American College of Radiology
ACR Appropriateness Criteria®
Dizziness and Ataxia

Variant: 1 **Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRA head and neck with IV contrast	Usually Not Appropriate	O
MRA head and neck without and with IV contrast	Usually Not Appropriate	O
MRA head and neck without IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine with IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine without and with IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine without IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal with IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal without and with IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal without IV contrast	Usually Not Appropriate	O
MRI head with IV contrast	Usually Not Appropriate	O
MRI head without and with IV contrast	Usually Not Appropriate	O
MRI head without IV contrast	Usually Not Appropriate	O
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CT head without IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without and with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without IV contrast	Usually Not Appropriate	☢☢☢
CTA head and neck with IV contrast	Usually Not Appropriate	☢☢☢

Variant: 2 **Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI head without IV contrast	May Be Appropriate	O
MRA head and neck with IV contrast	Usually Not Appropriate	O
MRA head and neck without and with IV contrast	Usually Not Appropriate	O
MRA head and neck without IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine with IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine without and with IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine without IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal with IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal without and with IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal without IV contrast	Usually Not Appropriate	O
MRI head with IV contrast	Usually Not Appropriate	O
MRI head without and with IV contrast	Usually Not Appropriate	O
CT head with IV contrast	Usually Not Appropriate	☢☢☢

Procedure	Appropriateness Category	Relative Radiation Level
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CT head without IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without and with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without IV contrast	Usually Not Appropriate	☢☢☢
CTA head and neck with IV contrast	Usually Not Appropriate	☢☢☢

Variant: 3   Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRI head without IV contrast	Usually Appropriate	O
MRA head and neck with IV contrast	May Be Appropriate (Disagreement)	O
MRA head and neck without and with IV contrast	May Be Appropriate (Disagreement)	O
MRA head and neck without IV contrast	May Be Appropriate (Disagreement)	O
MRI head without and with IV contrast	May Be Appropriate (Disagreement)	O
CT head without IV contrast	May Be Appropriate	☢☢☢
CTA head and neck with IV contrast	May Be Appropriate (Disagreement)	☢☢☢
MRI cervical and thoracic spine with IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine without and with IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine without IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal with IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal without and with IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal without IV contrast	Usually Not Appropriate	O
MRI head with IV contrast	Usually Not Appropriate	O
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without and with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without IV contrast	Usually Not Appropriate	☢☢☢

Variant: 4   Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRI head and internal auditory canal without and with IV contrast	Usually Appropriate	O
CT temporal bone without IV contrast	Usually Appropriate	☢☢☢
MRI head and internal auditory canal without IV contrast	May Be Appropriate	O
MRA head and neck with IV contrast	Usually Not Appropriate	O
MRA head and neck without and with IV contrast	Usually Not Appropriate	O
MRA head and neck without IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine with IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine without and with IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine without IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal with IV contrast	Usually Not Appropriate	O
MRI head with IV contrast	Usually Not Appropriate	O

MRI head without and with IV contrast	Usually Not Appropriate	O
MRI head without IV contrast	Usually Not Appropriate	O
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CT head without IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without and with IV contrast	Usually Not Appropriate	☢☢☢
CTA head and neck with IV contrast	Usually Not Appropriate	☢☢☢

Variant: 5   Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRA head and neck with IV contrast	Usually Appropriate	O
MRA head and neck without and with IV contrast	Usually Appropriate	O
MRA head and neck without IV contrast	Usually Appropriate	O
MRI head without IV contrast	Usually Appropriate	O
CTA head and neck with IV contrast	Usually Appropriate	☢☢☢
MRI head without and with IV contrast	May Be Appropriate (Disagreement)	O
CT head without IV contrast	May Be Appropriate	☢☢☢
MRI cervical and thoracic spine with IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine without and with IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine without IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal with IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal without and with IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal without IV contrast	Usually Not Appropriate	O
MRI head with IV contrast	Usually Not Appropriate	O
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without and with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without IV contrast	Usually Not Appropriate	☢☢☢

Variant: 6   Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRI head without and with IV contrast	Usually Appropriate	O
MRI head without IV contrast	Usually Appropriate	O
MRI cervical and thoracic spine without IV contrast	May Be Appropriate	O
MRA head and neck with IV contrast	Usually Not Appropriate	O
MRA head and neck without and with IV contrast	Usually Not Appropriate	O
MRA head and neck without IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine with IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine without and with IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal with IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal without and with IV contrast	Usually Not Appropriate	O

Procedure	Appropriateness Category	Relative Radiation Level
MRI head and internal auditory canal without IV contrast	Usually Not Appropriate	O
MRI head with IV contrast	Usually Not Appropriate	O
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CT head without IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without and with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without IV contrast	Usually Not Appropriate	☢☢☢
CTA head and neck with IV contrast	Usually Not Appropriate	☢☢☢

Variant: 7 Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRI cervical and thoracic spine without and with IV contrast	Usually Appropriate	O
MRI cervical and thoracic spine without IV contrast	Usually Appropriate	O
MRA head and neck with IV contrast	Usually Not Appropriate	O
MRA head and neck without and with IV contrast	Usually Not Appropriate	O
MRA head and neck without IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine with IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal with IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal without and with IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal without IV contrast	Usually Not Appropriate	O
MRI head with IV contrast	Usually Not Appropriate	O
MRI head without and with IV contrast	Usually Not Appropriate	O
MRI head without IV contrast	Usually Not Appropriate	O
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CT head without IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without and with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without IV contrast	Usually Not Appropriate	☢☢☢
CTA head and neck with IV contrast	Usually Not Appropriate	☢☢☢

Variant: 8 Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRI head without IV contrast	May Be Appropriate	O
MRA head and neck with IV contrast	Usually Not Appropriate	O
MRA head and neck without and with IV contrast	Usually Not Appropriate	O
MRA head and neck without IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine with IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine without and with IV contrast	Usually Not Appropriate	O
MRI cervical and thoracic spine without IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal with IV contrast	Usually Not Appropriate	O

MRI head and internal auditory canal without and with IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal without IV contrast	Usually Not Appropriate	O
MRI head with IV contrast	Usually Not Appropriate	O
MRI head without and with IV contrast	Usually Not Appropriate	O
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CT head without IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without and with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without IV contrast	Usually Not Appropriate	☢☢☢
CTA head and neck with IV contrast	Usually Not Appropriate	☢☢☢

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Summary of Literature Review

Introduction/Background

Diagnostic evaluation of a patient with dizziness or vertigo is complicated by a lack of standardized nomenclature, significant overlap in symptom descriptions, and the subjective nature of the patient's symptoms. Although dizziness is an imprecise term often used by patients to describe a feeling of being off-balance, in many cases dizziness can be subcategorized based on symptomatology as vertigo (false sense of motion or spinning), disequilibrium (imbalance with gait instability), presyncope (nearly fainting or blacking out), or lightheadedness (nonspecific). Interestingly, studies have demonstrated that around half of patients presenting to the emergency department with dizziness changed the description of their symptoms during their stay, and approximately 60% reported more than one subjective descriptor. For these reasons, current diagnostic paradigms focus on timing, triggers, and associated symptoms rather than subjective descriptions of dizziness type [1]. Keeping these limitations in mind, a complaint of dizziness or vertigo accounts for >7 million ambulatory care visits annually and up to 5% of emergency department visits [2,3].

Although dizziness or vertigo can be related to emergent and life-threatening conditions, the positivity rate of head CT in the emergency department in all patients presenting with these complaints is very low at approximately 2%, with the most common positive findings including ischemic stroke, neoplasm, and hemorrhage [2,4]. The clinical detection of associated neurologic symptoms is important in triaging these patients. In patients with isolated dizziness, the positivity rate of diffusion-weighted imaging (DWI) MRI was low (~4%) [4]. When associated neurologic findings were present, however, the diagnostic yield of MRI increased to 12% [5]. Various bedside tests have been developed and validated to assist in triaging patients to one of several defined

"dizziness syndromes," which helps in clinical decision making including the need for subsequent imaging. For example, response to Dix-Hallpike testing allows for differentiation between benign paroxysmal positional vertigo (BPPV) and more worrisome central paroxysmal positional vertigo (CPPV). In patients with acute vestibular syndrome (AVS), results of the head impulse, nystagmus, test of skew (HINTS) triad on clinical testing have shown good distinction between those with acute brain lesions (ie, mass, infarct, hemorrhage) and those without, when performed by examiners with specialized training [6]. The presented variants will go into further detail on the approach to imaging in these various clinical scenarios.

The first variant addresses brief episodes of vertigo associated with head movements most commonly due to BPPV. The second and third variants address acute onset of persistent vertigo with associated nausea/vomiting, gait instability, nystagmus, and head-motion intolerance that defines AVS without and with neurologic symptoms. The presence of neurologic symptoms is associated with increased risk of stroke, whereas the absence typically has benign pathology. Variants 4 and 5 address chronic recurrent vertigo. For those with associated hearing loss or tinnitus, Menière disease (MD) is the most common cause (Variant 4). For those with associated brainstem neurologic deficits, chronic vertebrobasilar insufficiency (VBI) is the most likely etiology (Variant 5). Chronic disequilibrium with signs of cerebellar ataxia and sensory/proprioceptive ataxia are addressed in Variants 6 and 7, respectively. The last variant, Variant 8, addresses remaining patients who present with nonspecific uncomplicated dizziness.

Dizziness and ataxia may coexist with other conditions. Please refer to relevant ACR Appropriateness Criteria® topics on "Cerebrovascular Disease" [7], "Hearing Loss and/or Vertigo" [8], "Tinnitus" [9], "Head Trauma" [10], and "Movement Disorders and Neurodegenerative Diseases" [11].

Special Imaging Considerations

Conventional diagnostic angiography (DA) may be used in a specific subset of patients presenting with episodic vertigo if there is clinical concern for positional insufficiency of the posterior circulation. DA allows for real-time dynamic evaluation of vessel patency in various neck positions, which is difficult to accomplish via conventional CT angiography (CTA) or MR angiography (MRA) imaging. This information may inform subsequent surgical management in these patients [12]. DA also remains the reference standard for confirmation of clinically suspected VBI as well as vertebral artery dissection, both of which can present with vertigo [13,14]. In cases of vertebral artery dissection documented by DA, however, CTA demonstrated a similar sensitivity approaching 100% [14]. The risks of DA include the potential for rare, severe, or life-threatening allergic-like reactions to contrast media, renal injury related to iodinated contrast administration, potential vascular injury, or infarct due to catheter manipulation in the vessels, as well as local complications at the vascular access site to include infection, hematoma, pseudoaneurysm, or arterial occlusion.

Transcranial Doppler ultrasound (US) has demonstrated differences in vascular flow parameters between patients with vertigo related to VBI, patients with vertigo unrelated to VBI, and asymptomatic controls, making this a potential diagnostic tool in the characterization of vertigo [13,15].

