American College of Radiology
ACR Appropriateness Criteria®
Cerebrovascular Diseases-Stroke and Stroke-Related Conditions

Variant 1: **Adult. Clinical transient ischemic attack (TIA). Symptoms resolved. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
US duplex Doppler carotid artery	Usually Appropriate	O
MRI head without IV contrast	Usually Appropriate	O
CT head without IV contrast	Usually Appropriate	☢☢☢
CTA head with IV contrast	Usually Appropriate	☢☢☢
CTA neck with IV contrast	Usually Appropriate	☢☢☢
MRA head without IV contrast	May Be Appropriate	O
MRA neck without and with IV contrast	May Be Appropriate	O
MRA neck without IV contrast	May Be Appropriate	O
US duplex Doppler transcranial	Usually Not Appropriate	O
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRA head without and with IV contrast	Usually Not Appropriate	O
MRI head perfusion with IV contrast	Usually Not Appropriate	O
MRI head without and with IV contrast	Usually Not Appropriate	O
MRV head without and with IV contrast	Usually Not Appropriate	O
MRV head without IV contrast	Usually Not Appropriate	O
CT head perfusion with IV contrast	Usually Not Appropriate	☢☢☢
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CTV head with IV contrast	Usually Not Appropriate	☢☢☢

Variant 2: **Adult. Focal neurologic deficit. Clinically suspected acute ischemic stroke. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI head without IV contrast	Usually Appropriate	O
CT head without IV contrast	Usually Appropriate	☢☢☢
CTA head with IV contrast	Usually Appropriate	☢☢☢
CTA neck with IV contrast	Usually Appropriate	☢☢☢
US duplex Doppler carotid artery	May Be Appropriate	O
MRA head without IV contrast	May Be Appropriate	O
MRA neck without and with IV contrast	May Be Appropriate	O
MRA neck without IV contrast	May Be Appropriate	O
MRI head perfusion with IV contrast	May Be Appropriate	O
CT head perfusion with IV contrast	May Be Appropriate	☢☢☢
US duplex Doppler transcranial	Usually Not Appropriate	O
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRA head without and with IV contrast	Usually Not Appropriate	O
MRI head without and with IV contrast	Usually Not Appropriate	O
MRV head without and with IV contrast	Usually Not Appropriate	O
MRV 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	☢☢☢
CTV head with IV contrast	Usually Not Appropriate	☢☢☢

Variant 3: **Adult. Recent ischemic infarct; less than 24 hours. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRA head without IV contrast	Usually Appropriate	O
MRA neck without and with IV contrast	Usually Appropriate	O
MRI head without IV contrast	Usually Appropriate	O
CT head without IV contrast	Usually Appropriate	☢☢☢
CTA head with IV contrast	Usually Appropriate	☢☢☢
CTA neck with IV contrast	Usually Appropriate	☢☢☢
US duplex Doppler carotid artery	May Be Appropriate	O
MRA neck without IV contrast	May Be Appropriate	O
MRI head perfusion with IV contrast	May Be Appropriate	O
CT head perfusion with IV contrast	May Be Appropriate	☢☢☢
US duplex Doppler transcranial	Usually Not Appropriate	O
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRA head without and with IV contrast	Usually Not Appropriate	O
MRI head without and with IV contrast	Usually Not Appropriate	O
MRV head without and with IV contrast	Usually Not Appropriate	O
MRV 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	☢☢☢
CTV head with IV contrast	Usually Not Appropriate	☢☢☢

Variant 4: **Adult. Recent ischemic infarct; greater than 24 hours. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI head without IV contrast	Usually Appropriate	O
CT head without IV contrast	Usually Appropriate	☢☢☢
CTA head with IV contrast	Usually Appropriate	☢☢☢
CTA neck with IV contrast	Usually Appropriate	☢☢☢
US duplex Doppler carotid artery	May Be Appropriate	O
MRA head without IV contrast	May Be Appropriate	O
MRA neck without and with IV contrast	May Be Appropriate	O
MRA neck without IV contrast	May Be Appropriate	O
US duplex Doppler transcranial	Usually Not Appropriate	O
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRA head without and with IV contrast	Usually Not Appropriate	O
MRI head perfusion with IV contrast	Usually Not Appropriate	O
MRI head without and with IV contrast	Usually Not Appropriate	O
MRV head without and with IV contrast	Usually Not Appropriate	O
MRV head without IV contrast	Usually Not Appropriate	O
CT head perfusion with IV contrast	Usually Not Appropriate	☢☢☢
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CTV head with IV contrast	Usually Not Appropriate	☢☢☢

Variant 5: **Adult. Prior ischemic infarct. Surveillance imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
CT head without IV contrast	Usually Appropriate	☢☢☢
US duplex Doppler carotid artery	May Be Appropriate	O
MRA head without IV contrast	May Be Appropriate (Disagreement)	O
MRA neck without and with IV contrast	May Be Appropriate (Disagreement)	O
MRA neck without IV contrast	May Be Appropriate	O
MRI head without IV contrast	May Be Appropriate (Disagreement)	O
CTA head with IV contrast	May Be Appropriate	☢☢☢
CTA neck with IV contrast	May Be Appropriate	☢☢☢
US duplex Doppler transcranial	Usually Not Appropriate	O
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRA head without and with IV contrast	Usually Not Appropriate	O
MRI head perfusion with IV contrast	Usually Not Appropriate	O
MRI head without and with IV contrast	Usually Not Appropriate	O
MRV head without and with IV contrast	Usually Not Appropriate	O
MRV head without IV contrast	Usually Not Appropriate	O
CT head perfusion with IV contrast	Usually Not Appropriate	☢☢☢
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CTV head with IV contrast	Usually Not Appropriate	☢☢☢

Variant 6: **Adult. Known intraparenchymal hemorrhage. No history of trauma. Follow-up imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI head without and with IV contrast	Usually Appropriate	O
MRI head without IV contrast	Usually Appropriate	O
CT head without IV contrast	Usually Appropriate	☢☢☢
CTA head with IV contrast	Usually Appropriate	☢☢☢
Arteriography cervicocerebral	May Be Appropriate	☢☢☢
MRA head without IV contrast	May Be Appropriate	O
MRV head without and with IV contrast	May Be Appropriate	O
MRV head without IV contrast	May Be Appropriate	O
CTV head with IV contrast	May Be Appropriate	☢☢☢
US duplex Doppler carotid artery	Usually Not Appropriate	O
US duplex Doppler transcranial	Usually Not Appropriate	O
MRA head without and with IV contrast	Usually Not Appropriate	O
MRA neck without and with IV contrast	Usually Not Appropriate	O
MRA neck without IV contrast	Usually Not Appropriate	O
MRI head perfusion with IV contrast	Usually Not Appropriate	O
CT head perfusion with IV contrast	Usually Not Appropriate	☢☢☢
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CTA neck with IV contrast	Usually Not Appropriate	☢☢☢

Variant 7: **Adult. Suspected venous sinus thrombosis. 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
MRV head without and with IV contrast	Usually Appropriate	O
MRV head without IV contrast	Usually Appropriate	O
CT head without IV contrast	Usually Appropriate	☢☢☢
CTV head with IV contrast	Usually Appropriate	☢☢☢
CT head with IV contrast	May Be Appropriate	☢☢☢
US duplex Doppler carotid artery	Usually Not Appropriate	O
US duplex Doppler transcranial	Usually Not Appropriate	O
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRA head without and with IV contrast	Usually Not Appropriate	O
MRA head without IV contrast	Usually Not Appropriate	O
MRA neck without and with IV contrast	Usually Not Appropriate	O
MRA neck without IV contrast	Usually Not Appropriate	O
MRI head perfusion with IV contrast	Usually Not Appropriate	O
CT head perfusion with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CTA head with IV contrast	Usually Not Appropriate	☢☢☢
CTA neck with IV contrast	Usually Not Appropriate	☢☢☢

Variant 8: **Adult. Known venous sinus thrombosis. Surveillance 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
MRV head without and with IV contrast	Usually Appropriate	O
MRV head without IV contrast	Usually Appropriate	O
CT head without IV contrast	Usually Appropriate	☢☢☢
CTV head with IV contrast	Usually Appropriate	☢☢☢
US duplex Doppler carotid artery	Usually Not Appropriate	O
US duplex Doppler transcranial	Usually Not Appropriate	O
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRA head without and with IV contrast	Usually Not Appropriate	O
MRA head without IV contrast	Usually Not Appropriate	O
MRA neck without and with IV contrast	Usually Not Appropriate	O
MRA neck without IV contrast	Usually Not Appropriate	O
MRI head perfusion with IV contrast	Usually Not Appropriate	O
CT head perfusion with IV contrast	Usually Not Appropriate	☢☢☢
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CTA head with IV contrast	Usually Not Appropriate	☢☢☢
CTA neck with IV contrast	Usually Not Appropriate	☢☢☢

Variant 9: **Adult. Asymptomatic cervical bruit. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
US duplex Doppler carotid artery	Usually Appropriate	O
MRA neck without and with IV contrast	Usually Appropriate	O
MRA neck without IV contrast	Usually Appropriate	O
CTA neck with IV contrast	Usually Appropriate	☢☢☢
US duplex Doppler transcranial	Usually Not Appropriate	O
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRA head without and with IV contrast	Usually Not Appropriate	O
MRA head without IV contrast	Usually Not Appropriate	O
MRI head perfusion 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
MRV head without and with IV contrast	Usually Not Appropriate	O
MRV head without IV contrast	Usually Not Appropriate	O
CT head perfusion with IV contrast	Usually Not Appropriate	☢☢☢
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	☢☢☢
CTA head with IV contrast	Usually Not Appropriate	☢☢☢
CTV head with IV contrast	Usually Not Appropriate	☢☢☢

