half "required" a procedure. Because of all of these mitigating factors, the consensus of our group of experts was that MRI is unnecessary in patients with t-EVS with a classic BPPV presentation and Dix-Hallpike test findings who respond to canalith repositioning maneuver treatments.

Benefits

The Dix-Hallpike test is a simple and rapid maneuver to diagnose pc-BPPV in patients with the t-EVS. Evidence shows that the Dix-Hallpike test can be utilized appropriately in the ED to correctly diagnose BPPV.(58, 60, 65, 134, 212) There is evidence from the ED to suggest that imaging (particularly CT) is over-utilized in BPPV(39), despite the fact that CT is generally unhelpful in ED dizziness. In addition to more rapid diagnosis, the Dix-Hallpike test, when positive, avoids unnecessary imaging, resulting in a large cost savings(7, 212) and a reduction in unnecessary radiation exposure.

Harms and burden

There are few documented harms to performing the Dix-Hallpike test in patients with t-EVS. Theoretically, instability of the cervical spine or atherosclerotic disease of the vertebrobasilar system could lead to complications when performing the Dix-Hallpike test.(61) Practically speaking, this risk is negligible. More germane would be the risk of improperly interpreting the results of the Dix-Hallpike test and ascribing a benign cause (i.e., pc-BPPV) to a patient with a serious one (i.e., CPPV). The main burden is the time, effort, and cost required for ***training*** emergency clinicians in proper use, application, and interpretation of the Dix-Hallpike test. This is also true for training in canalith repositioning maneuvers like the Epley maneuver, since successful treatment aids in correct diagnosis.

Decision criteria and additional considerations

Decision criteria are based on substantial indirect evidence supporting the role of Dix-Hallpike test in diagnosis of BPPV and the lack of utility of imaging. Consideration needs to be given to the fact that the existing literature on diagnosis of t-EVS and BPPV assumes proficiency in performance and interpretation of the Dix-Hallpike test. Our group recognizes and acknowledges that many emergency clinicians have limited experience or are uncomfortable diagnosing and treating different BPPV variants based on the nature of nystagmus elicited by the Dix-Hallpike test or other positional tests.

Another consideration our group acknowledges is that there may be limited access to specialty care (physicians or physical therapists with special vestibular training) or of telemedicine with VOG, depending on the practice setting. Nonetheless, establishing some follow up care for

patients with t-EVS is important. As noted previously, in some settings, a physical therapist with vestibular expertise may be the most qualified clinician available locally or within a reasonable time frame, so may be the best referral choice.

After a lengthy debate about hc-BPPV, the committee made a conscious decision to simplify our recommendations and to restrict them to pc-BPPV (the most common type). Some committee members felt that a recommendation for hc-BPPV should have been included because this variant constitutes an important minority of total BPPV patients, especially in acutely presenting patients in an ED population,(219) because hc-BPPV patients are often more severely symptomatic than patients with pc-BPPV.(220)

In a study of 352 consecutive ED patients with acute dizziness (not restricted to BPPV), hc-BPPV accounted for 20% of the total patients.(60) The recently completed AVERT trial (NCT02483429), which used the most rigorous diagnostic methods in any ED-based trial to date, found that, among 43 BPPV patients, 20 had pc-BPPV, 16 had hc-BPPV, and 7 had other variant forms (including multi-canal BPPV).(163) We encourage clinicians to consider hc-BPPV in patients whose histories suggest BPPV but whose Dix-Hallpike test is either negative or shows horizontal nystagmus.(133) The specific diagnostic maneuver for hc-BPPV is the supine roll test and the corresponding therapeutic maneuver is the Lempert (barbeque) roll. One alternative therapeutic technique is the Gufoni maneuver.(61, 221)

Conclusions and research needs

Direct evidence from the ED regarding the role of Dix-Hallpike test and/or imaging in the setting of t-EVS is limited. The Dix-Hallpike test is considered the "gold standard" maneuver to diagnose pc-BPPV. The available data suggest that proper use of the Dix-Hallpike test should be disseminated more widely and that there should be a very limited role for brain imaging in t-EVS patients. When patients have atypical nystagmus or fail to respond to canalith repositioning maneuver treatments, imaging should be by MRI, not CT.

Future work should focus on education and training of ED providers on appropriate application and interpretation of Dix-Hallpike test and treatment of BPPV. In addition, as providers become more familiar with pc-BPPV and if subsequent data confirm recent studies suggesting that hc-BPPV is more common in an early-presenting population than previously thought,(53, 60, 163, 164, 219) learning about other variants, especially typical geotropic hc-BPPV will allow correct management of a larger proportion of BPPV patients (and of all acute dizziness).