Brain PET using various radiotracers has shown promise in detecting presymptomatic neuronal dysfunction in patients with certain types of spinocerebellar ataxia (SCA) and in asymptomatic

mutation carriers. Changes on PET were detectable sooner than alterations in morphology and signal intensity on conventional MRI. As such, PET may be a valuable adjunct to conventional brain imaging in this patient population [16,17].

Initial Imaging Definition

Initial imaging is defined as imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care)

OR

- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously wherein each procedure provides unique clinical information to effectively manage the patient's care).

Discussion of Procedures by Variant

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.

Brief episodic vertigo triggered by specific head movements (eg, Dix-Hallpike maneuver) is referred to as triggered episodic vestibular syndrome (t-EVS) and is most commonly due to BPPV; however, more ominous central causes may clinically mimic BPPV and are collectively referred to as CPPV [1]. BPPV results from mobile debris (canaliths) in the vestibular labyrinth. The diagnostic criteria for BPPV are clinical and well established [18-20]. Imaging evaluation in BPPV with typical nystagmus on Dix-Hallpike testing is unnecessary. In contrast, patients with CPPV present with symptoms of t-EVS but negative or atypical Dix-Hallpike testing are at an increased risk of having an acute central cause of vertigo identified on imaging [6]. Potential causes of CPPV include mass lesions, hemorrhage, infarct, and demyelinating disease, among others [1]. Other specific t-EVS subgroups may also be at increased risk of incidental but potentially actionable findings on neuroimaging, including those with subjective symptoms but no objective signs, younger patients with post-traumatic onset of symptoms, elderly patients, those unresponsive to repositioning maneuvers, and those with short-term recurrence of symptoms [21]. Vestibular migraine may mimic a variety of causes of dizziness and vertigo, including t-EVS, but often has associated headache and other migrainous features (ie, photophobia, phonophobia, visual aura) [20,22]. Imaging is not required to diagnose vestibular migraine. To summarize, most patients with t-EVS will not require imaging unless there are atypical features such as lack of nystagmus on provoking maneuvers (eg, Dix-Hallpike) or lack of response to treatment maneuvers (eg, Epley).

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
A. CT head with IV contrast

There is no relevant literature regarding the use of CT head with IV contrast in the evaluation of t-EVS.

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-

Hallpike maneuver). Initial imaging.
B. CT head without and with IV contrast

There is no relevant literature regarding the use of CT head without and with IV contrast in the evaluation of t-EVS.

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
C. CT head without IV contrast

Imaging evaluation in BPPV with typical nystagmus on Dix-Hallpike testing is unnecessary. Head CT allows for the evaluation of the intracranial structures; however, soft tissue contrast is inferior to MRI. In a single-center retrospective study of patients with episodic vertigo triggered by specific head movements but negative or atypical Dix-Hallpike testing (CPPV), CT detected acute brain lesions in 6% of cases compared with 11% with MRI [6].

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
D. CT temporal bone with IV contrast

There is no relevant literature regarding the use of CT temporal bone with IV contrast in the evaluation of t-EVS.

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
E. CT temporal bone without and with IV contrast

There is no relevant literature regarding the use of CT temporal bone without and with IV contrast in the evaluation of t-EVS.

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
F. CT temporal bone without IV contrast

There is no relevant literature regarding the use of CT temporal bone without IV contrast in the evaluation of t-EVS.

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
G. CTA head and neck with IV contrast

There is no relevant literature regarding the use of CTA head and neck with IV contrast in the evaluation of t-EVS.

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
H. MRA head and neck with IV contrast

There is no relevant literature regarding the use of MRA head and neck with IV contrast in the evaluation of t-EVS.

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
I. MRA head and neck without and with IV contrast

There is no relevant literature regarding the use of MRA head and neck without and with IV contrast in the evaluation of t-EVS.

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
J. MRA head and neck without IV contrast

Imaging evaluation in BPPV with typical nystagmus on Dix-Hallpike testing is unnecessary. MRA allows for evaluation of the course and luminal caliber of the arteries. MRA can also detect luminal filling defects, which may include thrombus, embolus, atherosclerotic plaque, dissection flap, or vascular web. MRA of the head and neck can be performed either without intravenous (IV) contrast, with IV contrast, or as a combination of without and with IV contrast. Although imaging is not required in the setting of typical BPPV, MRA of the head and neck has been used to detect abnormalities of the carotid or vertebrobasilar arteries, which may be associated with symptoms of BPPV. The prevalence of vascular changes is higher in the elderly population with underlying comorbidities such as diabetes, hypertension, and hyperlipidemia in a small prospective study of 126 patients [23].

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
K. MRI cervical and thoracic spine with IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine with IV contrast in the evaluation of t-EVS.

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
L. MRI cervical and thoracic spine without and with IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine without and with IV contrast in the evaluation of t-EVS.

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
M. MRI cervical and thoracic spine without IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine without IV contrast in the evaluation of t-EVS.

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
N. MRI head and internal auditory canal with IV contrast

There is no relevant literature regarding the use of MRI head and internal auditory canal (IAC) with IV contrast in the evaluation of t-EVS.

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
O. MRI head and internal auditory canal without and with IV contrast

Imaging evaluation in BPPV with typical nystagmus on Dix-Hallpike testing is unnecessary. MRI of the head and IACs provides evaluation of the entire brain with the addition of specific sequences tailored toward assessment of the skull base and associated cranial nerves. The addition of these sequences allows improved detection of small masses and compressive vascular lesions (ie, aneurysm, vessel tortuosity) in and around the IACs. The addition of gadolinium-based IV contrast agents also improves the detection and characterization of masses as well as inflammatory, infectious, or demyelinating processes, which have been described in the setting of CPPV in a retrospective study of 500 patients [21].

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
P. MRI head and internal auditory canal without IV contrast

There is no relevant literature regarding the use of MRI head and IAC without IV contrast in the evaluation of t-EVS.

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
Q. MRI head with IV contrast

There is no relevant literature regarding the use of MRI head with IV contrast in the evaluation of t-EVS.

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
R. MRI head without and with IV contrast

Imaging evaluation in BPPV with typical nystagmus on Dix-Hallpike testing is unnecessary. MRI allows detailed evaluation of the intracranial structures with improved soft tissue resolution when compared with CT. The addition of MRI of the brain following the IV administration of gadolinium-based contrast allows further characterization of any detected lesions and improves the detection and characterization of masses as well as inflammatory, infectious, or demyelinating processes, which have been described in the setting of CPPV [20]. Acute brain lesions have been reported in 6% of patients undergoing head CT and 11% of those undergoing MRI for CPPV [6].

Variant 1: Adult. Brief episodic vertigo. Triggered by specific head movements (eg, Dix-Hallpike maneuver). Initial imaging.
S. MRI head without IV contrast

Imaging evaluation in BPPV with typical nystagmus on Dix-Hallpike testing is unnecessary. MRI allows detailed evaluation of the intracranial structures with improved soft tissue resolution when compared with CT. MRI of the head is not indicated for the initial diagnosis of typical BPPV. The presence of coexisting brain atrophy on MRI, however, is associated with a higher risk of prolonged dizziness following a diagnosis of BPPV and so may be of prognostic value in these patients in a retrospective study of 120 patients [24].

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.

The acute onset of persistent vertigo with associated nausea/vomiting, gait instability, nystagmus, and head-motion intolerance defines AVS. These patients may or may not have associated deficits on neurologic examination [1]. This variant will address the imaging approach to those presenting with AVS but a normal neurologic examination (isolated AVS). The approach to those with associated neurologic deficits will be discussed as a separate variant (Variant 3). Patients with vertigo of any cause are often initially evaluated in the emergency department. Although the use of CT imaging performed for this indication has dramatically increased over the past several decades, the detection rate of contributory central nervous system pathology in those with a normal neurologic examination remains very low (<1% in an emergency department in a single center, which included 3,165 patients); see Variant 8 [25]. This is not surprising because many patients with acute vertigo and a normal neurologic examination will have a benign peripheral etiology. In patients with AVS and a normal neurologic examination, the most common causes of symptoms are vestibular neuritis and labyrinthitis, neither of which has associated findings on CT

imaging.

The most worrisome cause of AVS to be excluded is a posterior circulation infarct involving the brainstem or cerebellum; see Variant 3. Although the prevalence of cerebrovascular disease in all patients presenting to the emergency department with dizziness or vertigo is approximately 4%, the prevalence of cerebrovascular disease in those presenting with AVS is closer to 25% and may be as high as 75% in the highest vascular risk cohorts [26]. Depending on the skill and training of the examiner, focal neurologic symptoms/signs are reportedly lacking in between one-third and two-thirds of these patients [27]. In one study, 11% of patients presenting with acute persistent vertigo but no focal neurologic symptoms/signs were found to have an acute infarct on CT or MRI of the brain [28]. Other studies estimate that 75% to 80% of patients presenting with AVS related to infarct have no associated focal neurologic deficits [29].

Isolated AVS is most commonly due to a benign peripheral cause; however, a lack of associated neurologic deficits does not exclude a central cause such as infarct. To address this, various bedside tests like the HINTS examination have been developed to distinguish AVS of benign cause from posterior circulation infarct. When performed by specially trained practitioners, these tests have been shown to be even more sensitive than early MRI for the detection of infarct (100% versus 46%) [30]. Similar testing performed by nonexperts has shown more mixed results [6,31]. In another retrospective study involving 610 patients in an emergency department, not a single patient with an AVS, in whom the complete HINTS triad was consistent with peripheral vertigo, had abnormalities on CT/MRI [6]. Multiple sclerosis involving the brainstem or cerebellar peduncles is an additional but rare cause of AVS, accounting for approximately 4% of cases. Of note, nearly all of these patients also have additional abnormal neurologic findings suggesting a central lesion [32]. Even rarer causes of isolated AVS include cerebellar hemorrhage and a variety of autoimmune, infectious, and metabolic conditions [25]. Vestibular migraine may mimic a variety of causes of dizziness/vertigo, including AVS, but often has associated headache and other migrainous features (ie, photophobia, phonophobia, visual aura) [22,33]. Imaging is not required to diagnose vestibular migraine. To summarize, patients with isolated AVS may not require imaging if HINTS examination by specially trained providers is available and negative; otherwise, imaging may be required to rule out stroke.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
A. CT head with IV contrast

There is no relevant literature regarding the use of CT head with IV contrast in the evaluation of isolated AVS.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
B. CT head without and with IV contrast

There is no relevant literature regarding the use of CT head without and with IV contrast in the evaluation of isolated AVS.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
C. CT head without IV contrast

Imaging evaluation in isolated AVS without features of central vertigo is unnecessary. Patients with

features of central vertigo or high baseline risk for stroke may be candidates for neuroimaging. Head CT allows for rapid evaluation of the intracranial structures. In isolated AVS, the detection rate of acute infarct may be as high at 11% at a single-center study involving 221 patients; therefore, noncontrast head CT may be of benefit in select patients [28]. Brain MRI may be useful for follow up evaluation if initial head CT is negative.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
D. CT temporal bone with IV contrast

There is no relevant literature regarding the use of CT temporal bone with IV contrast in the evaluation of isolated AVS.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
E. CT temporal bone without and with IV contrast

There is no relevant literature regarding the use of CT temporal bone without and with IV contrast in the evaluation of isolated AVS.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
F. CT temporal bone without IV contrast

There is no relevant literature regarding the use of CT temporal bone without IV contrast in the evaluation of isolated AVS.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
G. CTA head and neck with IV contrast

There is no relevant literature regarding the use of CTA head and neck with IV contrast in the evaluation of isolated AVS.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
H. MRA head and neck with IV contrast

There is no relevant literature regarding the use of MRA head and neck with IV contrast in the evaluation of isolated AVS.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
I. MRA head and neck without and with IV contrast

There is no relevant literature regarding the use of MRA head and neck without and with IV contrast in the evaluation of isolated AVS.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
J. MRA head and neck without IV contrast

There is no relevant literature regarding the use of MRA head and neck without IV contrast in the evaluation of isolated AVS.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.