Variant 10: **Adult. Asymptomatic carotid stenosis. Surveillance imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
US duplex Doppler carotid artery	Usually Appropriate	O
MRA neck without and with IV contrast	Usually Appropriate	O
MRA neck without IV contrast	Usually Appropriate	O
CTA neck with IV contrast	Usually Appropriate	☢☢☢
MRI head without IV contrast	May Be Appropriate (Disagreement)	O
US duplex Doppler transcranial	Usually Not Appropriate	O
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRA head without and with IV contrast	Usually Not Appropriate	O
MRA head without IV contrast	Usually Not Appropriate	O
MRI head perfusion with IV contrast	Usually Not Appropriate	O
MRI head without and with IV contrast	Usually Not Appropriate	O
MRV head without and with IV contrast	Usually Not Appropriate	O
MRV head without IV contrast	Usually Not Appropriate	O
CT head perfusion with IV contrast	Usually Not Appropriate	☢☢☢
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	☢☢☢
CTA head with IV contrast	Usually Not Appropriate	☢☢☢
CTV head with IV contrast	Usually Not Appropriate	☢☢☢

Variant 11: **Adult. Suspected cervical vascular dissection or injury. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRA neck without and with IV contrast	Usually Appropriate	O
MRA neck without IV contrast	Usually Appropriate	O
CT head without IV contrast	Usually Appropriate	☢☢☢
CTA neck with IV contrast	Usually Appropriate	☢☢☢
MRA head without IV contrast	May Be Appropriate	O
MRI head without IV contrast	May Be Appropriate	O
CTA head with IV contrast	May Be Appropriate	☢☢☢
US duplex Doppler carotid artery	Usually Not Appropriate	O
US duplex Doppler transcranial	Usually Not Appropriate	O
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRA head without and with IV contrast	Usually Not Appropriate	O
MRI head perfusion with IV contrast	Usually Not Appropriate	O
MRI head without and with IV contrast	Usually Not Appropriate	O
MRV head without and with IV contrast	Usually Not Appropriate	O
MRV head without IV contrast	Usually Not Appropriate	O
CT head perfusion with IV contrast	Usually Not Appropriate	☢☢☢
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CTV head with IV contrast	Usually Not Appropriate	☢☢☢

<u>Variant 12:</u> **Adult. Known cervical vascular dissection or injury. Surveillance imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRA neck without and with IV contrast	Usually Appropriate	O
MRA neck without IV contrast	Usually Appropriate	O
CTA neck with IV contrast	Usually Appropriate	☢☢☢
Arteriography cervicocerebral	May Be Appropriate	☢☢☢
MRA head without IV contrast	May Be Appropriate (Disagreement)	O
CTA head with IV contrast	May Be Appropriate	☢☢☢
US duplex Doppler carotid artery	Usually Not Appropriate	O
US duplex Doppler transcranial	Usually Not Appropriate	O
MRA head without and with IV contrast	Usually Not Appropriate	O
MRI head perfusion 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
MRV head without and with IV contrast	Usually Not Appropriate	O
MRV head without IV contrast	Usually Not Appropriate	O
CT head perfusion with IV contrast	Usually Not Appropriate	☢☢☢
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	☢☢☢
CTV head with IV contrast	Usually Not Appropriate	☢☢☢

CEREBROVASCULAR DISEASES-STROKE AND STROKE-RELATED CONDITIONS

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Summary of Literature Review

Introduction/Background

Cerebrovascular diseases encompass a range of varied clinical presentations and disease processes. This document focuses on clinical scenarios related to stroke and intraparenchymal hemorrhage (IPH), stroke-like conditions such as venous sinus thrombosis and arterial vascular dissection, and known vascular stroke-related risk factors such as cervical bruit and carotid stenosis. The clinical variants included in this document describe imaging management early in clinical presentation with acute or recent onset of symptoms, as well as ongoing imaging during management of known stroke and stroke-related conditions in the subacute and chronic phases. The subset of cerebrovascular diseases and presentations are broad and varied; therefore, the introduction and background of each variant will be discussed individually.

Stroke-like symptoms can overlap in their clinical presentation with other known conditions and clinical scenarios. Please see the ACR Appropriateness Criteria® topics on "Headache" [1], "Acute Mental Status Change, Delirium, and New Onset Psychosis" [2], "Cranial Neuropathy" [3], and "Penetrating Neck Injury" [4].

For a discussion of cerebrovascular diseases related to aneurysm, vascular malformation, and subarachnoid hemorrhage, please see the ACR Appropriateness Criteria® topic on "Cerebrovascular Diseases-Aneurysm, Vascular Malformation, and Subarachnoid Hemorrhage" [5]. For IPH related to head trauma, please see the ACR Appropriateness Criteria® topic on "Head Trauma" [6].

Special Imaging Considerations

In many stroke-related clinical scenarios, both parenchymal and vascular imaging procedures are commonly used, particularly in the initial imaging of acute clinical presentations. Noncontrast head CT can be performed rapidly, either alone or included in the performance of CT angiography (CTA) of the head. For the purposes of this document, both procedures are discussed separately for each variant, highlighting the individual usefulness of both the noncontrast examination and contrast-enhanced vascular imaging phase.

CTA of the head and neck are often acquired together, using a single contrast bolus for optimal arterial vascular opacification. Although the diagnostic usefulness and/or acuity of intracranial and extracranial vascular assessment may differ within a particular clinical context, the benefit of combined neck and head vascular imaging may have added clinical benefit in circumstances in which transcatheter arterial intervention is a potential consideration.

MRI perfusion imaging is most commonly performed using intravenous (IV) contrast; however, newer scanners may also have the ability to perform noncontrast perfusion imaging without IV contrast using arterial spin-labeled (ASL) techniques. Future Appropriateness Criteria documents may consider this technique as it achieves greater adoption in routine clinical practice.

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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 where each procedure provides unique clinical information to effectively manage the patient's care).

Discussion of Procedures by Variant

Variant 1: Adult. Clinical transient ischemic attack (TIA). Symptoms resolved. Initial imaging.

Transient ischemic attacks (TIA) are self-limited focal neurologic deficits resulting from a temporary interruption in blood supply to the brain, with no permanent clinical deficit or demonstrated infarct on subsequent imaging. In the United States, the incidence of TIA is approximately 1.2 per 1,000 [7]. The traditional time-based definition of TIA set the maximum duration at 24 hours. A newer imaging-based definition restricts the term TIA to those without neuroimaging evidence of tissue damage. Practically, those with and without tissue damage are considered together for diagnosis and management proposes [8,9]. Although symptoms may resolve within a short period of time, typically <1 hour, the risk for subsequent stroke is high: 8.8% at 7 days and 11.6% at 90 days [10]. In the setting of symptomatic carotid disease, the 90-day risk of ipsilateral stroke is 20.1% [11]. Given the high risk for stroke following TIA, expeditious initial imaging is important. There is a direct correlation between the risk of stroke following a carotid territory TIA or minor stroke and degree of carotid stenosis, and this drives the decision for carotid endarterectomy (CEA) or stenting [12,13]. Therefore, evaluation of patients with clinical carotid TIA or minor stroke requires rapid vascular imaging of the cervical carotid arteries [12,13] in addition to brain parenchymal imaging.

Arteriography Cervicocerebral

Although the spatial resolution of catheter-directed cerebral angiography is higher than any noninvasive technique, cerebral angiography is not preferred as an initial test due to the invasive nature and the diversity of etiologies for TIA. Cerebral angiography may be indicated later in the diagnostic pathway as a secondary examination in the workup of TIA, depending on the suspected underlying etiology and potential indications for endovascular therapy (EVT).

CT Head Perfusion With IV Contrast

CT perfusion (CTP) can identify abnormalities in the setting of TIA in up to one-third of cases. The detection of an underlying perfusion abnormality may be helpful for risk stratification [14-16]. Specific instances arise in patients with complete extracranial internal carotid artery occlusion in whom CTP can be used to determine its hemodynamic effect [17]. However, selection of patients with carotid occlusion for revascularization based on hemodynamic compromise does not improve outcome [18]. Therefore, CTP is not typically used for the initial assessment of TIA.

CT Head With IV Contrast

There is no relevant literature to support the use of contrast-enhanced CT of the head in the evaluation of TIA.

CT Head Without and With IV Contrast

There is no relevant literature to support the use of CT of the head without and with IV contrast in the evaluation of TIA.

CT Head Without IV Contrast

Noncontrast CT of the head is useful in the initial evaluation of TIA to exclude alternative etiologies and to evaluate for early ischemic changes. Many other lesions may mimic the symptoms of a TIA including intracranial hemorrhage (ICH), infection, and intracranial masses [14,19,20]. Most importantly, ICH must be excluded because it is a contraindication to administration of tissue thrombolytic agents, anticoagulants, and antiplatelet agents used to treat and prevent both TIA and stroke [13]. Moreover, the extent of ischemic changes seen on noncontrast CT, regardless of chronicity, is correlated with the risk of subsequent strokes [21].

CTA Head With IV Contrast

CTA of the head is a rapid means of evaluating the intracranial vasculature for underlying intracranial atherosclerosis and other intracranial steno-occlusive diseases, which may be useful in the secondary workup and triage of patients presenting with TIA. The identification of atherosclerotic intracranial vascular lesions in the setting of TIA may be useful in determining the most appropriate treatment options, although this is controversial [22,23].

CTA Neck With IV Contrast

CTA of the neck is a rapid means of evaluating the extracranial vasculature and is useful in the initial workup and triage of patients presenting with carotid territory TIA. Current American Heart Association (AHA) guidelines recommend noninvasive imaging of the cervical carotid arteries for patients with TIA or minor stroke who are candidates for CEA or stenting within 48 hours of onset [12]. Heavy calcifications or calcified plaque on both sides of the lumen can lead to overestimation of the stenosis [24].

CTV Head With IV Contrast

There is no relevant literature to support the use of CT venography (CTV) head in the evaluation of TIA in the absence of suspicion for cerebral venous thrombosis (CVT). Please see Variant 7 for further details.