QUESTION 4 – Should adult ED patients diagnosed with vestibular neuritis be treated with steroids?

[Evidence to decision frameworks in Appendix S7]

1. In adult ED patients with a clinical diagnosis of vestibular neuritis, we suggest shared decision-making with patients to weigh risks and benefits of short-term steroid

treatment for those presenting within three days of symptom onset. (Conditional recommendation, FOR) [Very low certainty of evidence]

Summary of evidence

Patients confirmed by bedside exam to have vestibular neuritis may benefit from acute treatment with steroids. The systematic review found mixed results, with some direct randomized trial evidence of efficacy on improved physiologic function but no evidence of symptomatic benefit or improved health-related quality of life with steroids. Given that loss of vestibular function may be well-compensated in the short term but create a state of less balance "reserve" in the longer term (e.g., as the patient ages and loses the ability to compensate for the loss), the group felt that the evidence supported a conditional recommendation for shared decision-making with patients around steroid treatments. Regardless of treatment choice, the group supported post-discharge referral for physical therapy, which is supported by systematic review evidence of efficacy.(222)

Direct and indirect evidence

Two types of outcome measures were reported at various time intervals – patient-reported (vertigo symptoms and the Dizziness Handicap Inventory score) and physiologic (laboratory testing of caloric function). There was no difference in patient-reported vertigo at 24 hours (2 studies, n=60, 53% vs 87%, RR 0.39, 95% CI 0.04-3.57, very low certainty of evidence).(84, 85) Measured at one month, there was no difference in the Dizziness Handicap Inventory score with steroids compared to either placebo or vestibular exercises (1 study, N=30, 20.9 vs 15.8 points, 73.3% vs 80.0% with persistent symptoms respectively, very low certainty of evidence). Different studies used different steroid protocols.

For laboratory outcomes, the steroid group had a higher rate of caloric recovery at 1 month (2 studies, N=50, RR 2.81, 95% CI 1.32-6.00, low certainty of evidence), and the rate of caloric lateralization was decreased at 1 month post-symptom onset (2 studies, n=80, mean difference -8.33, 95% CI -16.33 to -0.32, very low certainty of evidence).(223)

The committee including our patient representatives placed greater value on the patient-reported outcomes than on the physiologic ones. However, the committee also considered the hypothesis that well-compensated, asymptomatic reductions in vestibular function might become important later in life, either from a second vestibular insult or age-related decreases in vestibular function.(224) This may be analogous to small, asymptomatic decreases in left ventricular ejection fraction from delayed treatment of a myocardial infarction. For example, a patient may not perceive a drop from 65% to 50%, but a second cardiac event that further reduces the ejection fraction to 35% might become symptomatic.

There was no difference in serious adverse effects (2.9% vs 0%), although there were higher rates of minor adverse events in the steroid group (range 5.9 to 22.9% vs 0%).(223)

Benefits
In patients with vestibular neuritis, improvement in dizziness is an important outcome. Because the pathophysiology of acute vestibular neuritis (inflammation of the vestibular component of the eighth cranial nerve) is thought to be similar to that of seventh cranial nerve in Bell's palsy, many specialists routinely prescribe corticosteroids. Given the very low certainty of the evidence for this intervention, we feel that clinicians should weigh the pros and cons of steroid treatment in patients with vestibular neuritis and engage patients in shared decision making.(225) Relative contraindications (e.g., history of poorly controlled diabetes or bipolar disorder with mania) or a patient's concerns about steroid use should factor into this discussion.

Harms and burden
The harms of steroids are well known. Our umbrella review found one case of gastrointestinal bleeding that required intervention, and several cases of hyperglycemia.(223)

Decision criteria and additional considerations
Emergency clinicians commonly use "vestibular suppressants" (such as benzodiazepines, anticholinergics such as scopolamine, and antihistamines such as meclizine) for patients with acute dizziness. Meclizine is the most commonly administered medication for dizziness in the US.(20) Given the lack of current high-quality evidence addressing their use in vestibular neuritis, a formal evidence-based recommendation cannot be made at this time. However, content experts on the committee felt that for patients with vestibular neuritis, it is reasonable to use these medications for a very short period of time (several days) to reduce acute symptoms. Longer use is discouraged, in part because it inhibits the physiological compensation(226) and in part due to side effects.(227) The American Geriatric Society recommends ***against*** using meclizine in older individuals due to its anticholinergic side effects.(228)