K. MRI cervical and thoracic spine with IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine with IV contrast in the evaluation of isolated AVS.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
L. MRI cervical and thoracic spine without and with IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine without and with IV contrast in the evaluation of isolated AVS.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
M. MRI cervical and thoracic spine without IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine without IV contrast in the evaluation of isolated AVS.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
N. MRI head and internal auditory canal with IV contrast

There is no relevant literature regarding the use of MRI head and IAC with IV contrast in the evaluation of isolated AVS.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
O. MRI head and internal auditory canal without and with IV contrast

Imaging evaluation in isolated AVS without features of central vertigo is unnecessary. Routine MRI of the head in the setting of vestibular neuritis, the most common cause of isolated AVS, is characteristically normal. Dedicated imaging of the IACs allows for improved evaluation of the vestibular nerve and may show a decreased caliber of the nerve following vestibular neuritis; however, this is not always present and is not required to establish the diagnosis [34,35]. Detection of vestibular nerve enhancement following the IV administration of gadolinium-containing contrast would also support the clinical diagnosis of vestibular neuritis [36]. Labyrinthitis, another common cause of AVS, may also have findings on contrast-enhanced MRI of the IACs; however, this is often diagnosed clinically due to the presence of associated hearing loss or tinnitus and will be discussed separately (Variant 4) [1].

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
P. MRI head and internal auditory canal without IV contrast

There is no relevant literature regarding the use of MRI head and IAC without IV contrast in the evaluation of isolated AVS.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
Q. MRI head with IV contrast

There is no relevant literature regarding the use of MRI head with IV contrast in the evaluation of isolated AVS.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.

R. MRI head without and with IV contrast

Imaging evaluation in isolated AVS without features of central vertigo is unnecessary. MRI of the head without and with IV contrast would be the imaging modality of choice to evaluate demyelinating, autoimmune, inflammatory, or metabolic conditions involving the brainstem or cerebellum, which would all be rare causes of isolated AVS [25]. Although brain parenchymal signal alterations would be demonstrable on precontrast imaging, the addition of gadolinium-containing IV contrast allows for the differentiation of acute and chronic demyelinating lesions as well as detection of other acute inflammation.

Variant 2: Adult. Acute persistent vertigo. Normal neurologic examination and HINTS examination examination consistent with peripheral vertigo. Initial imaging.
S. MRI head without IV contrast

Imaging evaluation in isolated AVS without features of central vertigo is unnecessary. Because routine MRI of the head is characteristically normal in vestibular neuritis, MRI is not required for diagnosis. Patients with features of central vertigo or high baseline risk for stroke may be candidates for neuroimaging. In patients with isolated dizziness symptoms without associated neurological symptoms, the incidence of acute central lesions was 2.3% on MRI in a single center of 645 patients presented to the emergency department [37]. The presence of white matter abnormalities identified on MRI of the head, however, has been shown to positively correlate with the risk of developing subsequent chronic vestibular insufficiency and so may be prognostically useful especially in the elderly population [38]. Approximately 3% to 4% of patients presenting with isolated dizziness had acute stroke on MRI DWI [39]. MRI also has a better sensitivity than CT for the detection of parenchymal infarcts. Studies of patients presenting with AVS related to infarct have shown an overall sensitivity of approximately 80% for MRI performed within 24 hours of symptom onset. Early MRI, however, may be negative in half of cases when the area of infarct is small (<10 mm in size) and located in the brainstem/cerebellum. Patients with these small areas of infarct are also those more likely to present with isolated AVS. In these cases, delaying MRI until at least 48 hours from symptom onset or repeating an initially negative MRI will improve lesion detection [29].

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.

Posterior circulation strokes involving the brainstem and cerebellum account for a smaller proportion of acute stroke presentations but may have severe devastating and debilitating consequences. It is estimated that 25% of AVS are caused by stroke. Approximately 20% of these patients have focal neurologic signs whereas the remainder have isolated AVS. [29]. This subset of patients with abnormal neurologic examination should be evaluated according to the ACR Appropriateness Criteria® topic on "Cerebrovascular Diseases-Stroke and Stroke-Related Conditions" [40] stroke topic. Classic clinical Wallenberg or lateral medullary syndrome is seen with only a small proportion of patients [32]. The age, blood pressure, clinical features, duration, and diabetes (ABCD^2) score is a clinical stroke risk score, which has been found to help differentiating strokes from mimics [41]. HINTS is a useful tool to screen for stroke in this setting and was found to be better than ABCD^2 score in a study, but accuracy may be dependent on the examiner's experience [30]. Although some studies recommend that patients with negative HINTS should not receive brain imaging [6], a meta-analysis suggests that if HINTS is used in isolation by emergency physicians and not by neurologists, it is not adequately sensitive to exclude a stroke in patients presenting with AVS [31]. Recently published clinical guidelines by the Society for Academic Emergency Medicine and American College of Emergency Physicians state that most emergency

physicians have not yet received special training in use of HINTS and cannot be expected to perform it with sufficient accuracy as a first-line test before MRI [42,43].

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
A. CT head with IV contrast

There is no relevant literature regarding the use of postcontrast head CT in the evaluation of suspected acute posterior fossa stroke.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
B. CT head without and with IV contrast

There is no relevant literature regarding the use of postcontrast head CT in the evaluation of suspected acute posterior fossa stroke.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
C. CT head without IV contrast

CT is usually performed first in the emergency setting for workup of acute stroke. Hemorrhage can be excluded rapidly to select patients for thrombolysis. Posterior fossa ischemic strokes are difficult to detect on CT with a low sensitivity (~10% at a single academic emergency department in 610 patients in a 2-year period) [6]. Overall, the diagnostic yield for head CT ordered in the emergency department for acute dizziness is low (2.2%; 1.6% for emergent findings in an academic emergency department in 448 patients), but MRI changes the diagnosis up to 16% of the time, acutely in 8% of cases [2].

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
D. CT temporal bone with IV contrast

There is no relevant literature regarding the use of CT temporal bone with IV contrast in the evaluation of suspected acute posterior fossa stroke.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
E. CT temporal bone without and with IV contrast

There is no relevant literature regarding the use of CT temporal bone without and with IV contrast in the evaluation of suspected acute posterior fossa stroke.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
F. CT temporal bone without IV contrast

There is no relevant literature regarding the use of CT temporal bone without IV contrast in the evaluation of suspected acute posterior fossa stroke.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
G. CTA head and neck with IV contrast

CTA head and neck may be performed for evaluation of suspected acute posterior fossa stroke, particularly those who are eligible for mechanical thrombectomy.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
H. MRA head and neck with IV contrast

MRA head and neck may be performed for the evaluation of acute ischemic strokes and may assist in the management of patients, particularly those who are eligible for mechanical thrombectomy. The decision between CTA and MRA for initial vascular evaluation may depend on institutional preferences.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
I. MRA head and neck without and with IV contrast

MRA head and neck may be performed for the evaluation of acute ischemic strokes and may assist in the management of patients, particularly those who are eligible for mechanical thrombectomy. The decision between CTA and MRA for initial vascular evaluation may depend on institutional preferences.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
J. MRA head and neck without IV contrast

MRA head and neck with IV contrast is often performed as a combination of without and with IV contrast. Please see "MRA Head and Neck Without and With IV Contrast" for additional discussion.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
K. MRI cervical and thoracic spine with IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine with IV contrast in the evaluation of suspected acute posterior fossa stroke.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
L. MRI cervical and thoracic spine without and with IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine without and with IV contrast in the evaluation of suspected acute posterior fossa stroke.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
M. MRI cervical and thoracic spine without IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine without IV contrast in the evaluation of suspected acute posterior fossa stroke.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
N. MRI head and internal auditory canal with IV contrast

There is no relevant literature regarding the use of MRI head and IAC with IV contrast in the evaluation of suspected acute posterior fossa stroke.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
O. MRI head and internal auditory canal without and with IV contrast

There is no relevant literature regarding the use of MRI head and IAC without and with IV contrast in the evaluation of suspected acute posterior fossa stroke.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
P. MRI head and internal auditory canal without IV contrast

There is no relevant literature regarding the use of MRI head and IAC without IV contrast in the evaluation of suspected acute posterior fossa stroke.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
Q. MRI head with IV contrast

There is no relevant literature regarding the use of postcontrast brain MRI in the evaluation of suspected acute posterior fossa stroke.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
R. MRI head without and with IV contrast

There is no relevant literature regarding the use of postcontrast brain MRI in the evaluation of suspected acute posterior fossa stroke.

Variant 3: Adult. Acute persistent vertigo. Abnormal neurologic examination or HINTS examination is consistent with central vertigo. Initial imaging.
S. MRI head without IV contrast

The ability to detect an acute stroke on DWI is dependent on size [29]. False-negative MRIs with small strokes occurred 6 to 48 hours after the onset of vestibular symptoms. In this retrospective study, central oculomotor signs (odds ratio [OR] 2.8, 95% confidence interval [CI], 1.5-5.2) and focal abnormalities on clinical examination (OR 3.3, 95% CI, 1.8-6.2) are statistically significantly positive predictors for abnormal brain lesions on CT/MRI, whereas the transient nature of symptoms was associated with a reduced risk (OR 0.3, 95% CI, 0.1-0.6).

In a study of emergency department patients with dizziness, combined neurological symptoms with an OR of 16.72, $P < .01$, was found to be the strongest predictor of a lesion positive on MRI [37]. In a cross-sectional study of 190 high-risk patients with dizziness, HINTS examination outperforms ABCD^2 risk scores [30]. The diagnostic yield for head CT ordered in the emergency department for acute dizziness is low (2.2%; 1.6% for emergent findings), but MRI changes the diagnosis up to 16% of the time, acutely in 8% of cases [2].

Earlier MRI studies in posterior fossa stroke showed a high false-negative rate on DWI when performed within the first 24 hours of symptom onset [44,45]. This has improved with better imaging techniques over time. MRI has a higher sensitivity for acute ischemic strokes than CT, although within the first 48 hours DWI still can be falsely negative in approximately 50% of small ischemic strokes in the posterior fossa [6,46]. Some have advocated for delayed MRI (3-7 days) if initial imaging was negative [1,29]. One single-center study of 36 patients with basilar artery occlusion found DWI MRI helps predict outcome in basilar artery occlusion patients treated with intra-arterial thrombolysis [47].