MRA Head Without and With IV Contrast

There is no relevant literature to support the use of contrast-enhanced MR angiography (MRA) of the head in the evaluation of TIA.

MRA Head Without IV Contrast

MRA of the head is an alternative means of evaluating intracranial steno-occlusive disease and may be useful in the initial workup and triage of patients presenting with TIA. Owing to the relatively rapid and noninvasive nature of the examination obviating the need for IV contrast, MRA may be preferable to CTA in patients with renal impairment, x-ray contrast allergy, or repeat presentations. Typically, noncontrast time-of-flight (TOF) MRA technique is sufficiently sensitive to screen for culprit intracranial lesions in the setting of suspected TIA [25].

MRA Neck Without and With IV Contrast

MRA of the neck may be useful in screening for extracranial vascular disease in the initial workup and triage of patients presenting with TIA. Current AHA guidelines recommend noninvasive imaging of the cervical carotid arteries for patients with TIA or minor stroke who are candidates for CEA or stenting, within 48 hours of onset [12]. Noncontrast MRA of the neck tends to overestimate the degree of carotid stenosis when compared with contrast-enhanced MRA, particularly in cases of high-grade stenosis [26]. Typically, noncontrast TOF MRA technique is sufficiently sensitive to screen for culprit intracranial lesions in the setting of suspected TIA [27].

MRA Neck Without IV Contrast

MRA of the neck may be useful in screening for extracranial vascular disease in the initial workup and triage of patients presenting with TIA. Current AHA guidelines recommend noninvasive imaging of the cervical carotid arteries for patients with TIA or minor stroke who are candidates for CEA or stenting, within 48 hours of onset [12]. Noncontrast MRA of the neck tends to overestimate the degree of carotid stenosis when compared with contrast-enhanced MRA, particularly in cases of high-grade stenosis [26]. Typically, noncontrast TOF MRA technique is sufficiently sensitive to screen for culprit intracranial lesions in the setting of suspected TIA [27].

MRI Head Perfusion With IV Contrast

Contrast-enhanced MRI head perfusion imaging (or, if available, noncontrast ASL perfusion) may detect additional abnormalities not identified on initial vascular imaging or diffusion-weighted imaging (DWI) in some patients presenting with TIA. Either technique may be useful in the secondary workup and triage of patients presenting with TIA depending on the suspected underlying etiology, particularly if no abnormalities are identified on direct vascular or parenchymal imaging studies [28-30]. Specific instances arise in patients with complete extracranial internal carotid artery occlusion in whom MR perfusion can be used to determine its hemodynamic effect [31-33]. However, selection of patients with carotid occlusion for revascularization based on hemodynamic compromise does not improve outcome [18].

MRI Head Without and With IV Contrast

Noncontrast MRI head is typically sufficient for the routine assessment of uncomplicated TIA. Conditions rarely mimicking TIA include tumors and cerebral convexity subarachnoid hemorrhage due to amyloid angiopathy. MRI without and with IV contrast may be helpful in the secondary workup of patients presenting with transient focal neurological symptoms [34].

MRI Head Without IV Contrast
Owing to the relatively rapid noninvasive nature of MRI and the high sensitivity of DWI for ischemic change, MRI is the most sensitive test for acute infarct. MRI of the head may be useful in the initial or secondary evaluation of TIA to evaluate for ischemic changes on DWI or for other alternative etiologies [34,35]. MRI is particularly useful prognostically as an initial test in the setting of complete resolution of associated symptoms before presentation or shortly after presentation [29]. Additionally, MRI may be useful as an initial test on repeat clinical presentation [36].

MRV Head Without and With IV Contrast
There is no relevant literature to support the use of MR venography (MRV) of the head in the evaluation of TIA in the absence of suspicion of CVT, which can rarely present as a TIA [37].

MRV Head Without IV Contrast
There is no relevant literature to support the use of MRV of the head in the evaluation of TIA in the absence of suspicion of CVT, which can rarely present as a TIA [37].

US Duplex Doppler Carotid Artery
Ultrasound (US) duplex carotid Doppler is a useful test in the initial evaluation of the extracranial vasculature in the workup of TIA. Carotid Doppler US is noninvasive and is accurate in evaluating the degree of carotid stenosis [38]. Current AHA guidelines recommend noninvasive imaging of the cervical carotid arteries for patients with TIA or minor stroke who are candidates for CEA or stenting within 48 hours of onset [12].

US Duplex Doppler Transcranial
Transcranial Doppler can be used for the detection of microembolic events and in the detection of intracranial vascular pathology in the secondary workup of TIA. However, this is not typically used as an initial imaging test in the setting of TIA.

Variant 2: Adult. Focal neurologic deficit. Clinically suspected acute ischemic stroke. Initial imaging.

Stroke due to large vessel occlusions (LVO) is a significant source of death and disability, representing a true neurological emergency. Rapid stroke diagnosis and triage are key, because up to 2 million neurons can be lost per minute during an LVO stroke [39]. In the past, early imaging focused primarily on parenchymal imaging to exclude ICH within the thrombolytic window of <4.5 hours. Recently, several studies have shown the benefit of extending the thrombolytic window up to 9 hours using perfusion imaging [40-43]. However, a number of positive randomized controlled trials (RCTs) have demonstrated the benefit of EVT with mechanical thrombectomy (MT) in the treatment of stroke due to LVO up to 24 hours, underscoring the urgency of LVO detection and resulting in a paradigmatic shift in the urgency of obtaining vascular imaging [44-50]. Although some authors have attempted to stratify the priority of vascular imaging rapidity based upon the severity of presentation using the patient's National Institutes of Health Stroke Scale (NIHSS) score, the correlation between the NIHSS score and the presence of LVO is relatively poor [51]. This likely reflects the wide array of etiologies that may mimic stroke, the variability of patient collateral circulation, and the propensity for prehospital recumbency. In addition to vascular imaging and CT or MRI without IV contrast, determining eligibility for MT may require additional MRI sequences or perfusion imaging with CT or MRI depending on the time since last known normal and the severity of the neurological deficit [52]. In the absence of thrombolytics eligibility or an LVO, the workup of a new stroke becomes less critical in the hyperacute phase and more focused on treatment of complications, rehabilitation, and secondary prevention.

Arteriography Cervicocerebral
Cerebral angiography has the highest spatial and temporal resolution of any vascular imaging study. Due to the invasive nature of catheter-directed angiography, other modalities are typically preferred in the initial workup for stroke. However, in the setting of highly suspected LVO with no need for perfusion imaging or MRI to determine eligibility for EVT, initial catheter angiography after noncontrast CT may be the preferable vascular imaging study due to the ability to rapidly convert a diagnostic catheter angiogram to EVT [53,54]. More specifically, patients presenting with suspicious signs on noncontrast CT such as hyperdense middle cerebral artery sign with a clear etiology for the LVO such as new onset atrial fibrillation may benefit from proceeding directly to angiography, although prospective data are limited in this regard [55].

CT Head Perfusion With IV Contrast
Within the initial 6-hour window of presentation of an acute stroke, CTP of the head is usually not necessary as an initial examination; conversely, delay, created by obtaining and analyzing CTP in the setting of a known LVO patient who is a clear EVT candidate, may be harmful [13,56]. In contrast, determining eligibility for EVT for anterior circulation strokes due to LVO confirmed on CTA presenting in the extended window of 6 to 24 hours may require or be determined by CTP or MR perfusion imaging in some cases [46,57]. Although a major RCT showing benefit of EVT 6 to 24 hours after onset permitted eligibility based on DWI-MRI or CTP [46], the rapidity of diagnosis afforded by CTP is a strongly relevant clinical consideration in this situation in most settings.

CT Head With IV Contrast
There is no relevant literature to support the use of contrast-enhanced CT of the head in the evaluation of ischemic stroke.

CT Head Without and With IV Contrast
There is no relevant literature to support the use of CT of the head without and with IV contrast in the evaluation of ischemic stroke.

CT Head Without IV Contrast
Noncontrast CT of the head is essential in the initial evaluation of stroke to exclude underlying ICH and other potential etiologies for the patient's symptoms and to evaluate for early ischemic changes. It is essential to exclude ICH before the administration of IV thrombolytic therapy or before the initiation of EVT. Additionally, areas of early ischemic change can be used to estimate the extent of irreversible tissue damage. Because many RCTs of acute ischemic stroke treatments used the Alberta Stroke Program Early Computed Tomography Score (ASPECTS) or its posterior circulation derivative (pc-ASPECTS) based on noncontrast CT or DWI-MRI to exclude subjects with large, completed infarcts, an initial noncontrast CT or DWI-MRI is essential for making therapeutic decisions [58,59].

CTA Head With IV Contrast
CTA of the head is the most rapid means of assessment of the intracranial vasculature for LVO in the setting of stroke. CTA of the head has a high sensitivity and specificity for the detection of intracranial LVO [60]. Stroke, possibly due to LVO, is a true medical emergency in which the rapidity of diagnosis afforded by CTA is a strongly relevant clinical consideration. The use of CTA of the head for the initial test in the detection of LVO is supported by multiple RCTs and is the preferred means of LVO detection due to the time-sensitive nature of stroke care [44,46,48,49,57]. Moreover, in the absence of an LVO, other etiologies such as atherosclerosis, vasculitis, reversible cerebral vasoconstrictive syndrome, or other etiologies may be suggested by CTA of the head.

CTA Neck With IV Contrast
CTA of the neck is the most rapid means of assessment of the extracranial vasculature in the setting of stroke. CTA of the neck can be rapidly acquired together with CTA of the head, can further elucidate the etiology of the stroke, and may be useful for endovascular surgical planning for EVT in LVO [13]. Specifically, the degree of vascular tortuosity is directly correlated with the time from groin puncture to recanalization and must be factored into the decision-making process both with regards to indications and surgical approach, including the choice of access using radial artery or direct carotid puncture approach [61]. Current AHA guidelines recommend noninvasive imaging of the cervical carotid arteries for patients with TIA or minor stroke who are candidates for CEA or stenting, within 48 hours of onset [12].