Conclusions and research needs
Research needs to be done in sufficient numbers of patients with vestibular neuritis to test the hypothesis that earlier treatment with corticosteroids (e.g., within 2-3 days of onset) shows a signal for efficacy compared to later treatment.(229)

QUESTION 5 – Should ED adult patients diagnosed with BPPV be treated with a canalith repositioning maneuver, e.g., the Epley maneuver)?
[Evidence to decision frameworks in Appendix S8]

1. In adult ED patients with posterior canal BPPV diagnosed by a positive Dix-Hallpike test, we recommend the Epley† canalith repositioning maneuver be performed at the time of diagnosis. (Strong recommendation, FOR) [Moderate certainty of evidence]

Summary of evidence
Patients confirmed by bedside exam to have pc-BPPV may benefit from acute treatment with the Epley maneuver. The systematic review found clear results in favor of treatment for both short-term symptomatic improvement and normalization of the Dix-Hallpike test. The evidence supported a strong recommendation for treatment with the Epley canalith repositioning maneuver.

Direct and indirect evidence
There were two outcomes of interest – symptom resolution and conversion of a positive Dix-Hallpike test to a negative Dix-Hallpike test. For the outcome of complete symptom resolution, there was a significant difference in favor of the treatment group observed in each trial. We extracted the data of all RCTs that reported 7-day outcomes and complete resolution of symptoms was favorable for the intervention (4 RCTs, n=251, OR 5.32, 95% CI 2.95-9.59, low certainty).(230-232) Conversion to a negative Dix-Hallpike test was also favorable for patients that received canalith repositioning maneuvers (3 RCTs, n=195, OR 5.96, 95% CI 3.10 to 11.47, low certainty).(230-233) These studies were not on ED patients. Longer time intervals were also assessed (and also favored the intervention); however, we chose the seven-day outcome intentionally since over time, patients with BPPV will resolve spontaneously, which would dilute positive short-term outcomes. Sensitivity analysis including observational studies and outcomes at 30 days demonstrated a similar positive effect of the intervention (canal repositioning maneuvers). Figures 2-5 in Appendix S8.

In the two studies, all patients received an 'active treatment' (either medication or postural restriction exercises) and then randomized half the patients to receive the Epley maneuver, and the outcomes were reported as a composite measure of symptom resolution and Dix-Hallpike test result.(234, 235) For the purposes of analysis, this has been rationalized to a dichotomous variable of 'cured' versus 'persisting symptoms'. There was a statistically significant effect of treatment in each trial at seven days, favoring the group that also received an Epley treatment in each case: OR 12.35 (95% CI 1.51 to 101.36),(234) and OR 41.73 (95% CI 12.29 to 141.65).(235)

Both Neurology and Otolaryngology society guidelines on BPPV recommend performing the Epley maneuver for pc-BPPV.(61, 62) The 2008 Neurology practice parameter reported the Number Needed to Treat (NNT) from individual studies ranging from 1.4-3.6.(62) Most of the data on the efficacy of the Epley maneuver comes from specialty clinics, but one prospective, single-blind placebo-controlled trial of 22 consecutively enrolled ED patients with BPPV randomized to have the Epley performed by emergency clinicians or a placebo maneuver reported significant reduction of patient-reported symptoms treated with the Epley, (median decrease in 10-point visual analogue score of six (Epley) vs one (placebo).(236) Therefore, all of the evidence points in the same direction.

Benefits

BPPV is the most common vestibular disorder, with a population-level lifetime prevalence of 2.4%, one-year prevalence of 1.6% and a one-year incidence of 0.6%.(237) It is associated with significant reductions in quality of life,(238) but has highly effective, rapid bedside treatments. Prompt treatment of BPPV improves health-related quality of life,(239-241) while failure to treat BPPV doubles the recurrence rate (46% vs 20%, p=0.002)(68) and increases the odds of falls 6.5 fold(242), thereby increasing risk of fractures.(243)

The benefits of treating patients with pc-BPPV with a bedside therapeutic maneuver are large given the very small NNT. The primary benefits are decreased patient symptoms with potential subsequent fall and injury reduction.(244, 245) In addition, earlier treatment with an Epley maneuver in the ED may be more effective than later treatment that would result from referral,(70) and reduce the frequency of recurrences,(68) further supporting performing the Epley maneuver in the ED at the time of diagnosis. Diagnosing and treating this common condition should result in fewer consults, less imaging, and shorter ED lengths of stay. Patients with persistent pc-BPPV, whose Dix-Hallpike test is still positive after a correctly performed Epley maneuver, can have the procedure repeated.(133, 246) If the symptoms persist after repeated properly performed canalith repositioning maneuvers, clinicians should question the diagnosis and consider hc-BPPV or central causes.