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.

In contrast to an isolated episode of acute vertigo, chronic recurrent vertigo suggests an intermittently symptomatic long-standing condition. When associated unilateral hearing loss or tinnitus is present, the diagnosis of MD should be considered. MD is of unknown etiology. Patients have intermittent episodes of vertigo, fluctuating sensorineural hearing loss, tinnitus, and aural fullness. Previously a purely clinical diagnosis, imaging in MD has increased in the past decade. It is associated with endolymphatic hydrops (distension of labyrinthine structures). Imaging may also be used to exclude other causes of such symptoms, such as vestibular schwannoma, superior semicircular dehiscence, and other IAC masses. Most imaging facilities are unable to perform the specific type of MRI required for evaluation of endolymphatic hydrops. Outside of academic medical centers with specialized imaging protocols, IAC MRI is usually performed to negatively exclude other causes of vertigo with unilateral hearing loss or tinnitus, rather than to make a positive imaging-based diagnosis of MD.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
A. CT head with IV contrast

There is no relevant literature regarding the use of CT head with IV contrast in the evaluation of suspected MD.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
B. CT head without and with IV contrast

There is no relevant literature regarding the use of CT head without and with IV contrast in the evaluation of suspected MD.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
C. CT head without IV contrast

There is no relevant literature regarding the use of CT head without IV contrast in the evaluation of suspected MD.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
D. CT temporal bone with IV contrast

There is no relevant literature regarding the use of CT temporal bone with IV contrast in the evaluation of suspected MD.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
E. CT temporal bone without and with IV contrast

There is no relevant literature regarding the use of CT temporal bone without and with IV contrast in the evaluation of suspected MD.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
F. CT temporal bone without IV contrast

Superior semicircular canal dehiscence, which can present with similar symptoms to MD, can be readily diagnosed on a CT temporal bone without IV contrast.

Three-dimensional CT temporal bone may be used for the evaluation of stenosis of the vestibular aqueduct [48,49] and high jugular bulb in patients with suspected MD [50].

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
G. CTA head and neck with IV contrast

There is no relevant literature regarding the use of CTA head and neck with IV contrast in the evaluation of suspected MD.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
H. MRA head and neck with IV contrast

There is no relevant literature regarding the use of MRA head and neck with IV contrast in the evaluation of suspected MD.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
I. MRA head and neck without and with IV contrast

There is no relevant literature regarding the use of MRA head and neck without and with IV contrast in the evaluation of suspected MD.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
J. MRA head and neck without IV contrast

There is no relevant literature regarding the use of MRA head and neck without IV contrast in the evaluation of suspected MD.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
K. MRI cervical and thoracic spine with IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine with IV contrast in the evaluation of suspected MD.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
L. MRI cervical and thoracic spine without and with IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine without and with IV contrast in the evaluation of suspected MD.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
M. MRI cervical and thoracic spine without IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine without IV contrast in the evaluation of suspected MD.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
N. MRI head and internal auditory canal with IV contrast

MRI head and IAC with IV contrast is often performed as a combination of without and with IV contrast. Please see "MRI Head and Internal Auditory Canal Without and With IV Contrast" for

additional discussion.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
O. MRI head and internal auditory canal without and with IV contrast

The use of MRI of the IAC in suspected MD has been increasingly studied in recent years [51-53]. However, outside of very specialized centers, most radiology practices do not offer this test. A "standard" MRI IAC without and with IV contrast will not reveal the changes seen in these studies, but it will still be useful to negatively exclude other causes of vertigo with unilateral hearing loss or tinnitus.

Highly specialized techniques with high resolution such as delayed 3-D fluid-attenuated inversion recovery (FLAIR), inversion recovery turbo spin-echo with real reconstruction (3-D real-inversion recovery), and imaged after gadolinium administration demonstrates accumulation of gadolinium in the endolymphatic sac [53-57]. Intratympanic gadolinium may also be performed but is more invasive [58,59]. Some studies used double dose contrast. Volumetric assessment with ratio of endolymph to perilymph volume in the cochlea and vestibule are performed. Endolymphatic hydrops and grading on MRI in patients with MD has shown correlation with clinical symptoms in multiple studies [52,60-64] and histopathologic specimens [65].

The vestibular endolymphatic space contacting the oval window has a high specificity and positive predictive value in differentiating MD ears from other ears in a small study [66].

Although most of the recent studies have been focused on the postgadolinium enhancement, the noncontrast portion of the MR studies can be helpful in diagnosing alternative causes such as stroke, superior semicircular dehiscence, and other IAC masses. Volumetric measure of inner ear structures has been shown to be useful [67]. Although often not specifically mentioned, a sequence (typically heavily T2-weighted) that shows both perilymph and endolymph to help determine the area of the entire labyrinth is needed, and this is performed without IV contrast.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
P. MRI head and internal auditory canal without IV contrast

Nongadolinium techniques such as high-resolution T2-weighted steady-state free precession sequences have been used for the evaluation of suspected MD. However, most of the literature uses gadolinium to assess for enhancement of the inner ear structures. Please see "MRI Head and Internal Auditory Canal Without and With IV Contrast" for additional discussion.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
Q. MRI head with IV contrast

There is no relevant literature regarding the use of MRI head with IV contrast in the evaluation of suspected MD.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
R. MRI head without and with IV contrast

There is no relevant literature regarding the use of MRI head without and with IV contrast in the evaluation of suspected MD.

Variant 4: Adult. Chronic recurrent vertigo. Associated with unilateral hearing loss or tinnitus. Initial imaging.
S. MRI head without IV contrast

There is no relevant literature regarding the use of MRI head without IV contrast in the evaluation of suspected MD.

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.

In contrast to an isolated episode of acute vertigo, chronic recurrent vertigo suggests an intermittently symptomatic long-standing condition. When associated brainstem neurologic deficits are present, the diagnosis of VBI should be considered. VBI is characterized by transient disruption of blood flow in the posterior (vertebrobasilar) circulation, which supplies the thalami, cerebellum, and brainstem. If this disruption of blood flow is pronounced or prolonged, frank infarct and permanent disability may result [13]. There remains a relative paucity of information regarding optimal imaging evaluation and management of those with symptomatic stenotic disease of the vertebrobasilar circulation when compared with the more thoroughly studied anterior (carotid) circulation. Patients with VBI are also at a higher perioperative risk from revascularization procedures when compared with similar lesions in the anterior circulation [68]. VBI is most often related to atherosclerotic disease in the elderly. Vertebral artery dissection or positional narrowing of the vertebral arteries would be additional uncommon causes of VBI. In contrast to atherosclerotic disease, dissection is often accompanied by headache or neck pain in the setting of recent trauma (see ACR Appropriateness Criteria® topic on "Head Trauma" [10]).

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
A. CT head with IV contrast

There is no relevant literature regarding the use of CT head with IV contrast in the evaluation of suspected VBI.

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
B. CT head without and with IV contrast

There is no relevant literature regarding the use of CT head without and with IV contrast in the evaluation of suspected VBI.

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
C. CT head without IV contrast

CT head without IV contrast may be useful in the evaluation of suspected VBI, although brain MRI is expected to be more sensitive for the detection of posterior fossa infarcts.

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
D. CT temporal bone with IV contrast

There is no relevant literature regarding the use of CT temporal bone with IV contrast in the evaluation of suspected VBI.

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.

E. CT temporal bone without and with IV contrast

There is no relevant literature regarding the use of CT temporal bone without and with IV contrast in the evaluation of suspected VBI.

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
F. CT temporal bone without IV contrast

There is no relevant literature regarding the use of CT temporal bone without IV contrast in the evaluation of suspected VBI.

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
G. CTA head and neck with IV contrast

CTA allows for the evaluation of the course and luminal caliber of the studied arteries. CTA can also detect luminal filling defects, which may include thrombus, embolus, atherosclerotic plaque, dissection flap, or vascular web. In cases of vertebral artery dissection confirmed by conventional angiography, CTA has the highest reported sensitivity (100%), followed by MRA (77%) and Doppler US (71%), in a systematic review of 75 observational studies. Because symptomatic dissection may involve any portion of the vertebral artery, from the origin at the aortic arch branch vessels to the basilar artery, the entirety of the vessel should be included for evaluation [14].

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
H. MRA head and neck with IV contrast

MRA allows for evaluation of the course and luminal caliber of the arteries. MRA can also detect luminal filling defects, which may include thrombus, embolus, atherosclerotic plaque, dissection flap, or vascular web. MRA of the head and neck can be performed without IV contrast, with IV contrast, or as a combination of without and with IV contrast. Although 3-D time-of-flight MRA of the head is typically diagnostic without the use of IV gadolinium-based contrast agents, MRA of the neck is often best performed with contrast for better evaluation of the vessels with increased spatial resolution and decreased flow-related artifacts.

In a study comparing the diagnostic performance of contrast-enhanced MRA of the neck to digital subtraction angiography in evaluation of vertebral artery origin stenosis, the sensitivity, specificity, and accuracy of MRA were shown to be as high as 97%, 98%, and 93%, respectively, in 49 patients [69]. However, MRA has not demonstrated significant differences in the degree of arterial stenosis between symptomatic patients with VBI and asymptomatic controls [13]. In cases of vertebral artery dissection confirmed by conventional angiography, CTA has the highest reported sensitivity (100%), followed by MRA (77%) and Doppler US (71%). The addition of nonluminal vessel wall imaging sequences likely improves the detection of nonstenotic arterial dissection, but it is unclear whether these types of lesions would result in VBI. Because symptomatic dissection may involve any portion of the vertebral artery, from the origin at the aortic arch branch vessels to the basilar artery, the entirety of the vessel should be included for evaluation [14].

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
I. MRA head and neck without and with IV contrast

MRA allows for the evaluation of the course and luminal caliber of the arteries. MRA can also

detect luminal filling defects, which may include thrombus, embolus, atherosclerotic plaque, dissection flap, or vascular web. MRA of the head and neck can be performed without IV contrast, with IV contrast, or as a combination of without and with IV contrast. Although 3-D time-of-flight MRA of the head is typically diagnostic without the use of IV gadolinium-based contrast agents, MRA of the neck is often best performed with contrast for better evaluation of the vessels with increased spatial resolution and decreased flow-related artifacts.

In a study comparing the diagnostic performance of contrast-enhanced MRA of the neck to digital subtraction angiography in evaluation of vertebral artery origin stenosis, the sensitivity, specificity, and accuracy of MRA were shown to be as high as 97%, 98%, and 93%, respectively in 49 patients [69]. However, MRA has not demonstrated significant differences in the degree of arterial stenosis between symptomatic patients with VBI and asymptomatic controls [13]. In cases of vertebral artery dissection confirmed by conventional angiography, CTA has the highest reported sensitivity (100%), followed by MRA (77%) and Doppler US (71%). The addition of nonluminal vessel wall imaging sequences likely improves the detection of nonstenotic arterial dissection, but it is unclear whether these types of lesions would result in VBI. Because symptomatic dissection may involve any portion of the vertebral artery, from the origin at the aortic arch branch vessels to the basilar artery, the entirety of the vessel should be included for evaluation [14].