CTV Head With IV Contrast
There is no relevant literature to support the use of CTV head in the evaluation of suspected ischemic stroke in the absence of suspicion for CVT.

MRA Head Without and With IV Contrast
There is no relevant literature to support the use of contrast-enhanced MRA of the head in the evaluation of suspected ischemic stroke.

MRA Head Without IV Contrast
Although sensitive and specific in the detection of LVO, TOF MRA of the head may delay EVT in the setting of stroke due to LVO, which possibly detracts from the usefulness of this procedure due to the potential harm of delayed treatment [39,56]. Stroke due to LVO is a true medical emergency in which the rapidity of diagnosis afforded by CTA is a strongly relevant clinical consideration. In patients with renal insufficiency or x-ray contrast

allergy, TOF MRA can be used to identify arterial occlusions without putting the patient at risk and inform subsequent therapeutic decisions [52].

MRA Neck Without and With IV Contrast

Although sensitive and specific in the detection of extracranial vascular disease and delineation of anatomy, MRA of the neck may delay EVT in the setting of stroke due to LVO, which possibly detracts from the usefulness of this procedure due to the potential harm of delayed treatment [39,56]. Stroke due to LVO is a true medical emergency in which the rapidity of diagnosis afforded by CTA is a strongly relevant clinical consideration. In patients with renal insufficiency or x-ray contrast allergy, TOF MRA can be used to delineate arterial anatomy without putting the patient at risk and inform subsequent therapeutic decisions [52]. Current AHA guidelines recommend noninvasive imaging of the cervical carotid arteries for patients with TIA or minor stroke who are candidates for CEA or stenting, within 48 hours of onset [12].

MRA Neck Without IV Contrast

Although sensitive and specific in the detection of extracranial vascular disease and delineation of anatomy, MRA of the neck may delay EVT in the setting of stroke due to LVO, which possibly detracts from the usefulness of this procedure due to the potential harm of delayed treatment [39,56]. Stroke due to LVO is a true medical emergency in which the rapidity of diagnosis afforded by CTA is a strongly relevant clinical consideration. In patients with renal insufficiency or x-ray contrast allergy, TOF MRA can be used to delineate arterial anatomy without putting the patient at risk and inform subsequent therapeutic decisions [52].

MRI Head Perfusion With IV Contrast

MRI head perfusion is sensitive and specific in the detection of reversible ischemia. MRI head perfusion may delay EVT in the setting of stroke due to LVO, which detracts from the usefulness of this study in the acute phase due to the potential harm of delayed treatment [39]. Although major RCTs showing benefit of EVT 6 to 24 hours after onset permitted eligibility based on MRI perfusion or CTP [46,57], the rapidity of diagnosis afforded by CTP is a strongly relevant clinical consideration in this situation in most settings.

MRI Head Without and With IV Contrast

Rarely, brain tumors or other conditions can mimic ischemic stroke. MRI without and with IV contrast may be helpful in the secondary workup of patients presenting with stroke-like symptoms [62].

MRI Head Without IV Contrast

Although sensitive and specific in the detection of the extent of irreversible ischemia, MRI head may delay EVT in the setting of stroke due to anterior circulation LVO, which detracts from the usefulness of this study due to the potential harm of delayed treatment [39,46,56]. Although a major RCT showing benefit of EVT 6 to 24 hours after onset permitted eligibility based on DWI-MRI or CTP [46], the rapidity of diagnosis afforded by CTP is a strongly relevant clinical consideration in this situation in most settings. Similarly, the 2 positive RCTs for EVT in basilar occlusion used pc-ASPECTS from either DWI-MRI or noncontrast CT for eligibility. The rapidity of CT makes it preferable in this situation as well [48,49]. However, for some wake-up strokes and for some anterior circulation strokes with large infarcts, DWI-MRI and fluid-attenuated inversion recovery (FLAIR) sequences are necessary to determine eligibility for thrombolytics and EVT, respectively [40,47].

In patients with renal insufficiency or x-ray contrast allergy, the combination TOF MRA to identify arterial occlusions and DWI-MRI head without IV contrast can identify patients eligible for EVT 6 to 24 hours without putting the patient at risk and inform subsequent therapeutic decisions [46,47,52].

MRI is a reasonable complementary examination used in the initial workup of a focal neurological deficit if LVO is excluded by CTA, when there are confounding imaging and clinical variables.

MRV Head Without and With IV Contrast

There is no relevant literature to support the use of MRV of the head in the evaluation of suspected ischemic stroke in the absence of specific suspicion for CVT.

MRV Head Without IV Contrast

There is no relevant literature to support the use of MRV of the head in the evaluation of suspected ischemic stroke in the absence of specific suspicion for CVT.

US Duplex Doppler Carotid Artery
Although sensitive and specific in the detection of extracranial vascular disease, duplex carotid Doppler does not provide the information necessary to determine eligibility for thrombolytics or thrombolysis or EVT. US duplex carotid Doppler, which is noninvasive and is accurate in evaluating the degree of carotid stenosis, is a useful test for the evaluation of the extracranial vasculature to determine eligibility for CEA or stenting if this information has not already been obtained from other vascular imaging [63,64]. Current AHA guidelines recommend noninvasive imaging of the cervical carotid arteries for patients with TIA or minor stroke who are candidates for CEA or stenting, within 48 hours of onset [12].

US Duplex Doppler Transcranial
Transcranial Doppler may be useful, both in the detection of microembolic events and in the detection of intracranial vascular pathology. However, this is typically not an initial imaging test in the setting of stroke due to the poor anatomical delineation of US and potential consequences of delayed treatment in the setting of LVO [39].

Variant 3: Adult. Recent ischemic infarct; less than 24 hours. Initial imaging.

This variant is focused on new clinical presentation of stroke in the acute phase, <24 hours from onset of symptoms, but beyond hyperacute clinical presentation. Because stroke due to LVO is a significant source of death and disability, rapid stroke diagnosis and triage remain essential, particularly in the setting of possible LVO [39]. Recent studies have shown the benefit of extending the thrombolytic window up to 9 hours using perfusion imaging [40-43]. However, a number of positive RCTs have demonstrated the benefit of EVT in the treatment of stroke due to LVO up to 24 hours underscoring the urgency of LVO detection and resulting in a paradigmatic shift in the urgency of obtaining vascular imaging [44-49]. In the context of nonemergent suspected stroke, parenchymal and vascular imaging are still needed, although the determination of eligibility for EVT in cases of delayed or unknown presentation may require additional MRI sequences or perfusion imaging with CT or MRI depending on the time since last known normal and the severity of the neurological deficit [52]. In the absence of LVO, the workup of a new stroke focuses on treatment of complications, rehabilitation, and secondary prevention.

Arteriography Cervicocerebral
Cerebral angiography has the highest spatial and temporal resolution of any vascular imaging study. Due to the invasive nature of catheter-directed angiography, other modalities are typically preferred in the initial workup for stroke. However, in the setting of highly suspected LVO with no need for perfusion imaging or MRI to determine eligibility for EVT, initial catheter angiography after noncontrast CT may be the preferable vascular imaging study due to the ability to rapidly convert a diagnostic catheter angiogram to EVT [53,54]. More specifically, patients presenting with suspicious signs on noncontrast CT such as hyperdense middle cerebral artery sign with a clear etiology for the LVO such as new onset atrial fibrillation may benefit from proceeding directly to angiography, although prospective data are limited in this regard [55].

CT Head Perfusion With IV Contrast
Beyond the early 6-hour time window, determining eligibility for EVT for anterior circulation strokes due to LVO confirmed on CTA in the extended window of 6 to 24 hours may require or be determined by CTP or MR perfusion imaging in some cases [46,57]. Although a major RCT showing benefit of EVT 6 to 24 hours after onset permitted eligibility based on DWI-MRI or CTP [46], the rapidity of diagnosis afforded by CTP is a strongly relevant clinical consideration in this situation in most settings.

CT Head With IV Contrast
There is no relevant literature to support the use of contrast-enhanced CT of the head in the evaluation of ischemic stroke.

CT Head Without and With IV Contrast
There is no relevant literature to support the use of CT of the head with and without contrast in the evaluation of ischemic stroke.

CT Head Without IV Contrast
Noncontrast CT of the head is essential in the early evaluation of stroke to exclude underlying ICH and other potential etiologies for the patient’s symptoms and to evaluate for early ischemic changes. Deterioration in a patient’s clinical condition should prompt consideration of a noncontrast CT of the head to evaluate for possible hemorrhagic conversion. It is essential to exclude ICH before the administration of IV thrombolytic therapy or before the initiation of EVT. Additionally, areas of early ischemic change can be used to estimate the extent of

irreversible tissue damage. Because many RCTs of acute ischemic stroke treatments used the ASPECTS or pc-ASPECTS based on noncontrast CT or DWI-MRI to exclude subjects with large, completed infarcts, an initial noncontrast CT or DWI-MRI is essential for making therapeutic decisions [44,46-49,57-59].

CTA Head With IV Contrast
CTA of the head is the most rapid means of assessment of the intracranial vasculature for LVO in the setting of stroke. CTA of the head has a high sensitivity and specificity for the detection of intracranial LVO [60]. Acute stroke possibly due to LVO is a true medical emergency requiring rapid diagnosis, and the use of CTA of the head for the initial test in the detection of LVO is supported by multiple RCTs and is the preferred means of LVO detection due to the time-sensitive nature of stroke care [44,46,48,49,57]. Moreover, in the absence of an LVO, other etiologies such as atherosclerosis, vasculitis, reversible cerebral vasoconstrictive syndrome, or other etiologies may be suggested by CTA of the head.