Harms and burden

Other than transient patient discomfort and occasional vomiting during the Epley maneuver, (which, when effectively performed, will reproduce the patient's symptoms), there are no harms of performing the Epley maneuver. Both discomfort and vomiting can be mitigated with adequate patient coaching and prophylactic antiemetics, although the latter do not need to be used routinely. The only "burden" is the necessary training for emergency clinicians to learn how to do the procedure.

Decision criteria and additional considerations

Emergency clinicians commonly use "vestibular suppressants" (such as benzodiazepines, anticholinergics such as scopolamine, and antihistamines such as meclizine) for patients with acute dizziness. Given the lack of current high-quality evidence addressing use of suppressants in BPPV, a formal evidence-based recommendation cannot be made at this time. Meclizine is the most commonly administered medication for dizziness in the US, even for BPPV, which should generally be treated instead by using highly effective canalith repositioning maneuvers (e.g., Epley maneuver).(20)

However, with regard to using vestibular suppressants in patients with BPPV, we agree with both the 2008 American Academy of Neurology and the 2017 American Academy of Otolaryngology Head and Neck Surgery guidelines that discourage the use of these medications.(61, 62) In select patients who have residual mild symptoms after a successfully administered Epley (or other canalith repositioning) maneuver, as evidenced by conversion of the Dix-Hallpike test from positive to negative, a few days of vestibular suppressants may help reduce symptoms but should not be used for longer periods of time. Earlier treatment with an Epley maneuver is more effective than later treatment,(70) and can reduce the incidence of

falls.(242, 244, 245) A systematic review on this subject recommends against using vestibular suppressants.(247)

As discussed above, we encourage clinicians to consider hc-BPPV in patients whose histories suggest BPPV but whose Dix-Hallpike test is either negative or shows horizontal nystagmus; if properly trained and comfortable with the diagnosis, clinicians should treat hc-BPPV in the ED.(133)

Conclusions and research needs

Focused training is key for treating pc-BPPV with an Epley maneuver. Although the precise duration and components of that training remain to be fully determined, the ability to watch one of many easily accessible web-based video examples just prior to performing the procedure should mitigate the lack of familiarity with this procedure and minimize the time required for training. Approaching this procedure with the same deliberate practice as other high-yield procedures in emergency medicine will improve patient outcomes and health.

GENERAL ISSUES NECESSARY FOR CORRECT INTERPRETATION AND IMPLEMENTATION OF RECOMMENDATIONS

Limitations

The largest limitation is that the majority of the studies that we found either included ED patients with unspecified acute dizziness or vertigo (i.e., without specifying vestibular syndromes) or a cohort of patients with AVS. Very few studies evaluated patients with spontaneous or triggered EVS, and physical exam maneuvers were not always performed by emergency clinicians. However, because the diagnostic maneuvers we analyzed are heavily rooted in basic neurophysiology, there is no biologically plausible reason that they would not work if performed in an ED population by trained emergency clinicians. The crucial caveat is that that emergency clinicians must learn to perform the maneuvers and interpret results effectively and, currently, no validated training program exists. Creation of such a program with validated content, methods and duration should be a priority for emergency medicine.(248)

Assumed values and preferences

Our three patient representatives played an active role in this domain, but there are no systematic data about patient preferences on a large scale. When discussing issues related to communication in the ED, although patients initially expressed a sense of relief upon hearing that a CT scan was normal, once they understood the lack of utility of a CT in the vast majority of acutely dizzy patients, they placed less value on having a “negative test” that in reality, added little to their care and may have actually conferred harm from radiation.(44) Our patient representatives are active with patient advocacy and educational organizations and related that many patients with recurrent episode of dizziness avoid the ED because of prior negative experiences.

These discussions highlight two points. First, the patient representatives felt that they had received care that was not as nuanced as it should be – both with regard to diagnosis (e.g.,

indiscriminate use of CT) and to treatment (e.g., indiscriminate use of meclizine). The second relates to doctor-patient communication. The patient representatives placed high value on clear communication both in terms of the diagnosis and of uncertainty. They also saw value in receiving discharge instructions that at least opened the door to options beyond, "see your PCP" (see sample discharge instruction sheet).