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
J. MRA head and neck without IV contrast

MRA of the head and neck is often performed as a combination of without and with IV contrast. Please see "MRA Head and Neck Without and With IV Contrast" for additional discussion.

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
K. MRI cervical and thoracic spine with IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine with IV contrast in the evaluation of suspected VBI.

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
L. MRI cervical and thoracic spine without and with IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine without and with IV contrast in the evaluation of suspected VBI.

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
M. MRI cervical and thoracic spine without IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine without IV contrast in the evaluation of suspected VBI.

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
N. MRI head and internal auditory canal with IV contrast

There is no relevant literature regarding the use of MRI head and IAC with IV contrast in the evaluation of suspected VBI.

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic

deficits. Initial imaging.
O. MRI head and internal auditory canal without and with IV contrast

There is no relevant literature regarding the use of MRI head and IAC without and with IV contrast in the evaluation of suspected VBI.

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
P. MRI head and internal auditory canal without IV contrast

There is no relevant literature regarding the use of MRI head and IAC without IV contrast in the evaluation of suspected VBI.

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
Q. MRI head with IV contrast

Contrast-enhanced MRI of the head is often performed as a combination of without and with IV contrast. Please see "MRI Head Without and With IV Contrast" for additional discussion.

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
R. MRI head without and with IV contrast

MRI allows for detailed evaluation of the intracranial structures with improved soft tissue resolution when compared with CT. MRI before and after the administration of gadolinium-containing IV contrast allows for the additional characterization of these tissues and improved detection of intracranial pathology. In the setting of VBI, high-resolution vessel wall imaging of the posterior circulation using IV contrast may be of use as both a diagnostic and prognostic tool, but it is not used as initial imaging in the evaluation of suspected VBI. In a single-center study of 219 patients, when compared with MRA, atherosclerotic plaque in the basilar artery and associated luminal stenosis of >50% was more often identified on vessel wall imaging; however, the degree of narrowing was felt to be likely overestimated. Although atherosclerotic vessel narrowing can certainly result in VBI, the clinical applicability of these findings on vessel wall imaging has yet to be fully elucidated [70]. Interestingly, the degree of vessel wall enhancement in basilar artery stenosis on vessel wall imaging has been shown to correlate with the risk of subsequent infarct and may serve as a noninvasive prognostic marker in patients with VBI [71]. Additionally, alterations of perfusion parameters using arterial-spin labelling in the brain has been shown to correlate with the presence and severity of vertebrobasilar stenosis and serves as an adjunct to contrast-enhanced imaging of the vessel wall as well as luminal imaging via MRA/CTA [68].

Variant 5: Adult. Chronic recurrent vertigo. Associated with other brainstem neurologic deficits. Initial imaging.
S. MRI head without IV contrast

MRI head without IV contrast is useful in the evaluation of VBI and for the detection of posterior fossa infarcts. A negative MRI does not exclude the possibility of chronic ischemia without completed infarction and therefore does not replace the need for vascular imaging.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.

Disequilibrium refers to a sensation of imbalance, unsteadiness, or instability. Disequilibrium in addition to loss of muscle coordination is a common finding in cerebellar ataxia, which indicates loss of coordination due to loss of normal motor control by the cerebellum. Cerebellar ataxia includes a variety of clinical conditions characterized by neurodegeneration of the cerebellum

and/or brainstem and may result from inherited or sporadic etiologies. The current classification system for the inherited cerebellar ataxias includes autosomal dominant spinocerebellar, autosomal recessive, congenital, mitochondrial, X-linked, and sporadic types. Autosomal ataxias have complex genetic heterogeneity and variable phenotypic expression, which makes diagnosis difficult [72]. Adult-onset sporadic ataxia encompasses a more heterogeneous group of etiologies, which includes toxic/nutritional, immune-mediated, infectious, degenerative, and reclassification as having a genetic basis [73]. Some patients with cerebellar ataxia may also have coexisting symptoms of central or peripheral vestibulopathy, which can further confound the clinic picture [74]. Imaging in cerebellar ataxia is aimed at primarily detecting parenchymal injury in the form of volume loss or alternations in attenuation (CT) or signal intensity (MRI). Patterns of parenchymal injury may suggest a certain ataxia subtype; however, there is a significant overlap of imaging features among various etiologies, and conventional neuroimaging may be unremarkable in early disease. As such, diagnosis relies on the combination of history, a thorough clinical neurologic examination, and imaging with confirmatory laboratory and/or genetic testing based on these findings [73]. In some forms of ataxia, detection of abnormal iron deposition or calcification may also be helpful [75,76]. Finally, imaging is also important to exclude nondegenerative central etiologies of ataxia such as mass lesion or infarct [77].

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
A. CT head with IV contrast

There is no relevant literature regarding the use of CT head with IV contrast in the evaluation of cerebellar ataxia.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
B. CT head without and with IV contrast

There is no relevant literature regarding the use of CT head without and with IV contrast in the evaluation of cerebellar ataxia.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
C. CT head without IV contrast

Head CT allows for evaluation of the intracranial structures; however, soft tissue contrast is inferior to MRI. Certain materials, however, are more conspicuous on CT imaging including calcification. Rare subtypes of SCA may show calcification within the brain parenchyma; however, other more common brain parenchymal changes in patients with cerebellar ataxia are best evaluated with MRI [76]. Additionally, parenchymal calcification can often be adequately detected and characterized on MRI.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
D. CT temporal bone with IV contrast

There is no relevant literature regarding the use of CT temporal bone with IV contrast in the evaluation of cerebellar ataxia.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
E. CT temporal bone without and with IV contrast

There is no relevant literature regarding the use of CT temporal bone without and with IV contrast in the evaluation of cerebellar ataxia.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
F. CT temporal bone without IV contrast

There is no relevant literature regarding the use of CT temporal bone without IV contrast in the evaluation of cerebellar ataxia.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
G. CTA head and neck with IV contrast

There is no relevant literature regarding the use of CTA head and neck with IV contrast in the evaluation of cerebellar ataxia.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
H. MRA head and neck with IV contrast

There is no relevant literature regarding the use of MRA head and neck with IV contrast in the evaluation of cerebellar ataxia.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
I. MRA head and neck without and with IV contrast

There is no relevant literature regarding the use of MRA head and neck without and with IV contrast in the evaluation of cerebellar ataxia.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
J. MRA head and neck without IV contrast

There is no relevant literature regarding the use of MRA head and neck without IV contrast in the evaluation of cerebellar ataxia.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
K. MRI cervical and thoracic spine with IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine with IV contrast in the evaluation of cerebellar ataxia.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
L. MRI cervical and thoracic spine without and with IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine without and with IV contrast in the evaluation of cerebellar ataxia.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
M. MRI cervical and thoracic spine without IV contrast

MRI of the spine allows for evaluation of the spinal column as well as the soft tissues within and surrounding the spinal column including the spinal cord. Atrophy of the cervical spinal cord on MRI has been described in SCA type 1 (SCA1) and shown to be correlated with symptom severity, disease duration, and the number of pathologic cytosine, adenine, and guanine repeats, which serves at the genetic cause of SCA1 [78]. Similar atrophy has been reported in SCA type 7, Friedreich ataxia, and ataxia with vitamin E deficiency [79,80]. Spinal findings were associated with abnormalities of the brain parenchyma and generally not reported in isolation. Imaging of the spinal cord in other forms of cerebellar ataxia has either been reported as normal or, more often, not specifically described in the literature [81]. Spine MRI may be considered in patients with cerebellar ataxia and additional signs of spinal cord involvement, such as motor spasticity or sensory ataxia (see Variant 7).

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
N. MRI head and internal auditory canal with IV contrast

There is no relevant literature regarding the use of MRI head and IAC with IV contrast in the

evaluation of cerebellar ataxia.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
O. MRI head and internal auditory canal without and with IV contrast

There is no relevant literature regarding the use of MRI head and IAC without and with IV contrast in the evaluation of cerebellar ataxia.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
P. MRI head and internal auditory canal without IV contrast

There is no relevant literature regarding the use of MRI head and IAC without IV contrast in the evaluation of cerebellar ataxia.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
Q. MRI head with IV contrast

Contrast-enhanced MRI of the head is often performed as a combination of without and with IV contrast. Please see "MRI Head Without and With IV Contrast" for additional discussion.

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
R. MRI head without and with IV contrast

MRI of the head is the preferred initial imaging modality for the evaluation of patients with cerebellar ataxia. In cerebellar ataxia, morphologic changes (atrophy) and signal alterations primarily involve the cerebellum and brainstem. These findings are typically adequately evaluated on MRI without IV contrast; however, if there is concern for an inflammatory or neoplastic cause of cerebellar ataxia, contrast-enhanced imaging should be included. Advanced MRI techniques such as DWI/diffusion-tensor imaging and spectroscopy do not require contrast administration and have shown promise in detecting early changes in ataxia and may also be useful in distinguishing between some ataxia subtypes in some studies [82-84].

Variant 6: Adult. Chronic disequilibrium with signs of cerebellar ataxia. Initial imaging.
S. MRI head without IV contrast

MRI of the head is the preferred initial imaging modality for the evaluation of patients with cerebellar ataxia. In cerebellar ataxia, morphologic changes (atrophy) and signal alterations primarily involve the cerebellum and brainstem. These findings are typically adequately evaluated on MRI without IV contrast. Lack of contrast, however, may impair the ability to distinguish between degenerative and inflammatory/infectious causes of cerebellar ataxia. Advanced MRI techniques such as DWI/diffusion-tensor imaging and spectroscopy do not require contrast administration and have shown promise in detecting early changes in ataxia and may also be useful in distinguishing between some ataxia subtypes in some studies [82-84].

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.