CTA Neck With IV Contrast
CTA of the neck is the most rapid means of assessment of the extracranial vasculature in the setting of stroke. CTA of the neck can be rapidly acquired together with CTA of the head, can further elucidate the etiology of the stroke, and may be useful for endovascular surgical planning for EVT in LVO [13]. Specifically, the degree of vascular tortuosity is directly correlated with the time from groin puncture to recanalization and must be factored into the decision-making process both with regards to indications and surgical approach, including the choice of access using radial artery or direct carotid puncture approach [61]. Current AHA guidelines recommend noninvasive imaging of the cervical carotid arteries for patients with TIA or minor stroke who are candidates for CEA or stenting, within 48 hours of onset [12].

CTV Head With IV Contrast
There is no relevant literature to support the use of CTV head in the evaluation of suspected ischemic stroke in the absence of suspicion for CVT.

MRA Head Without and With IV Contrast
There is no relevant literature to support the use of contrast-enhanced MRA of the head in the evaluation of suspected ischemic stroke.

MRA Head Without IV Contrast
TOF MRA of the head is sensitive and specific in the detection of LVO and characterization of intracranial atherosclerosis. In the acute setting, CTA is generally acquired more rapidly than MRI and delay due to MRI should be avoided, unless MRA is readily available in the hyperacute setting [39,56]. Stroke due to LVO is a true medical emergency in which the rapidity of diagnosis afforded by CTA is a strongly relevant clinical consideration. In patients with renal insufficiency or x-ray contrast allergy, TOF MRA can be used to identify arterial occlusions without putting the patient at risk and inform subsequent therapeutic decisions [52].

MRA Neck Without and With IV Contrast
Although sensitive and specific in the detection of extracranial vascular disease and delineation of anatomy, MRA of the neck may delay EVT in the setting of stroke due to LVO, which possibly detracts from the usefulness of this procedure due to the potential harm of delayed treatment, unless MRA is readily available in the hyperacute setting [39,56]. Stroke due to LVO is a true medical emergency in which the rapidity of diagnosis afforded by CTA is a strongly relevant clinical consideration. In patients with renal insufficiency or x-ray contrast allergy, TOF MRA can be used to delineate arterial anatomy without putting the patient at risk and inform subsequent therapeutic decisions [52]. Current AHA guidelines recommend noninvasive imaging of the cervical carotid arteries for patients with TIA or minor stroke who are candidates for CEA or stenting, within 48 hours of onset [12].

MRA Neck Without IV Contrast
Although sensitive and specific in the detection of extracranial vascular disease and delineation of anatomy, MRA of the neck may delay EVT in the setting of stroke due to LVO, which possibly detracts from the usefulness of this procedure due to the potential harm of delayed treatment, unless MRA is readily available in the hyperacute setting [39,56]. Stroke due to LVO is a true medical emergency in which the rapidity of diagnosis afforded by CTA is a strongly relevant clinical consideration. In patients with renal insufficiency or x-ray contrast allergy, TOF MRA can be used to delineate arterial anatomy without putting the patient at risk and inform subsequent therapeutic decisions [52].

MRI Head Perfusion With IV Contrast
MRI head perfusion is sensitive and specific in the detection of reversible ischemia. MRI head perfusion may delay EVT in the setting of stroke due to LVO, which detracts from the usefulness of this study in the acute phase due to the potential harm of delayed treatment [39]. Although major RCTs showing a benefit of EVT 6 to 24 hours after onset permitted eligibility based on MRI perfusion or CTP [46,57], the rapidity of diagnosis afforded by CTP is a strongly relevant clinical consideration in this situation in most settings.

MRI Head Without and With IV Contrast
Rarely, brain tumors or other conditions can mimic ischemic stroke. MRI without and with IV contrast may be helpful in the secondary workup of patients presenting with stroke-like symptoms [62].

MRI Head Without IV Contrast
Although sensitive and specific in the detection of the extent of irreversible ischemia, MRI head may delay EVT in the setting of stroke due to anterior circulation LVO, which detracts from the usefulness of this study due to the potential harm of delayed treatment [39,46,56]. Although a major RCT showing benefit of EVT 6 to 24 hours after onset permitted eligibility based on DWI-MRI or CTP [46], the rapidity of diagnosis afforded by CTP is a strongly relevant clinical consideration in this situation in most settings Similarly, the 2 positive RCTs for EVT in basilar occlusion used pc-ASPECTS from either DWI-MRI or noncontrast CT for eligibility. The rapidity of CT makes it preferable in this situation as well [48,49]. However, for some wake-up strokes and for some anterior circulation strokes with large infarcts, DWI-MRI and FLAIR sequences are necessary to determine eligibility for thrombolytics and EVT, respectively [40,47].

In patients with renal insufficiency or x-ray contrast allergy, the combination TOF MRA to identify arterial occlusions and DWI-MRI head without IV contrast can identify patients eligible for EVT 6 to 24 hours without putting the patient at risk and inform subsequent therapeutic decisions [46,47,52].

MRI is a reasonable complementary examination used in the initial workup of a focal neurological deficit if LVO is excluded by CTA, when there are confounding imaging and clinical variables.

MRV Head Without and With IV Contrast
There is no relevant literature to support the use of MRV of the head in the evaluation of suspected ischemic stroke in the absence of specific suspicion for CVT.

MRV Head Without IV Contrast
There is no relevant literature to support the use of MRV of the head in the evaluation of suspected ischemic stroke in the absence of specific suspicion for CVT.

US Duplex Doppler Carotid Artery
Although sensitive and specific in the detection of extracranial vascular disease, duplex carotid Doppler does not provide the information necessary to determine eligibility for thrombolytics or EVT. US duplex carotid Doppler, which is noninvasive and is accurate in evaluating the degree of carotid stenosis, is a useful test for the evaluation of the extracranial vasculature to determine eligibility for CEA or stenting if this information has not already been obtained from other vascular imaging. [63,64]. Current AHA guidelines recommend noninvasive imaging of the cervical carotid arteries for patients with TIA or minor stroke who are candidates for CEA or stenting, within 48 hours of onset [12].

US Duplex Doppler Transcranial
Transcranial Doppler may be useful, both in the detection of microembolic events and in the detection of intracranial vascular pathology. However, this is typically not an initial imaging test in the setting of stroke due to the poor anatomical delineation of US and potential consequences of delayed treatment in the setting of LVO [39].

Variant 4: Adult. Recent ischemic infarct; greater than 24 hours. Initial imaging.

This variant addresses cases of clinically suspected recent ischemic infarct, although beyond the established and extended stroke windows, that is, >24 hours after symptom onset. Whereas some observational studies suggest benefit [65], no large RCTs have demonstrated the benefit of EVT for LVO strokes after the 24 hour mark. Given the lack of supporting evidence for the usefulness for EVT beyond 24 hours, the urgency of exclusion of stroke due to LVO is largely abated and the workup of a new stroke becomes less urgent. At this stage, imaging is more focused on stroke follow-up and treatment of complications, rehabilitation planning, and secondary prevention [13].

Arteriography Cervicocerebral
Cerebral angiography has the highest spatial resolution and temporal resolution of any vascular study and may detect underlying etiologies in patients presenting with stroke in a delayed fashion beyond 24 hours, which may not be detectable by other modalities, and can potentially help guide management. The usefulness of revascularization for intracranial LVO beyond 24 hours has not been demonstrated by RCT, which reduces the urgency of diagnosis [65]. Moreover, the urgency of diagnosis of many other stroke etiologies detected only by arteriography in the setting of delayed presentation is less well defined beyond 24 hours. Cerebral angiography is typically reserved for diagnoses not excluded by less invasive modalities and even then is of uncertain specificity and sensitivity [66].

CT Head Perfusion With IV Contrast
CT head perfusion imaging may detect an underlying lesion not identified by other imaging modalities in some cases of late presenting with strokes and may identify additional at-risk regions of the brain. Specific instances arise in patients with complete extracranial internal carotid artery occlusion in whom CTP can be used to determine its hemodynamic effect [17]. However, selection of patients with carotid occlusion for revascularization based on hemodynamic compromise does not improve outcome [18]. CTP may be a reasonable examination in the secondary workup of late presenting strokes, but it is not generally a first-line test in this clinical context.

CT Head With IV Contrast
There is no relevant literature to support the use of contrast-enhanced CT of the head in the evaluation of ischemic stroke; in fact, contrast may obscure early complications such as hemorrhage.

CT Head Without and With IV Contrast
There is no relevant literature to support the use of CT of the head without and with IV contrast in the evaluation of ischemic stroke; in fact, contrast may obscure early complications such as hemorrhage.

CT Head Without IV Contrast
Noncontrast CT of the head is essential in the initial evaluation of delayed presenting strokes to evaluate for complications such as hemorrhagic conversion, mass effect, and herniation. Moreover, noncontrast CT is more sensitive for the evaluation of early ischemic changes in late presenting strokes than in the hyperacute setting [67]. Dual-energy CT may play a role in the setting of prior contrast administration for other studies or for prior EVT in evaluating for underlying hemorrhage [68].

CTA Head With IV Contrast
CTA of the head is a rapid and highly sensitive means of evaluating the intracranial vasculature for underlying intracranial atherosclerosis, LVO, and other intracranial steno-occlusive diseases, which may be useful in the management of late presenting strokes, although this is controversial [22,23,69]. However, the urgency of diagnosis of the underlying etiology is less well defined. Moreover, similar information can be obtained from MRA of the head, when there is no need for rapid triage and vascular diagnosis.

CTA Neck With IV Contrast
CTA of the neck is a rapid and highly sensitive means of evaluating the extracranial vasculature underlying carotid stenosis and other steno-occlusive disease of the cervical vasculature, which is useful in the management of late presenting strokes. However, the urgency of diagnosis of the underlying etiology is less well defined. Moreover, similar information can be obtained from MRA of the head, when there is no need for rapid triage and vascular diagnosis. Current AHA guidelines recommend noninvasive imaging of the cervical carotid arteries for patients with minor stroke who are candidates for CEA or stenting, within 24 hours of hospitalization or 48 hours of onset due to the high early risk of recurrent stroke in patients with symptomatic carotid stenosis [12,13].