Similarly, the physicians on the committee placed great value on making a specific diagnosis, especially in diagnosing acute stroke. Again, this underscores the critical importance of developing a mechanism by which emergency clinicians in routine practice can become trained and/or certified in physical exam elements with which most are not currently familiar or not comfortable. This training coupled with better knowledge about limitations of imaging in these patients can lead to more nuanced and informative shared decision-making conversations.

Training and on-line resources

Although the committee did not include the issue of training (in performing and interpreting these bedside diagnostic and therapeutic maneuvers) as a formal PICO question, the findings from the literature were clear and consistent that without training, emergency clinicians do not often use them properly,(55, 57, 208) and that with training, their accuracy is excellent.(58, 60) Training is therefore a critical step in improving the care of ED patients with acute dizziness and we created a recommendation to address this.

1. We suggest that all ED clinicians be trained* in the performance and interpretation of the HINTS exam and bedside maneuvers to diagnose and treat posterior canal BPPV, since untrained ED physicians do not reliably apply or accurately interpret results of this bedside eye movement examination. [Ungraded Good Practice Statement]

There is currently an ACEP website (acep.org/dizzy) that contains many free access video clips that are very useful for clinicians not used to using these bedside techniques. In addition, committee members contributed to a smart phone App on diagnosis and treatment of patients with acute dizziness that is hosted by Johns Hopkins (link to come)

Implementation considerations

Guidelines can inform management decisions for many patients. However, in real world practice, mitigating factors or nuanced, variable presentations often result in logical reasons to deviate from a recommendation and employ alternative strategies. These may be due to biological diversity (e.g., a patient with isolated dizziness but with a severe acute onset headache), situational realities (e.g., a rural ED with no MRI or consultant availability) or patient-specific factors (e.g., contraindications to MRI). In Box 3, we have listed some of these factors that may affect the implementation of these guidelines in specific situations.

Box 3 – Implementation considerations

Situation	Implementation consideration
Question 1 – Diagnosis of patients with the Acute Vestibular Syndrome (AVS)	
Unavailability of a clinician trained in the HINTS exam	
	For emergency clinicians who are not adequately trained in performance and interpretation of HINTS, either consultation with an appropriately trained specialist should be obtained to perform HINTS testing or neuroimaging by MRI should be used to aid in differentiating stroke from non-stroke cases, assuming the availability of consultants and/or MRI. **Potential solutions**: Training emergency clinicians is the main fix to this problem but is a long-term one. In some environments, physical therapists with vestibular testing capability may be available. Use of VOG may also help facilitate access to specialists remotely.
	For emergency clinicians who are not adequately trained in performance and interpretation of HINTS and who also lack routine access to MRI neuroimaging, CT (with or without CTA) is insufficient to "rule out" ischemic stroke. **Potential solutions**: Several options exist to help maximize patient safety including hospital admission for observation, transfer to a facility that has MRI, empirically initiating aspirin or other appropriate prophylaxis if there is a high suspicion for stroke, or arranging an urgent outpatient MRI.
Optimal timing of MRI	
	The sensitivity of MRI for stroke causing an AVS evolves with elapsed time. Overall sensitivity is approximately 80-90% in the first 48 hours (using a criterion standard of delayed MRI > 72 hours from symptom onset). **Potential solutions**: In patients with a central or equivocal HINTS exam or when a clinician trained in HINTS is unavailable, this relationship between time and sensitivity should be factored into the decision about when to perform MRI and how to interpret an early-performed MRI.
Possible candidate for thrombolysis, reperfusion or other time-sensitive interventions	
	In adult ED patients with acute vestibular syndrome who are potential candidates for reperfusion therapies (or other treatments that must be applied rapidly (such as ventriculostomy for hydrocephalus or decompressive suboccipital craniectomy for brainstem compression or impending herniation) which may require definitive exclusion of intracranial hemorrhage prior to initiation, CT is generally much faster than MRI in most EDs. can be obtained if MRI instead would delay acute treatments for ischemic stroke.