Disequilibrium refers to a sensation of imbalance, unsteadiness, or instability. Symptoms of disequilibrium may result from neurodegeneration or inflammation involving the spinocerebellar tracts, dorsal columns of the spinal cord, dorsal root ganglia, or more peripheral sensory nerves. In contrast to cerebellar ataxia (see Variant 6), sensory or proprioceptive ataxia indicates loss of coordination due to loss of normal position sense and is characterized by worsening with closed eyes (eg, Romberg test). SCAs may manifest with these symptoms if there is involvement of the described spinal structures. Peripheral neuropathy (ataxic neuropathy) can also be seen in various forms of SCA; however, cerebellar symptoms should be present [81]. The combination of cerebellar

ataxia and sensory neuropathy, both of which can contribute to symptoms of disequilibrium, has also been described in cerebellar ataxia with neuropathy and bilateral vestibular areflexia syndrome [85]. In these cases, neuroimaging is primarily directed at evaluating the coexisting central abnormalities of the cerebellum and brainstem (see Variant 6). There are also several known autoimmune sensory ataxic neuropathies, which result in symptoms of disequilibrium without cerebellar or brainstem involvement. Diagnostic confirmation of these neuropathies is generally via clinical evaluation and electrodiagnostic testing; however, targeted US has also been used to detect changes in size of the affected nerve in a small study [86]. Most of the studies in patients with SCA involve a small number of patients due to the rarity of the disease and particular mutations.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
A. CT head with IV contrast

There is no relevant literature regarding the use of CT head with IV contrast in the evaluation of sensory ataxia.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
B. CT head without and with IV contrast

There is no relevant literature regarding the use of CT head without and with IV contrast in the evaluation of sensory ataxia.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
C. CT head without IV contrast

There is no relevant literature regarding the use of CT head without IV contrast in the evaluation of sensory ataxia.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
D. CT temporal bone with IV contrast

There is no relevant literature regarding the use of CT temporal bone with IV contrast in the evaluation of sensory ataxia.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
E. CT temporal bone without and with IV contrast

There is no relevant literature regarding the use of CT temporal bone without and with IV contrast in the evaluation of sensory ataxia.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
F. CT temporal bone without IV contrast

There is no relevant literature regarding the use of CT temporal bone without IV contrast in the evaluation of sensory ataxia.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
G. CTA head and neck with IV contrast

There is no relevant literature regarding the use of CTA head and neck with IV contrast in the evaluation of sensory ataxia.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
H. MRA head and neck with IV contrast

There is no relevant literature regarding the use of MRA head and neck with IV contrast in the evaluation of sensory ataxia.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
I. MRA head and neck without and with IV contrast

There is no relevant literature regarding the use of MRA head and neck without and with IV contrast in the evaluation of sensory ataxia.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
J. MRA head and neck without IV contrast

There is no relevant literature regarding the use of MRA head and neck without IV contrast in the evaluation of sensory ataxia.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
K. MRI cervical and thoracic spine with IV contrast

Contrast-enhanced MRI of the spine is often performed as a combination of without and with IV contrast. Please see "MRI Cervical and Thoracic Spine Without and With IV Contrast" for additional discussion.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
L. MRI cervical and thoracic spine without and with IV contrast

MRI of the spine allows for evaluation of the spinal column as well as the soft tissues within and surrounding the spinal column including the spinal cord. Atrophy of the cervical spinal cord has been reported in several forms of degenerative ataxia, which may be a helpful diagnostic finding in patients presenting with disequilibrium [78-80]. In patients with chronic disequilibrium due to sensory ataxia and loss of proprioception that is out of proportion to other sensory modalities and motor function, spine MRI is useful to evaluate the dorsal columns of the spinal cord (eg, compressive myelopathy, B12/copper deficiency, or tabes dorsalis neurosyphilis). These findings are typically adequately evaluated on MRI without IV contrast; however, if there is concern for an inflammatory or infectious neoplastic cause of sensory ataxia, contrast-enhanced imaging should be included.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
M. MRI cervical and thoracic spine without IV contrast

MRI of the spine allows for evaluation of the spinal column as well as the soft tissues within and surrounding the spinal column including the spinal cord. Atrophy of the cervical spinal cord has been reported in several forms of degenerative ataxia, which may be a helpful diagnostic finding in patients presenting with disequilibrium [78-80]. In patients with chronic disequilibrium due to

sensory ataxia and loss of proprioception that is out of proportion to other sensory modalities and motor function, spine MRI is useful to evaluate the dorsal columns of the spinal cord (eg, compressive myelopathy, B12/copper deficiency, or tabes dorsalis neurosyphilis).

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
N. MRI head and internal auditory canal with IV contrast

There is no relevant literature regarding the use of MRI head and IAC with IV contrast in the evaluation of sensory ataxia.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
O. MRI head and internal auditory canal without and with IV contrast

There is no relevant literature regarding the use of MRI head and IAC without and with IV contrast in the evaluation of sensory ataxia.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
P. MRI head and internal auditory canal without IV contrast

There is no relevant literature regarding the use of MRI head and IAC without IV contrast in the evaluation of sensory ataxia.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
Q. MRI head with IV contrast

There is no relevant literature regarding the use of MRI head with IV contrast in the evaluation of sensory ataxia.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
R. MRI head without and with IV contrast

There is no relevant literature regarding the use of MRI head without and with IV contrast in the evaluation of sensory ataxia.

Variant 7: Adult. Chronic disequilibrium with signs of sensory or proprioceptive ataxia. Initial imaging.
S. MRI head without IV contrast

There is no relevant literature regarding the use of MRI head without IV contrast in the evaluation of sensory ataxia.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.

In the United States, dizziness accounts for 10 million ambulatory visits, and 25% of these go to the emergency department [27]. Although dizziness can be related to emergent and life-threatening conditions, one large study evaluating neuroimaging yields in isolated dizziness—dizziness in the absence of vertigo, ataxia, or other neurologic deficits—found that this complaint accounted for 2.5% of all emergency department presentations. The study also described a continuing trend of increasing imaging performed in these patients, with 22% undergoing CT and 10% underdoing MRI. However, the diagnostic yield of CT remains very low (<1%), whereas the yield of MRI DWI

was slightly greater but still low (4%) [4]. The probability of detecting an abnormality on CT or MRI in patients with "spontaneous transient vestibular syndrome" was very low on early CT imaging (2%) and only moderate on delayed MRI (9%) [6]. In one study, all patients with isolated dizziness and contributory findings on noncontrast head CT were suspected to have a central cause based on bedside evaluation, further supporting the critical need for appropriate clinical triage in patients with dizziness [3]. Lightheadedness or presyncope related to systemic causes such as dehydration, hypotension, vasovagal reaction, or anxiety are often diagnosed clinically and do not require imaging evaluation of the central nervous system. Of note, persistent isolated dizziness may also result from autonomic dysfunction, even if symptoms do not appear to be orthostatic in nature [87].

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
A. CT head with IV contrast

There is no relevant literature regarding the use of CT head with IV contrast in the evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
B. CT head without and with IV contrast

There is no relevant literature regarding the use of CT head without and with IV contrast in the evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
C. CT head without IV contrast

Head CT allows for evaluation of the intracranial structures; however, soft tissue contrast is inferior to MRI. This is especially true of lesions in the posterior cranial fossa, which are more likely to cause dizziness [2]. In 29,510 patients with isolated dizziness presenting to a large academic emergency department, the overall diagnostic yield of CT is very low (<1%) [4]. In multiple studies, CT has demonstrated a high negative predictive value of approximately 90% but a low sensitivity (20%-40%) for detecting a causative etiology [2,3].

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
D. CT temporal bone with IV contrast

There is no relevant literature regarding the use of CT temporal bone with IV contrast in the evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
E. CT temporal bone without and with IV contrast

There is no relevant literature regarding the use of CT temporal bone without and with IV contrast in the evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
F. CT temporal bone without IV contrast

There is no relevant literature regarding the use of CT temporal bone without IV contrast in the

evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
G. CTA head and neck with IV contrast

CTA allows for evaluation of the course and luminal caliber of the studied arteries. CTA can also detect luminal filling defects, which may include thrombus, embolus, atherosclerotic plaque, dissection flap, or vascular web. CTA of the head and neck has been shown to have a low overall diagnostic yield of approximately 3% in the setting of isolated dizziness. CTA also did not contribute any additional information over noncontrast head CT in this clinical setting. Overall, CTA in isolated dizziness was shown to have a sensitivity of 14%, specificity of 98%, positive predicative value of 40% and negative predicative value of 92% [3].

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
H. MRA head and neck with IV contrast

There is no relevant literature regarding the use of MRA head and neck with IV contrast in the evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
I. MRA head and neck without and with IV contrast

There is no relevant literature regarding the use of MRA head and neck without and with IV contrast in the evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
J. MRA head and neck without IV contrast

There is no relevant literature regarding the use of MRA head and neck without IV contrast in the evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
K. MRI cervical and thoracic spine with IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine with IV contrast in the evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
L. MRI cervical and thoracic spine without and with IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine without and with IV contrast in the evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
M. MRI cervical and thoracic spine without IV contrast

There is no relevant literature regarding the use of MRI cervical and thoracic spine without IV contrast in the evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits.

Initial imaging.
N. MRI head and internal auditory canal with IV contrast

There is no relevant literature regarding the use of MRI head and IAC with IV contrast in the evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
O. MRI head and internal auditory canal without and with IV contrast

There is no relevant literature regarding the use of MRI head and IAC without and with IV contrast in the evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
P. MRI head and internal auditory canal without IV contrast

There is no relevant literature regarding the use of MRI head and IAC without IV contrast in the evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
Q. MRI head with IV contrast

There is no relevant literature regarding the use of MRI head with IV contrast in the evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
R. MRI head without and with IV contrast

There is no relevant literature regarding the use of MRI head without and with IV contrast in the evaluation of isolated dizziness.

Variant 8: Adult. Nonspecific dizziness without vertigo, ataxia, or other neurologic deficits. Initial imaging.
S. MRI head without IV contrast

MRI allows for detailed evaluation of the intracranial structures with improved soft tissue resolution when compared with CT. Despite this, the diagnostic yield of noncontrast MRI head in patients presenting to the emergency department with isolated dizziness is low (~4%). Of those with positive findings on MRI, ischemic stroke was the most common abnormality seen in nearly 70% of cases. Approximately two-thirds of these were located in the posterior circulation [4]. In another study with patients presenting with dizziness, 3.6% had acute lesions. Risk factors include older age, hypertension, atrial fibrillation, nonwhirling type of dizziness symptoms, and combined neurological symptoms (see Variant 3) [37].

Summary of Highlights

- **Variant 1**: In brief episodic vertigo triggered by specific head movements, BPPV is the most likely cause, and no imaging is indicated, unless there are atypical features such as lack of nystagmus on provoking maneuvers (eg, Dix-Hallpike) or lack of response to treatment maneuvers (eg, Epley).
- **Variant 2**: In acute persistent vertigo with a normal neurologic examination and HINTS

examination consistent with peripheral vertigo, vestibular neuritis is the most likely cause, and imaging is not recommended. Since a normal neurologic examination does not exclude a posterior circulation infarct, MRI head without IV contrast may be helpful in high vascular risk patients or when a HINTS trained practitioner is not available.

- **Variant 3**: In acute persistent vertigo with an abnormal neurologic examination or HINTS examination by a trained specialist consistent with central vertigo, posterior circulation infarct is suspected, and MRI head without IV contrast is recommended. A CT head without IV contrast is less sensitive, but may be appropriate as initial imaging before MRI. There was disagreement on whether MRA and CTA are appropriate as initial imaging in this scenario.
- **Variant 4**: In chronic recurrent vertigo associated with unilateral hearing loss or tinnitus, which may be due to Meniere disease, MRI head and IAC without and with IV contrast and CT temporal bone without IV contrast are useful for the exclusion of other causes of such symptoms, such as vestibular schwannoma or superior semicircular canal dehiscence.
- **Variant 5**: In chronic recurrent vertigo associated with other brainstem neurologic deficits, which may be due to vertebrobasilar insufficiency, MRI head without IV contrast is useful for evaluation of posterior circulation infarcts, and MRA or CTA of the head and neck are useful for evaluation of the vasculature. CT head without IV contrast may also be appropriate as initial imaging.
- **Variant 6**: In chronic disequilibrium with signs of cerebellar ataxia, MRI head without IV contrast or MRI head without and with IV contrast is most helpful for the assessment of atrophy or other pathology of the cerebellum. MRI cervical and thoracic spine without IV contrast may be useful in patients with additional signs of spinal cord involvement.
- **Variant 7**: In chronic disequilibrium with signs of sensory or proprioceptive ataxia, MRI cervical and thoracic spine without IV contrast or MRI cervical and thoracic spine without and with IV contrast is most helpful for the evaluation of spinal cord atrophy or other dorsal column pathology.
- **Variant 8**: In nonspecific dizziness without vertigo, ataxia, or other neurologic deficits, usually no imaging is indicated, due to low diagnostic yield. MRI head without IV contrast may be useful in high risk patients for the detection of a posterior circulation infarct.