CTV Head With IV Contrast
There is no relevant literature to support the use of CTV head in the evaluation of ischemic stroke in the absence of suspicion for CVT.

MRA Head Without and With IV Contrast
There is no relevant literature to support the use of contrast-enhanced MRA of the head in the evaluation of ischemic stroke.

MRA Head Without IV Contrast
MRA of the head is a rapid, noninvasive tool, which is useful in the initial workup of late presenting stroke to evaluate for intracranial steno-occlusive disease when there is no indication for urgent EVT, although the clinical value of this information is controversial [22,23,69].

MRA Neck Without and With IV Contrast
MRA of the neck may be useful in screening for extracranial carotid disease. However, MRA of the neck tends to overestimate the degree of carotid stenosis in the absence of contrast administration [70] and is often limited in evaluation of vertebral origin disease due to respiratory motion artifacts [71].

MRA Neck Without IV Contrast
MRA of the neck may be useful in screening for extracranial carotid disease. However, MRA of the neck tends to overestimate the degree of carotid stenosis in the absence of contrast administration [70] and is often limited in evaluation of vertebral origin disease due to respiratory motion artifacts [71].

MRI Head Perfusion With IV Contrast
Contrast-enhanced MRI head perfusion imaging (or, if available, noncontrast ASL perfusion) may detect additional at-risk regions not demonstrated by DWI and aid in identifying the underlying etiology in some patients presenting with stroke beyond the 24-hour period. Specific instances arise in patients with complete extracranial internal carotid artery occlusion in whom MR perfusion can be used to determine its hemodynamic effect [31-33]. However, selection of patients with carotid occlusion for revascularization based on hemodynamic compromise does not improve outcome [18]. Perfusion imaging is not generally considered a first-line test in this clinical context [72,73].

MRI Head Without and With IV Contrast
Rarely, brain tumors or other conditions can mimic ischemic stroke. MRI without and with IV contrast may be helpful in the secondary workup of patients presenting with stroke-like symptoms [62].

MRI Head Without IV Contrast
DWI-MRI and T2-weighted sequences are highly sensitive for ischemic changes in the patient with acute ischemic stroke. Although often performed as part of the initial evaluation of late presenting strokes to delineate the extent of completed ischemic infarct, evaluate potential underlying etiology, and identify any complications, the value of the information provided by MRI over initial CT for improving patient outcome is unclear, as are the circumstances in which it is useful [74-79]. Current AHA guidelines only specify MRI in 2 circumstances: evaluation for wake-up strokes and evaluation for patent foramen ovale closure [12,13].

MRV Head Without and With IV Contrast
There is no relevant literature to support the use of MRV of the head without and with IV contrast in the evaluation of ischemic stroke in the absence of suspicion for CVT.

MRV Head Without IV Contrast
There is no relevant literature to support the use of MRV of the head without IV contrast in the evaluation of ischemic stroke in the absence of suspicion for CVT.

US Duplex Doppler Carotid Artery
Current AHA guidelines recommend noninvasive imaging of the cervical carotid arteries for patients with minor stroke who are candidates for CEA or stenting, within 24 hours of hospitalization or 48 hours of onset due to the high early risk of recurrent stroke in patients with symptomatic carotid stenosis [12,13]. US duplex carotid Doppler is useful for assessing the degree of carotid stenosis in anterior circulation infarcts due to the noninvasive nature of the examination, the high degree of accuracy, and the absence of time pressure of EVT candidacy associated with delayed presenting strokes [38,80]. Carotid Doppler is a highly accurate tool for evaluating for and assessing the degree of carotid stenosis in anterior circulation infarcts, which CTA may overestimate, particularly in the setting of significant carotid calcification [24,38].

US Duplex Doppler Transcranial
Transcranial Doppler may be useful, both in the detection of microembolic events and in the detection of intracranial vascular pathology. However, this is typically not an initial imaging test in the setting of stroke.

Variant 5: Adult. Prior ischemic infarct. Surveillance imaging.

After the initial ischemic injury is defined, identifying the presence of any complications such as hemorrhagic conversion or associated mass effect become the focus of evaluation of recent ischemic infarcts, which are both less emergent than identifying EVT candidates. The extent of the initial ischemic injury plays a key role in defining the risk for delayed complications and the need for and expected duration of ongoing surveillance. Ongoing ischemia or hemorrhagic complication may impact the timeline for initiation of anticoagulant and/or antiplatelet therapy. For large hemispheric or cerebellar infarcts, prolonged observation or early craniectomy may be indicated, which would argue for delaying any preventative measures and/or treatments that pose a risk of operative bleeding [13]. If not previously performed during initial triage, cardiocerebrovascular assessment has a secondary but important clinical role.

Arteriography Cervicocerebral
Cerebral angiography has the highest spatial resolution and temporal resolution of any vascular study and may detect early progression of known steno-occlusive intracranial or cervical atherosclerotic disease before detection on other studies. As such, cerebral angiography may be useful in follow-up imaging in select ischemic strokes, particularly those in which the findings on noninvasive imaging are indeterminate. Cerebral angiography is typically reserved for diagnoses not excluded by less invasive modalities and even then is of uncertain specificity and sensitivity [66].

CT Head Perfusion
CT head perfusion imaging may identify the progression of known underlying intracranial or extracranial atherosclerotic disease, which could predict recurrent or new ischemic events in the future. CTP may be used for surveillance examination in the cases in which known vascular lesions are present. In the absence of a known steno-occlusive lesion, there is no literature to support the use of CTP in surveillance imaging of prior ischemic strokes. In patients with complete extracranial internal carotid artery occlusion in whom CTP can be used to determine its hemodynamic effect [17]. However, selection of patients with carotid occlusion for revascularization based on hemodynamic compromise does not improve outcome [18].

CT Head With IV Contrast
There is no role for IV contrast in the CT evaluation of evolving or subacute infarct. In fact, contrast enhancement within previously undocumented subacute infarcts can paradoxically cause confusion with other more aggressive brain lesions or hemorrhagic conversion of prior infarcts.

CT Head Without and With IV Contrast
There is no role for IV contrast in the CT evaluation of evolving or subacute infarct. In fact, contrast enhancement within previously undocumented subacute infarcts can paradoxically cause confusion with other more aggressive brain lesions or hemorrhagic conversion of prior infarcts.

CT Head Without IV Contrast
Noncontrast CT of the head can be useful in the early surveillance of ischemic strokes to evaluate for complications such as hemorrhagic conversion, mass effect, and herniation when clinically indicated. Moreover, noncontrast CT is more sensitive for the evaluation of the extent of ischemic changes on follow-up imaging of strokes than in the hyperacute setting [67]. In circumstances in which ongoing surveillance is warranted, CT is usually preferred due to its quick repeatability and ease of comparison to prior examinations. Dual-energy CT may play a role in the setting of prior contrast administration for other studies or for prior EVT in evaluating for underlying hemorrhage [68].

CTA Head With IV Contrast
CTA of the head is a rapid means of evaluating the intracranial vasculature for underlying intracranial atherosclerosis and steno-occlusive diseases, although the clinical value of this information is controversial [22,23,69]. Identification of the underlying etiology in the absence of progressive symptoms is less time sensitive than with patients undergoing EVT evaluation. Moreover, similar information can be obtained from MRA of the head without the need for rapid triage and vascular diagnosis. CTA of the head may be indicated in unstable patients presenting with uncertainty or concern for progression of prior ischemic infarcts.

CTA Neck With IV Contrast
CTA of the neck is a rapid means of evaluating the extracranial vasculature underlying carotid stenosis and other steno-occlusive disease of the cervical vasculature, which is useful in the management of late presenting strokes. Current AHA guidelines recommend noninvasive imaging of the cervical carotid arteries for patients with minor stroke who are candidates for CEA or stenting, within 24 hours of hospitalization or 48 hours of onset due to the high early risk of recurrent stroke in patients with symptomatic carotid stenosis [12,13]. In the absence of bilateral disease, carotid Doppler is more accurate in evaluating the degree of carotid stenosis; CTA typically overestimates stenosis, particularly in the setting of dense carotid calcification [24]. In the setting of cryptogenic stroke, CTA may be helpful to diagnose unsuspected carotid webs or other features of unstable plaque [81,82].

CTV Head With IV Contrast
There is no relevant literature to support the use of CTV of the head in the evaluation of ischemic stroke in the absence of suspicion for CVT.

MRA Head Without and With IV Contrast
There is no relevant literature to support the use of contrast-enhanced MRA of the head in the evaluation of ischemic stroke.

MRA Head Without IV Contrast
MRA of the head is a useful initial screening tests for intracranial steno-occlusive disease in the setting of late presenting stroke, owing to the lack of indication for emergent EVT in delayed presenting strokes and relatively rapid noninvasive nature of the examination without the need for IV contrast, although the clinical value of this information is controversial [22,23,69].

MRA Neck Without and With IV Contrast
MRA of the neck may be useful in screening for extracranial carotid disease given the lack of urgency in evaluation of delayed presenting strokes. Current AHA guidelines recommend noninvasive imaging of the cervical carotid arteries for patients with minor stroke who are candidates for CEA or stenting, within 24 hours of hospitalization or 48 hours of onset due to the high early risk of recurrent stroke in patients with symptomatic carotid stenosis [12,13]. Noncontrast MRA of the neck tends to overestimate the degree of carotid stenosis. In the setting of cryptogenic stroke, MRA can be useful to identify unstable plaque or other culprit lesions [83-85].

MRA Neck Without IV Contrast
MRA of the neck may be useful in screening for extracranial carotid disease given the lack of urgency in the evaluation of delayed presenting strokes. Noncontrast MRA of the neck tends to overestimate the degree of carotid stenosis and is often limited in evaluation of vertebral origin disease due to respiratory motion artifacts. Contrast-enhanced MRA may more accurately quantify stenosis and identify ostial stenoses. In the setting of cryptogenic stroke, MRA can be useful to identify unstable plaque or other culprit lesions [83-85].