	Potential solutions: Use a cognitive "timeout" to consider the possibility of an acute stroke. These patients will usually have other clinical findings. Using thrombolysis for a patient with a very low NIH stroke score is a judgment call, but if it is a possible action, obtaining a CT first will facilitate the intervention. If reperfusion therapy is indicated, CT/CTA or CT/CTP should also be obtained to optimize acute stroke interventions. Consider activating local stroke guidelines.
Symptoms or signs strongly suggestive of intracranial hemorrhage (ICH)	
	In adult ED patients with acute vestibular syndrome and neurological symptoms or signs strongly suggesting the possibility of intracranial hemorrhage (e.g., severe headache, lethargy/confusion/mental status abnormality, hemiparesis, inability to maintain upright posture sitting or standing), and especially those patients who may require urgent neurosurgical intervention (e.g., ventriculostomy or posterior fossa decompression), waiting for an MRI will delay treatments. **Potential solutions**: Use a cognitive "timeout" to consider the possibility that this could be an ICH. Almost all ICH patients presenting with dizziness will have other clinical clues at the bedside. Obtaining a CT first may facilitate treatment.
Absolute contraindication to MRI	
	In adult ED patients with AVS and central signs (including central HINTS exam findings) who have absolute contraindications to MRI (e.g., non-MRI-safe metallic implants), CT/CTA plus CT/CTP should be performed (Note: CT/CTA should be performed first to be able to complete both tests without a second contrast dye load). **Potential solutions**: Some patients can be pre-treated to prevent or minimize an anaphylactoid reaction to contrast. Some patients with pacemakers can undergo MRI with cardiology consultation. If the MRI absolutely cannot be done, manage the patient understanding the intrinsic limitations of CT-based tests.
Relative contraindication to MRI	
	In adult ED patients with acute vestibular syndrome and central signs (including central HINTS exam findings) who have relative contraindications to MRI (e.g., severe claustrophobia, unstable cardiac/medical status), MRI may or may not be possible. **Potential solutions**: Most relative contraindications can be mitigated by medications (severe anxiety or claustrophobia) or intubation (for altered mental status). If the MRI absolutely cannot be done, manage the patient understanding the limitations of CT-based tests – CT/CTA or CTP.

	(NOTE: CT/CTA should be performed first to be able to complete both tests without a second contrast dye load) as a possible alternative to MRI if the balance of risks and benefits with respect to possible stroke diagnosis disfavor MRI.
Question 2 – Diagnosis of patients with the Spontaneous Episodic Vestibular Syndrome (s-EVS)	
Probable vestibular migraine diagnosis	
	In adult ED patients with spontaneous episodic vestibular syndrome whose presentation suggests a vestibular migraine or Menière diagnosis referral both to the primary care physician and a neurologist, ENT, or vestibular specialist should be considered. **Potential solutions**: None required; be aware that vestibular migraine is a common condition that is commonly missed or misdiagnosed.
Possible TIA diagnosis	
	In adult ED patients with spontaneous episodic vestibular syndrome, no specific decision rules currently exist to guide who should receive advanced neuroimaging; however, the Canadian TIA score may help clinicians estimate short term risk. **Potential solutions**: None required; however, understand that risk stratification tools have intrinsic limitations and the Canadian rule in particular removes points for a history of vertigo.
Question 3 – Diagnosis of patients with the Triggered Episodic Vestibular Syndrome (t-EVS)	
When to consider horizontal canal BPPV	
	Posterior canal BPPV is the most common type. In adult ED patients who present with a suggestive history of BPPV but have a negative Dix-Hallpike test (or one that elicits horizontal nystagmus), testing for horizontal canal BPPV with a supine roll test should be considered. Newer data suggest that hc-BPPV is more common in ED populations than has been reported in outpatient referral clinics. **Potential solutions**: Educational programs for ED clinicians will likely need to include certification in diagnosis and treatment of hc-BPPV as well as pc-BPPV. Note that the direction of nystagmus determines both the affected canal and the appropriate canalith repositioning maneuver treatment, even if the nystagmus was elicited by the "wrong" positional testing maneuver (e.g., if Dix-Hallpike test elicits horizontal nystagmus, it is not pc-BPPV and it is likely hc-BPPV; likewise, if the supine roll test elicits upbeat-torsional nystagmus it is not hc-BPPV and it is likely pc-BPPV).
When to consider CPPV (central paroxysmal positional vertigo)	
	In adult ED patients with triggered episodic vestibular syndrome who have additional neurological symptoms or signs (e.g., acute headache, visual