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.

May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria[®] Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

References

1. Edlow JA, Gurley KL, Newman-Toker DE. A New Diagnostic Approach to the Adult Patient with Acute Dizziness. J Emerg Med. 54(4):469-483, 2018 04.

2. Lawhn-Heath C, Buckle C, Christoforidis G, Straus C. Utility of head CT in the evaluation of vertigo/dizziness in the emergency department. EMERG. RADIOL.. 20(1):45-9, 2013 Jan.

3. Guarnizo A, Farah K, Lelli DA, Tse D, Zakhari N. Limited usefulness of routine head and neck CT angiogram in the imaging assessment of dizziness in the emergency department. Neuroradiol. j.. 34(4):335-340, 2021 Aug.

4. Idil H, Ozbay Yenice G, Kilic TY, Eyler Y, Duman Atilla O. The Incidence of Central Neurological Disorders Among Patients With Isolated Dizziness and the Diagnostic Yield of Neuroimaging Studies. Neurolog. 25(4):85-88, 2020 Jul.

5. Ahsan SF, Syamal MN, Yaremchuk K, Peterson E, Seidman M. The costs and utility of imaging in evaluating dizzy patients in the emergency room. Laryngoscope. 123(9):2250-3, 2013 Sep.

6. Machner B, Choi JH, Trillenberg P, Heide W, Helmchen C. Risk of acute brain lesions in dizzy patients presenting to the emergency room: who needs imaging and who does not?. J Neurol. 267(Suppl 1):126-135, 2020 Dec.

7. Salmela MB, Mortazavi S, Jagadeesan BD, et al. ACR Appropriateness Criteria® Cerebrovascular Disease. J Am Coll Radiol 2017;14:S34-S61.

8. Sharma A, Kirsch CFE, Aulino JM, et al. ACR Appropriateness Criteria® Hearing Loss and/or Vertigo. J Am Coll Radiol 2018;15:S321-S31.

9. Kessler MM, Moussa M, Bykowski J, et al. ACR Appropriateness Criteria R Tinnitus. Journal of the American College of Radiology. 14(11S):S584-S591, 2017 Nov.

10. Shih RY, Burns J, Ajam AA, et al. ACR Appropriateness Criteria® Head Trauma: 2021 Update. J Am Coll Radiol 2021;18:S13-S36.

11. Harvey HB, Watson LC, Subramaniam RM, et al. ACR Appropriateness Criteria® Movement Disorders and Neurodegenerative Diseases. J Am Coll Radiol 2020;17:S175-S87.

12. Zaidi HA, Albuquerque FC, Chowdhry SA, Zabramski JM, Ducruet AF, Spetzler RF. Diagnosis and management of bow hunter's syndrome: 15-year experience at barrow neurological institute. World Neurosurg. 82(5):733-8, 2014 Nov.

13. Neto ACL, Bor-Seng-Shu E, Oliveira ML, Macedo-Soares A, Topciu FR, Bittar RSM. Magnetic resonance angiography and transcranial Doppler ultrasound findings in patients with a clinical diagnosis of vertebrobasilar insufficiency. Clinics. 75:e1212, 2020.

14. Gottesman RF, Sharma P, Robinson KA, et al. Imaging characteristics of symptomatic vertebral artery dissection: a systematic review. [Review]. Neurolog. 18(5):255-60, 2012 Sep.

15. Mohamed ES, Kaf WA, Rageh TA, Kamel NF, Elattar AM. Evaluation of patients with vertigo of vertebrobasilar insufficiency origin using auditory brainstem response, electronystagmography, and transcranial Doppler. Int J Audiol. 51(5):379-88, 2012 May.

16. Brockmann K, Reimold M, Globas C, et al. PET and MRI reveal early evidence of neurodegeneration in spinocerebellar ataxia type 17. J Nucl Med. 53(7):1074-80, 2012 Jul.

17. Aguiar P, Pardo J, Arias M, et al. PET and MRI detection of early and progressive neurodegeneration in spinocerebellar ataxia type 36. Mov Disord. 32(2):264-273, 2017 02.

18. Imai T, Takeda N, Ikezono T, et al. Classification, diagnostic criteria and management of benign paroxysmal positional vertigo. [Review]. Auris Nasus Larynx. 44(1):1-6, 2017 Feb.

19. Perez-Vazquez P, Franco-Gutierrez V, Soto-Varela A, et al. Practice Guidelines for the Diagnosis and Management of Benign Paroxysmal Positional Vertigo Otoneurology

Committee of Spanish Otorhinolaryngology and Head and Neck Surgery Consensus Document. Acta Otorrinolaringol Esp (Engl Ed). 69(6):345-366, 2018 Nov - Dec.

20. von Brevern M, Bertholon P, Brandt T, et al. Benign paroxysmal positional vertigo: Diagnostic criteria Consensus document of the Committee for the Classification of Vestibular Disorders of the Barany Society. Acta Otorrinolaringol Esp (Engl Ed). 68(6):349-360, 2017 Nov - Dec.

21. Tan F, Bartels C, Walsh RM. Our experience with 500 patients with benign paroxysmal positional vertigo: Reexploring aetiology and reevaluating MRI investigation. Auris Nasus Larynx. 45(2):248-253, 2018 Apr.

22. Beh SC. Vestibular Migraine: How to Sort it Out and What to Do About it. [Review]. J Neuroophthalmol. 39(2):208-219, 2019 06.

23. Zhang D, Zhang S, Zhang H, et al. Evaluation of vertebrobasilar artery changes in patients with benign paroxysmal positional vertigo. Neuroreport. 24(13):741-5, 2013 Sep 11.

24. Cha WW, Song K, Yu IK, et al. Magnetic resonance imaging predicts chronic dizziness after benign paroxysmal positional vertigo. Am J Otolaryngol. 38(4):428-432, 2017 Jul - Aug.

25. Chuang PC, Huang YS, Chiang CY, Zhang EW, Cheng FJ. Effectiveness of peer pressure on computed tomography use for dizziness/vertigo patients. Medicine (Baltimore). 98(11):e14887, 2019 Mar.

26. Kattah JC, Talkad AV, Wang DZ, Hsieh YH, Newman-Toker DE. HINTS to diagnose stroke in the acute vestibular syndrome: three-step bedside oculomotor examination more sensitive than early MRI diffusion-weighted imaging. Stroke 2009;40:3504-10.

27. Tarnutzer AA, Berkowitz AL, Robinson KA, Hsieh YH, Newman-Toker DE. Does my dizzy patient have a stroke? A systematic review of bedside diagnosis in acute vestibular syndrome. [Review]. CMAJ. 183(9):E571-92, 2011 Jun 14.

28. Doijiri R, Uno H, Miyashita K, Ihara M, Nagatsuka K. How Commonly Is Stroke Found in Patients with Isolated Vertigo or Dizziness Attack? J Stroke Cerebrovasc Dis 2016;25:2549-52.

29. Saber Tehrani AS, Kattah JC, Mantokoudis G, et al. Small strokes causing severe vertigo: frequency of false-negative MRIs and nonlacunar mechanisms. Neurology. 83(2):169-73, 2014 Jul 08.

30. Newman-Toker DE, Kerber KA, Hsieh YH, et al. HINTS outperforms ABCD2 to screen for stroke in acute continuous vertigo and dizziness. Acad Emerg Med. 20(10):986-96, 2013 Oct.

31. Ohle R, Montpellier RA, Marchadier V, et al. Can Emergency Physicians Accurately Rule Out a Central Cause of Vertigo Using the HINTS Examination? A Systematic Review and Meta-analysis. Acad Emerg Med. 27(9):887-896, 2020 09.

32. Pula JH, Newman-Toker DE, Kattah JC. Multiple sclerosis as a cause of the acute vestibular syndrome. J Neurol. 260(6):1649-54, 2013 Jun.

33. von Brevern M, Lempert T. Vestibular migraine. [Review]. Handb. clin. neurol.. 137:301-16, 2016.

34. Fundakowski CE, Anderson J, Angeli S. Cross-sectional vestibular nerve analysis in vestibular neuritis. Ann Otol Rhinol Laryngol. 121(7):466-70, 2012 Jul.

35. Freund W, Weber F, Schneider D, Mayer U, Scheithauer M, Beer M. Vestibular Nerve Atrophy After Vestibular Neuritis - Results from a Prospective High-Resolution MRI Study. ROFO Fortschr Geb Rontgenstr Nuklearmed. 192(9):854-861, 2020 Sep.

36. Venkatasamy A, Huynh TT, Wohlhuter N, et al. Superior vestibular neuritis: improved detection using FLAIR sequence with delayed enhancement (1 h). Eur Arch Otorhinolaryngol. 276(12):3309-3316, 2019 Dec.

37. Lee DH, Kim WY, Shim BS, et al. Characteristics of central lesions in patients with dizziness determined by diffusion MRI in the emergency department. Emerg Med J. 31(8):641-4, 2014 Aug.

38. Adamec I, Krbot Skoric M, Ozretic D, Habek M. Predictors of development of chronic vestibular insufficiency after vestibular neuritis. J Neurol Sci. 347(1-2):224-8, 2014 Dec 15.

39. Perloff MD, Patel NS, Kase CS, Oza AU, Voetsch B, Romero JR. Cerebellar stroke presenting with isolated dizziness: Brain MRI in 136 patients. Am J Emerg Med. 35(11):1724-1729, 2017 Nov.

40. American College of Radiology. ACR Appropriateness Criteria®: Cerebrovascular Diseases-Stroke and Stroke-Related Conditions. Available at: https://acsearch.acr.org/docs/3149012/Narrative/.

41. Kerber KA, Meurer WJ, Brown DL, et al. Stroke risk stratification in acute dizziness presentations: A prospective imaging-based study. Neurology. 85(21):1869-78, 2015 Nov 24.

42. Edlow JA, Carpenter C, Akhter M, et al. Guidelines for reasonable and appropriate care in the emergency department 3 (GRACE-3): Acute dizziness and vertigo in the emergency department. Acad Emerg Med 2023;30:442-86.

43. Lo BM, Carpenter CR, Ducey S, et al. Clinical Policy: Critical Issues in the Management of Adult Patients Presenting to the Emergency Department With Acute Ischemic Stroke. Annals of emergency medicine 2023;82:e17-e64.