MRI Head Perfusion With IV Contrast
Contrast-enhanced MRI head perfusion imaging (or, if available, noncontrast ASL perfusion) may detect additional at-risk regions not demonstrated by DWI in some patients presenting with stroke beyond the 24-hour period. In patients with complete extracranial internal carotid artery occlusion in whom MR perfusion can be used to determine its hemodynamic effect [31-33]. However, selection of patients with carotid occlusion for revascularization based on hemodynamic compromise does not improve outcome [18]. However, this procedure is more useful as a problem-solving tool and is not considered standard as surveillance imaging in the setting of prior infarct.

MRI Head Without and With IV Contrast
Rarely, brain tumors or other conditions can mimic ischemic stroke. MRI without and with IV contrast may be helpful in the secondary workup of patients presenting with stroke-like symptoms [62].

MRI Head Without IV Contrast
MRI of the head may be a useful initial test in evaluation of the extent of completed ischemic infarct in the setting of late presenting strokes owing to the relatively rapid noninvasive nature of the examination, the lack of need for IV contrast, and the high sensitivity of DWI for concurrent acute ischemic change. Although often performed as part of the initial evaluation of late presenting strokes to delineate the extent of completed ischemic infarct, evaluate potential underlying etiology, and identify any complications, the value of the information provided by MRI over initial CT for improving patient outcome is unclear, as are the circumstances in which it is useful [74-79]. Current AHA guidelines only specify MRI in 2 circumstances: evaluation for wake-up strokes and evaluation for patent foramen ovale closure [12,13].

MRV Head Without and With IV Contrast
There is no relevant literature to support the use of MRV of the head without and with IV contrast in the evaluation of ischemic stroke in the absence of suspicion for CVT.

MRV Head Without IV Contrast
There is no relevant literature to support the use of MRV of the head without IV contrast in the evaluation of ischemic stroke in the absence of suspicion for CVT.

US Duplex Doppler Carotid Artery

Duplex carotid Doppler is a very useful screening test in the evaluation of the extracranial vasculature for carotid stenosis in delayed presenting strokes, due to the high degree of accuracy in evaluating the degree of carotid stenosis in the absence of multifocal disease and the absence of time pressure of EVT candidacy associated with delayed presenting strokes [38]. Current AHA guidelines recommend noninvasive imaging of the cervical carotid arteries for patients with minor stroke who are candidates for CEA or stenting, within 24 hours of hospitalization or 48 hours of onset due to the high early risk of recurrent stroke in patients with symptomatic carotid stenosis [12,13].

US Duplex Doppler Transcranial

Transcranial Doppler may be useful, both in the detection of microembolic events and in the detection of intracranial vascular pathology. However, this is typically not an initial imaging test in the setting of stroke.

Variant 6: Adult. Known intraparenchymal hemorrhage. No history of trauma. Follow-up imaging study.

IPH may complicate many cerebrovascular and systemic conditions including hypertension, cerebral amyloid angiopathy, coagulopathy, arteriovenous malformation, dural arteriovenous fistula, CVT, cortical venous thrombosis, aneurysm, certain primary central nervous system neoplasms, cerebral hyperperfusion syndromes in the setting of carotid revascularization, metastatic disease, cavernous malformations, prior ischemic infarct, and Moyamoya disease [86]. Hypertensive hemorrhage is the most common etiology for atraumatic IPH and is often supported by clinical history of hypertension and associated imaging findings of a single deep IPH in the basal ganglia, thalamus, pons, or cerebellum. Cerebral amyloid angiopathy is the second most common cause of IPH. Without pathological conformation, it can be diagnosed with acceptable accuracy based on MRI [87]. Diagnostic evaluation of IPH is directed at determining causes for IPH that may require specific interventions beyond supportive care for the IPH itself. These include arteriovenous malformation, dural arteriovenous fistula, CVT, cortical venous thrombosis, aneurysm, central nervous system neoplasms, cerebral hyperperfusion syndromes in the setting of carotid revascularization, metastatic disease, cavernous malformations, and Moyamoya disease. In cases of typical hypertensive hemorrhage or cerebral amyloid angiopathy, additional imaging may not even be warranted [87,88].

This variant focuses on imaging follow-up of patients previously diagnosed with IPH. Patients with IPH may require advanced monitoring or undergo emergent neurosurgical intervention depending on the degree of associated mass effect, edema, and the rate of expansion associated with the hemorrhage. Many potential etiologies for IPH may require both vascular imaging and advanced parenchymal imaging for full evaluation, if not previously performed during initial imaging triage.

Arteriography Cervicocerebral

Catheter-directed arteriography is the reference standard for identifying vascular lesions in patients with IPH. However, catheter angiography is an invasive procedure, and noninvasive vascular imaging studies are typically preferable as first-line vascular imaging once hemorrhage is identified. Catheter angiography is useful to further characterize vascular malformations, particularly if suggested by noninvasive testing. Although CTA and MRI/MRA have a high sensitivity and specificity compared with catheter arteriography (see below), they may miss important lesions. In one series of 89 patients with IPH not in the typical hypertensive locations who had negative CTA and MRI/MRA, catheter arteriography identified 7 arteriovenous malformations and 3 dural arteriovenous fistulas [89]. In the acute period, catheter arteriography may miss vascular lesions that are detected by repeat arteriography several weeks later [90]. In addition, catheter arteriography is usually performed in patients with pure intraventricular hemorrhage, due to the high prevalence of vascular lesions [88].

CT Head Perfusion

In the setting of known IPH, there is no relevant literature to support CTP of the head in follow-up imaging. CTP of the head may be useful in the subsequent evaluation for underlying etiologies that may be associated with hyperperfusion, including recent carotid revascularization, hypervascular tumors, prior ischemic strokes, and underlying arteriovenous shunt lesions if not apparent on other imaging studies, and is particularly useful when MRI may be limited due to susceptibility-associated artifacts due to hemorrhage. Recommendations for imaging in the setting of suspected aneurysm, arteriovenous shunt lesion, or vasculitis are guided by the ACR Appropriateness Criteria® topic on "Cerebrovascular Diseases-Aneurysm, Vascular Malformation, and Subarachnoid Hemorrhage" [5].

CT Head With IV Contrast
Contrast-enhanced CT is typically not helpful in the setting of typical hypertensive hemorrhage or in serial follow-up, except in cases in which underlying metastatic disease is suspected and MRI is not feasible for a specific patient.

CT Head Without and With IV Contrast
Contrast-enhanced CT is typically not helpful in the setting of typical hypertensive hemorrhage or in serial follow-up, except in cases in which underlying metastatic disease is suspected and MRI is not feasible for a specific patient.

CT Head Without IV Contrast
In the setting of IPH, noncontrast CT examinations of the head is essential, both for the initial diagnosis and, if clinically indicated, for follow-up examinations to evaluate for expansion and worsening mass effect. Additional noncontrast CT imaging may not be warranted when the patient is stable.

CTA Head With IV Contrast
In the setting of IPH, CTA is useful in the follow-up evaluation of the underlying etiology. CTA has a reported sensitivity and specificity exceeding 90% compared with catheter arteriography for the identification of culprit vascular lesions such as aneurysms or arteriovenous malformations [91-94]. This can be helpful when determining disposition as some facilities may not be able to handle all types of ICH. Additionally, the presence or absence of a CTA spot sign in intracerebral hemorrhage may be useful in prognosis [95]. Recommendations for imaging in the setting of suspected aneurysm, arteriovenous shunt lesion, or vasculitis are guided by the ACR Appropriateness Criteria® topic on "Cerebrovascular Diseases-Aneurysm, Vascular Malformation, and Subarachnoid Hemorrhage" [5].

CTA Neck With IV Contrast
In the setting of IPH, CTA of the neck is not supported by the literature. CTA of the neck may be useful for treatment planning when endovascular management is expected.

CTV Head With IV Contrast
In the setting of typical hypertensive hemorrhage, there is no relevant literature to support CTV of the head. However, CTV of the head may be useful to exclude CVT as a potential etiology. Imaging features on noncontrast CT suggesting venous infarction with hemorrhage may include atypical distributions not matching arterial vascular territories, infarcts with cortical sparing, typical parasagittal or temporoparietal location, or dural venous/cortical venous hyperdensity suggestive of thrombus. For further discussion of the evaluation of CVT, see Variant 7.

MRA Head Without and With IV Contrast
There is a limited role for MRA of the head with IV contrast except when dynamic imaging is performed, such as in the setting of known arteriovenous malformations.

MRA Head Without IV Contrast
In the setting of typical hypertensive hemorrhage, there is no relevant literature to support MRA of the head. However, MRA of the head may be useful in advanced workups to exclude underlying vascular malformations if the etiology is uncertain. In a 2014 review, MRA had a reported sensitivity and specificity exceeding 90% compared with catheter arteriography for detecting intracranial vascular malformations [93]. More recently, MRA was shown to be useful in identifying macrovascular causes such of IPH as aneurysms or arteriovenous malformations [95].

MRA Neck Without and With IV Contrast
In the setting of IPH, MRA of the neck is not supported by the literature. MRA of the neck may be useful for treatment planning when endovascular management is expected.

MRA Neck Without IV Contrast
In the setting of IPH, MRA of the neck is not supported by the literature. MRA of the neck may be useful for treatment planning when endovascular management is expected.

MRI Head Perfusion With IV Contrast
In the setting of typical hypertensive hemorrhage, there is no relevant literature to support MRI perfusion of the head as a follow-up imaging study. MRI perfusion of the head may be useful in evaluating for secondary etiologies such as hyperperfusion associated with carotid revascularization, tumors, prior ischemic strokes, arteriovenous shunt lesions, or other cerebrovascular malformations, particularly if clinically suspected or suggested on prior imaging. Recommendations for imaging in the setting of suspected aneurysm, arteriovenous shunt lesion, or

vasculitis are guided by the ACR Appropriateness Criteria® topic on "Cerebrovascular Diseases-Aneurysm, Vascular Malformation, and Subarachnoid Hemorrhage" [5].