	disturbance, unilateral hearing loss, diplopia, new inability to walk independently), that are not seen in typical BPPV, CPPV must be considered. **Potential solutions**: This is very uncommon in an all-comer ED population but can be suspected based on additional neurologic symptoms or atypical nystagmus patterns for BPPV (see text). These patients should undergo MRI to diagnose central causes. In those with atypical nystagmus (not fitting typical pc-BPPV or typical geotropic hc-BPPV), MRI to diagnose central causes should be considered.
Question 4 – Steroid treatment for patients with vestibular neuritis	
Clinical diagnosis of vestibular neuritis and timing of initiation of steroid treatment	
	In adult ED patients diagnosed with vestibular neuritis, data suggest that earlier initiation of steroids is more effective than later treatment and should ideally be applied within 72 hours of symptom onset. **Potential solutions**: In patients diagnosed with vestibular neuritis, IF you have decided with the patients that steroids are to be given, start them in the ED or on the same day as the ED visit. Shared decision-making with the patient and a discussion with a specialist about starting steroids in the ED should be considered rather than referring and delaying a treatment decision
Question 5 - Treatment of patients clinically diagnosed with BPPV	
Wrong nystagmus	
	Presentation suggests BPPV but the Dix-Hallpike test does not show the expected nystagmus (upbeat-torsional). **Potential solutions**: In this situation, first consider performing the supine roll test for hc-BPPV. If brisk geotropic horizontal nystagmus is found, consider treating the patient for hc-BPPV with a canalith repositioning maneuver (e.g., Lempert [barbecue] roll or Gufoni maneuver). If no nystagmus is found but the patient is symptomatic ("subjective" BPPV), block fixation if you can (e.g., Frenzel lenses). If not, consider attempting the canalith repositioning maneuver "empirically" for the symptomatic test even without the confirmatory nystagmus (e.g., if Dix-Hallpike test right is symptomatic but Dix-Hallpike test left is not, treat with right Epley as if the Dix-Hallpike test had shown the nystagmus [which may be less apparent if you do not have special lenses to block visual fixation]).
Epley does not work	
	Epley or other canalith repositioning maneuver does not result in resolution of symptoms.

	Potential solutions: Most commonly this is because the diagnosis is incorrect (either the wrong canal is being treated or it is not BPPV). In this situation, consider performing a supine roll test, and, if positive, treating the patient for hc-BPPV with either a Lempert (barbecue) roll or Gufoni maneuver. If the diagnosis is correct, the most common cause for a treatment failure is suboptimal technique in performing the Epley. The most common mistake is not hanging the head far enough over the edge of the bed during the rotation. Also, treating more than once with good technique increases the chances of treatment success. Most specialists will repeat the maneuver until the patient is asymptomatic during the Dix-Hallpike test and then finish with one final Epley; it is not uncommon for specialists or physical therapists to treat 2-4 times with the Epley. If the patient remains symptomatic despite multiple properly-performed canalith repositioning maneuvers, consider obtaining MRI to exclude a structural cause.

Planning for updating these guidelines

Evidence is constantly growing. These guidelines should be updated within five years, or when significant new relevant high-quality research requires reassessment and revision of the relevant recommendation(s). Adoption of these guidelines should be tailored to local policies and practices and availability of specialists and telemedicine and video oculography, which may differ in different locations.

CONFLICT OF INTERESTS

Declaration and management of competing interests

All group members disclosed conflicts of interest using SAEM's standard methods. All members were able to participate as a voting member with the following disclosures and management.

Murtaza Akhter, MD: Nothing to disclose.

Fernanda Bellolio, MD, MS: Dr. Bellolio receives funding from AHRQ for the study of diagnostic errors, NIH, FDA and Kern Center for palliative and geriatric care related research.

Christopher Carpenter, MD, MSc: Dr. Carpenter is the Deputy Editor-in-Chief Academic Emergency Medicine, Associate Editor, Annals of Internal Medicine's ACP Journal Club, and Associate Editor, Journal of the American Geriatrics Society. Dr. Carpenter serves on the American College of Emergency Physicians Clinical Policy Committee and the American Board of Emergency Medicine, MyEMCert Editor. Dr. Carpenter's involvement with the ACEP Clinical Policy Committee as a member of the "Acute Stroke" Writing Team was disclosed to the GRACE-3 Writing Team, Academic Emergency Medicine Editorial Board, and Society for Academic Emergency Medicine Board of Directors in writing and verbally on multiple occasions during the course of developing GRACE-3. In order to minimize the potential for divergent recommendations between the ACEP "Acute Stroke" Clinical Policy and GRACE-3, the GRACE-3 PICO questions and emerging direction of recommendations were discussed repeatedly with