44. Morita S, Suzuki M, Iizuka K. False-negative diffusion-weighted MRI in acute cerebellar stroke. Auris Nasus Larynx. 38(5):577-82, 2011 Oct.

45. Shono Y, Koga M, Toyoda K, et al. Medial medullary infarction identified by diffusion-weighted magnetic resonance imaging. Cerebrovasc Dis. 30(5):519-24, 2010.

46. Kabra R, Robbie H, Connor SE. Diagnostic yield and impact of MRI for acute ischaemic stroke in patients presenting with dizziness and vertigo. Clin Radiol. 70(7):736-42, 2015 Jul.

47. Karameshev A, Arnold M, Schroth G, et al. Diffusion-weighted MRI helps predict outcome in basilar artery occlusion patients treated with intra-arterial thrombolysis. Cerebrovasc Dis. 32(4):393-400, 2011.

48. Mainnemarre J, Hautefort C, Toupet M, et al. The vestibular aqueduct ossification on temporal bone CT: an old sign revisited to rule out the presence of endolymphatic hydrops in Meniere's disease patients. Eur Radiol. 30(11):6331-6338, 2020 Nov.

49. Yamane H, Konishi K, Sakamaoto H, et al. Practical 3DCT imaging of the vestibular aqueduct for Meniere's disease. Acta Otolaryngol (Stockh). 135(8):799-806, 2015 Aug.

50. Hu J, Peng A, Deng K, et al. Value of CT and three-dimensional reconstruction revealing specific radiological signs for screening causative high jugular bulb in patients with

Meniere's disease. BMC med. imaging. 20(1):103, 2020 08 31.

51. Sousa R, Raposo F, Guerreiro C, et al. Magnetic resonance imaging and Meniere's disease-unavoidable alliance. [Review]. Neuroradiology. 63(11):1749-1763, 2021 Nov.

52. Pai I, Mendis S, Murdin L, Touska P, Connor S. Magnetic resonance imaging of Meniere's disease: early clinical experience in a UK centre. J Laryngol Otol. 134(4):302-310, 2020 Apr.

53. Paskoniene A, Baltagalviene R, Lengvenis G, et al. The Importance of the Temporal Bone 3T MR Imaging in the Diagnosis of Meniere's Disease. Otol Neurotol. 41(2):235-241, 2020 02.

54. Sepahdari AR, Ishiyama G, Vorasubin N, Peng KA, Linetsky M, Ishiyama A. Delayed intravenous contrast-enhanced 3D FLAIR MRI in Meniere's disease: correlation of quantitative measures of endolymphatic hydrops with hearing. Clin Imaging. 39(1):26-31, 2015 Jan-Feb.

55. Eliezer M, Attye A, Toupet M, Hautefort C. Imaging of endolymphatic hydrops: A comprehensive update in primary and secondary hydropic ear disease. J Vestib Res. 31(4):261-268, 2021.

56. Liu Y, Jia H, Shi J, et al. Endolymphatic hydrops detected by 3-dimensional fluid-attenuated inversion recovery MRI following intratympanic injection of gadolinium in the asymptomatic contralateral ears of patients with unilateral Meniere's disease. Med Sci Monit. 21:701-7, 2015 Mar 06.

57. Barlet J, Vaussy A, Ejzenberg Y, et al. Optimized 3D-FLAIR sequences to shorten the delay between intravenous administration of gadolinium and MRI acquisition in patients with Meniere's disease. Eur Radiol. 32(10):6900-6909, 2022 Oct.

58. Wesseler A, Ovari A, Javorkova A, Kwiatkowski A, Meyer JE, Kivelitz DE. Diagnostic Value of the Magnetic Resonance Imaging With Intratympanic Gadolinium Administration (IT-Gd MRI) Versus Audio-Vestibular Tests in Meniere's Disease: IT-Gd MRI Makes the Difference. Otol Neurotol. 40(3):e225-e232, 2019 03.

59. Gu X, Fang ZM, Liu Y, Huang ZW, Zhang R, Chen X. Diagnostic advantages of intratympanically gadolinium contrast-enhanced magnetic resonance imaging in patients with bilateral Meniere's disease. Am J Otolaryngol. 36(1):67-73, 2015 Jan-Feb.

60. Bernaerts A, Vanspauwen R, Blaivie C, et al. The value of four stage vestibular hydrops grading and asymmetric perilymphatic enhancement in the diagnosis of Meniere's disease on MRI. Neuroradiology. 61(4):421-429, 2019 Apr.

61. Shi S, Guo P, Li W, Wang W. Clinical Features and Endolymphatic Hydrops in Patients With MRI Evidence of Hydrops. Ann Otol Rhinol Laryngol. 128(4):286-292, 2019 Apr.

62. Xie J, Zhang W, Zhu J, et al. Differential Diagnosis of Endolymphatic Hydrops Between "Probable" and "Definite" Meniere's Disease via Magnetic Resonance Imaging. Otolaryngol Head Neck Surg. 165(5):696-700, 2021 11.

63. Li X, Wu Q, Sha Y, Dai C, Zhang R. Gadolinium-enhanced MRI reveals dynamic development of endolymphatic hydrops in Meniere's disease. Rev Bras Otorrinolaringol (Engl Ed). 86(2):165-173, 2020 Mar - Apr.

64. Sluydts M, Bernaerts A, Casselman JW, et al. The relationship between cochleovestibular function tests and endolymphatic hydrops grading on MRI in patients with Meniere's disease. Eur Arch Otorhinolaryngol. 278(12):4783-4793, 2021 Dec.

65. Lopez-Escamez JA, Attye A. Systematic review of magnetic resonance imaging for diagnosis of Meniere disease. J Vestib Res. 29(2-3):121-129, 2019.

66. Conte G, Caschera L, Calloni S, et al. MR Imaging in Meniere Disease: Is the Contact between the Vestibular Endolymphatic Space and the Oval Window a Reliable Biomarker?. AJNR Am J Neuroradiol. 39(11):2114-2119, 2018 11.

67. Inui H, Sakamoto T, Ito T, Kitahara T. Volumetric measurements of the inner ear in patients with Meniere's disease using three-dimensional magnetic resonance imaging. Acta Otolaryngol (Stockh). 136(9):888-93, 2016 Sep.

68. Macintosh BJ, Marquardt L, Schulz UG, Jezzard P, Rothwell PM. Hemodynamic alterations in vertebrobasilar large artery disease assessed by arterial spin-labeling MR imaging. AJNR Am J Neuroradiol. 33(10):1939-44, 2012 Nov.

69. Yi TY, Chen WH, Zhang MF, et al. Diagnostic ability of 3-dimensional contrast-enhanced MR angiography in identifying vertebral basilar artery stenosis. J Neurol Sci. 363:121-5, 2016 Apr. 15.

70. Kim YS, Lim SH, Oh KW, et al. The advantage of high-resolution MRI in evaluating basilar plaques: a comparison study with MRA. Atherosclerosis. 224(2):411-6, 2012 Oct.

71. Lou X, Ma N, Ma L, Jiang WJ. Contrast-enhanced 3T high-resolution MR imaging in symptomatic atherosclerotic basilar artery stenosis. AJNR Am J Neuroradiol. 34(3):513-7, 2013 Mar.

72. Heidelberg D, Ronsin S, Bonneville F, Hannoun S, Tilikete C, Cotton F. Main inherited neurodegenerative cerebellar ataxias, how to recognize them using magnetic resonance imaging?. [Review]. J Neuroradiol. 45(5):265-275, 2018 Sep.

73. Barsottini OG, Albuquerque MV, Braga-Neto P, Pedroso JL. Adult onset sporadic ataxias: a diagnostic challenge. [Review]. Arq Neuropsiquiatr. 72(3):232-40, 2014 Mar.

74. Kirchner H, Kremmyda O, Hufner K, et al. Clinical, electrophysiological, and MRI findings in patients with cerebellar ataxia and a bilaterally pathological head-impulse test. Ann N Y Acad Sci. 1233:127-38, 2011 Sep.

75. Oz G, Harding IH, Krahe J, Reetz K. MR imaging and spectroscopy in degenerative ataxias: toward multimodal, multisite, multistage monitoring of neurodegeneration. [Review]. Curr Opin Neurol. 33(4):451-461, 2020 08.

76. Storey E, Gardner RJ. Spinocerebellar ataxia type 20. [Review]. Handb. clin. neurol.. 103:567-73, 2012.

77. Cocozza S, Pontillo G, De Michele G, et al. Conventional MRI findings in hereditary degenerative ataxias: a pictorial review. [Review]. Neuroradiology. 63(7):983-999, 2021 Jul.

78. Martins CR Jr, Martinez ARM, de Rezende TJR, et al. Spinal Cord Damage in Spinocerebellar Ataxia Type 1. Cerebellum. 16(4):792-796, 2017 08.

79. Hernandez-Castillo CR, Diaz R, Rezende TJR, et al. Cervical Spinal Cord Degeneration in Spinocerebellar Ataxia Type 7. AJNR Am J Neuroradiol. 42(9):1735-1739, 2021 09.

80. Mascalchi M, Vella A. Neuroimaging Applications in Chronic Ataxias. [Review]. Int Rev Neurobiol. 143:109-162, 2018.

81. Klaes A, Reckziegel E, Franca MC Jr, et al. MR Imaging in Spinocerebellar Ataxias: A

Systematic Review. AJNR Am J Neuroradiol. 37(8):1405-12, 2016 Aug.

82. Salvatore E, Tedeschi E, Mollica C, et al. Supratentorial and infratentorial damage in spinocerebellar ataxia 2: a diffusion-weighted MRI study. Mov Disord. 29(6):780-6, 2014 May.

83. Lirng JF, Wang PS, Chen HC, et al. Differences between spinocerebellar ataxias and multiple system atrophy-cerebellar type on proton magnetic resonance spectroscopy. PLoS ONE. 7(10):e47925, 2012.

84. Chen HC, Lee LH, Lirng JF, Soong BW. Radiological hints for differentiation of cerebellar multiple system atrophy from spinocerebellar ataxia. Sci. rep.. 12(1):10499, 2022 06 22.

85. Szmulewicz DJ, Waterston JA, Halmagyi GM, et al. Sensory neuropathy as part of the cerebellar ataxia neuropathy vestibular areflexia syndrome. Neurology. 76(22):1903-10, 2011 May 31.

86. Garcia-Santibanez R, Zaidman CM, Sommerville RB, et al. CANOMAD and other chronic ataxic neuropathies with disialosyl antibodies (CANDA). J Neurol. 265(6):1402-1409, 2018 Jun.

87. Lee H, Kim HA. Autonomic dysfunction in chronic persistent dizziness. J Neurol Sci. 344(1-2):165-70, 2014 Sep 15.

88. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: https://edge.sitecorecloud.io/americancoldf5f-acrorgf92a-productioncb02-3650/media/ACR/Files/Clinical/Appropriateness-Criteria/ACR-Appropriateness-Criteria-Radiation-Dose-Assessment-Introduction.pdf.

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