both the Clinical Policy Committee and the GRACE-3 Writing Team over the course of 12-months as both documents were being developed.
Jonathan Edlow, MD: Dr. Edlow is a compensated Section Editor for UpToDate and a compensated reviewer for both defense and plaintiff medical malpractice cases, some of which are related to dizziness and stroke.
Danya Khoujah, MD, MBBS: Nothing to disclose.
Jeff Kline, MD: Dr. Kline's spouse, Anne Messman, MD, is an emergency medicine physician uninvolved in the writing of GRACE-3. Anne Messman is on the ACGME transitional year residency review committee.
Evie Marcolini, MD: Dr. Marcolini is an Assistant Editor to American Journal of Emergency Medicine.
Will Meurer, MD, MS: Dr. Meurer is an Associate Editor to Annals of Emergency Medicine And Senior Editor of Trials. Dr. Meurer provides medicolegal consulting via Meurer Consulting, LLC without compensation in any cases of isolated acute or episodic vestibular syndrome. Dr. Meurer is a former compensated reviewer of legal cases pertaining to stroke.
David Morrill: Nothing to disclose.
James Naples, MD: Dr. Naples is the Editor-in-Chief for Decker Med Publisher - Otolaryngology Weekly Curriculum in which he participates in designing online curriculum content for ENT. Dr. Napes is the Editor of Ear & Hearing Journal, serves on the Editorial Board of Otolaryngology Head & Neck Surgery, and is a voting member of the Otology & Neurotology Education Committee. Dr. Napes develops curriculum for Otology & Neurotology section of the American Academy of Otolaryngology.
David Newman-Toker, MD, PhD: Dr. Newman-Toker conducts research related to diagnosis of dizziness and stroke, as well as diagnostic error. He serves as the principal investigator for multiple grants and contracts on these topics, including the NIH-sponsored AVERT clinical trial (NIDCD U01 DC013778, ClinicalTrials.gov #NCT02483429). Johns Hopkins has been loaned research equipment (video-oculography [VOG] systems) by two companies for use in Dr. Newman-Toker's research; one of these companies has also provided funding for research on diagnostic algorithm development related to dizziness, inner ear diseases, and stroke. Dr. Newman-Toker has no other financial interest in these or any other companies. Dr. Newman-Toker is an inventor on a provisional patent (US No. 62/883,373) for smartphone-based stroke diagnosis in patients with dizziness. He gives frequent academic lectures on these topics and occasionally serves as a medico-legal consultant for both plaintiff and defense in cases related to dizziness, stroke, and diagnostic error.
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Lucas Silva, MD, MS: Nothing to disclose.
Etta Sundberg: Ms. Sundberg is a patient ambassador for vestibular.org.
Karen Tartt: Ms. Tartt is the founder of Clear Spirit & Mind.
Suneel Upadhye, MD: Dr. Upadhye is a Decision Editor for the Canadian Journal of Emergency Medicine (CJEM), Canadian Association of Emergency Physicians (CAEP) Choosing Wisely Canada (CWC) Working Group, and is Co-Chair of the Best Evidence in Emergency Medicine

(BEEM) course which produces and presents CME events annually. Dr. Upadhye is also the creator of Emergency Medicine Guidelines Website. **Management:** Recused from decisions on GRACE-3 distribution.
Simone Vanni, MD, PhD: Nothing to disclose.

AUTHOR CONTRIBUTIONS

All authors participated in the writing and review of this manuscript.

ORCID

Christopher R Carpenter https://orcid.org/0000-0002-2603-7157
Fernanda Bellolio https://orcid.org/0000-0002-1632-4750
Lucas Oliveira J e Silva https://orcid.org/0000-0001-5388-9163
Suneel Upadhye https://orcid.org/0000-0002-6380-161X
Sameer Sharif https://orcid.org/0000-0002-3346-0308
Robert Ohle https://orcid.org/0000-0001-8263-0556
Matthew Siket https://orcid.org/0000-0003-0018-1019
Simone Vanni https://orcid.org/0000-0002-1201-5715
Jonathan A. Edlow http://orcid.org/0000-0001-6855-0912
M. Hassan Murad https://orcid.org/0000-0001-5502-5975
Evie Marcolini https://orcid.org/0000-0002-1166-1045
Rodney Omron https://orcid.org/0000-0002-6981-2846
Danya Khoujah https://orcid.org/0000-0002-0373-606X
Murtaza Akhter https://orcid.org/0000-0001-9693-6871
David Newman-Toker https://orcid.org/0000-0003-2789-4115
James Naples https://orcid.org/0000-0002-6676-6418
Jeffrey Kline https://orcid.org/0000-0001-7190-3109
William J. Meurer https://orcid/org/0000-0002-1158-5302

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