MRI Head Without and With IV Contrast
MRI of the head is a useful test for evaluating alternative etiologies in patients <55 years of age who do not have typical hypertensive hemorrhage [96]. MRI without and with IV contrast can be useful in evaluating for cerebral amyloid angiopathy, tumor, vasculitis, dural venous sinus thrombosis, vascular shunt lesions, and in further characterizing other etiologies seen on noncontrast imaging [97,98].

MRI Head Without IV Contrast
MRI of the head is a useful test for evaluating alternative etiologies when the diagnosis of hypertensive hemorrhage is in doubt. Noncontrast MRI can exclude stroke and may suggest certain etiologies including cerebral amyloid angiopathy and cavernous malformations [97,98].

MRV Head Without and With IV Contrast
In the setting of typical hypertensive hemorrhage, there is no relevant literature to support MRV of the head. However, MRV of the head may be useful to exclude CVT as an etiology, particularly if suggested by features of hemorrhage on initial CT imaging or the diagnosis is in doubt based on contrast-enhanced MRI.

MRV Head Without IV Contrast
In the setting of typical hypertensive hemorrhage, there is no relevant literature to support MRV of the head. However, MRV of the head may be useful to exclude CVT as an etiology, particularly if suggested by features of hemorrhage on initial CT imaging or the diagnosis is in doubt based on contrast-enhanced MRI.

US Duplex Doppler Carotid Artery
In the setting of IPH, US duplex Doppler carotid of the neck is not supported by the literature.

US Duplex Doppler Transcranial
In the setting of suspected hypertensive hemorrhage, there is no relevant literature to support transcranial Doppler.

Variant 7: Adult. Suspected venous sinus thrombosis. Initial imaging.

CVT is an uncommon cause for stroke, accounting for approximately 1% to 2% of all strokes [99]. The patients often have hypercoagulable risk factors (cancer, recent oral contraceptive use, and pregnancy) and may present with headaches, seizures, or decreased level of consciousness due to either venous ischemic or hemorrhagic complications. Unlike other stroke etiologies, the presence of ICH is often not a contraindication to anticoagulation but necessitates serial assessment for hematoma expansion in this patient population. Venous infarction and hemorrhage may complicate venous thrombosis, particularly cortical venous thrombosis. Imaging features suggesting venous infarction with hemorrhage may include atypical distributions not matching arterial vascular territories, infarcts with cortical sparing, typical parasagittal or temporoparietal location, or dural venous/cortical venous hyperdensity on noncontrast CT suggestive of thrombus.

Arteriography Cervicocerebral
Catheter-directed cerebral angiography and runoff venography are infrequently necessary in the setting of dural venous sinus thrombosis due to the sensitivity and specificity of CTV and MRV. In the setting of progressive infarct despite adequate medical therapy, catheter-directed angiography and venography may be useful to assess potential endovascular treatment targets.

CT Head Perfusion With IV Contrast
Some studies demonstrate a possible role for perfusion imaging in prognostic evaluation of the ischemic penumbra in the setting of CVT [100]. However, perfusion imaging is typically a follow-up imaging study after the diagnosis of CVT. Moreover, the requirement for iodinated contrast may limit use of CTP in patients with acute or severe chronic renal insufficiency.

CT Head With IV Contrast
Contrast-enhanced CT is less commonly performed than CTV in initial screening but may demonstrate the thrombus in the form of the "empty delta sign" in some cases.

CT Head Without and With IV Contrast
Contrast-enhanced CT is less commonly performed than CTV in initial screening but may demonstrate the thrombus in the form of the "empty delta sign" in some cases. There is no relevant literature to support the use of CT of the

head without and with IV contrast specifically for the evaluation of venous sinus thrombosis unless noncontrast CT is otherwise indicated for parenchymal assessment.

CT Head Without IV Contrast
Noncontrast CT of the head is essential in the initial evaluation of CVT. The primary usefulness of noncontrast CT of the head in the initial evaluation of CVT is to evaluate for hemorrhagic complication and alternative etiologies. Noncontrast CT may show sinus hyperdensity. However, only 30% of noncontrast head CT examinations are abnormal in the setting of CVT [99].

CTA Head With IV Contrast
CTA of the head may be useful in the exclusion of alternative etiologies in the setting of IPH in the setting of CVT. For a discussion of cerebrovascular diseases that may present alternatives to the diagnosis of CVT, please see the ACR Appropriateness Criteria® topic on "Cerebrovascular Diseases-Aneurysm, Vascular Malformation, and Subarachnoid Hemorrhage" [5]. Depending on the contrast bolus timing, CTA may also diagnose CVT. However, in the absence of concern for an alternative diagnosis, there is no relevant literature to support the use of CTA of the head in the initial evaluation of CVT.

CTA Neck With IV Contrast
There is no relevant literature to support the use of CTA of the neck in the initial evaluation of CVT. CTA of the neck may be useful for endovascular surgical planning for venous sinus thrombectomy, if clinically relevant.

CTV Head With IV Contrast
CTV of the head is a useful, rapid initial evaluation with a high sensitivity and specificity for detection of CVT. CT is particularly useful when MRI is contraindicated or when MRI artifacts are suspected that could obscure the diagnosis. Specifically, CTV is as accurate in diagnosis of CVT as MRV [101].

MRA Head Without and With IV Contrast
There is no relevant literature to support the use of MRA of the head in the initial evaluation of CVT.

MRA Head Without IV Contrast
There is no relevant literature to support the use of MRA of the head in the initial evaluation of CVT.

MRA Neck Without and With IV Contrast
There is no relevant literature to support the use of MRA of the neck in the initial evaluation of CVT.

MRA Neck Without IV Contrast
There is no relevant literature to support the use of MRA of the neck in the initial evaluation of CVT.

MRI Head Perfusion With IV Contrast
Some studies demonstrate a possible role for perfusion imaging in prognostic evaluation of the ischemic penumbra in the setting of CVT [100]. Although perfusion imaging is not the most appropriate initial imaging study, ASL perfusion is often acquired with conventional brain MRI as part of the diagnostic workup.

MRI Head Without and With IV Contrast
MRI of the head is a useful initial examination in the workup of CVT. MRI of the head is useful not only for evaluation of the extent of cytotoxic and vasogenic edema but also in the initial detection of petechial hemorrhage and the actual thrombus in many cases. Contrast is not always required for structural brain imaging but adds to the overall MRI evaluation of venous sinus thrombosis [102] and is commonly administered when MRI is performed together with MRV. Noncontrast black blood thrombus imaging may approach the accuracy of contrast-enhanced MRV and negate the need for either MRV or contrast-enhanced examination, but it is less well-validated in clinical practice [103].

MRI Head Without IV Contrast
MRI of the head is a useful initial examination in the workup of CVT. MRI of the head is useful not only for evaluation of the extent of cytotoxic and vasogenic edema but also in the initial detection of petechial hemorrhage and the actual thrombus in many cases. Contrast is not always required for structural brain imaging but adds to the overall MRI evaluation of venous sinus thrombosis [102] and is commonly administered when MRI is performed together with MRV. Noncontrast black blood thrombus imaging may approach the accuracy of contrast-enhanced MRV and negate the need for either MRV or contrast-enhanced examination, but it is less well-validated in clinical practice [103].

MRV Head Without and With IV Contrast
MRV of the head along with MRI of the head is an essential component of the workup of CVT in most cases. The MRV of the head is useful for confirming the presence of thrombus and ideally consists of both noncontrast TOF and contrast-enhanced MRV. Although contrast-enhanced venography is the most accurate means of assessment for CVT [104], contrast-enhanced and TOF MRV imaging techniques are complementary in that a contrast-enhanced MRV may provide a better assessment of a hypoplastic dural venous sinus with slow flow and TOF MRV mitigates against T1 isointense thrombus, which may mimic normal opacification of the sinus on contrast-enhanced MRV. Additionally, T1 hyperintense thrombus can mimic normal flow and enhancement patterns, which necessitates evaluation with noncontrast MRI. Volumetric MRI sequences are essential for contrast-enhanced MRV. Delayed postcontrast imaging can further increase the sensitivity for detection of T1 isointense thrombus.

MRV Head Without IV Contrast
MRV of the head along with MRI of the head is an essential component of the workup of CVT in most cases. Although contrast-enhanced venography is the most accurate means of assessment for CVT [104], TOF and phase-contrast MRV are noncontrast alternatives for the diagnosis of CVT. If the findings on noncontrast MRV are unclear, then further imaging with contrast-enhanced CTV or MRV should be considered.

US Duplex Doppler Carotid Artery
There is no relevant literature to support the use of carotid Doppler in the setting of CVT. However, US assessment of the adjacent venous structures could yield useful information about the extent of the thrombus if extending into the neck.

US Duplex Doppler Transcranial
There is no relevant literature to support the use of transcranial Doppler in the setting of CVT.

Variant 8: Adult. Known venous sinus thrombosis. Surveillance imaging.

CVT is an uncommon cause for stroke, accounting for approximately 1% to 2% of all strokes [99]. The patients often have hypercoagulable risk factors (cancer, recent oral contraceptive use, and pregnancy) and may present with headaches, seizures, or decreased level of consciousness due to either venous ischemic or hemorrhagic complications. Unlike other stroke etiologies, the presence of ICH is often not a contraindication to anticoagulation but necessitates serial assessment for hematoma development and/or expansion in the acute and early subacute phases in this patient population. An early follow-up is recommended in patients with CVT with persistent or evolving symptoms despite medical treatment or with symptoms suggestive of propagation of thrombus. In patients with previous CVT who present with recurrent symptoms suggestive of CVT, repeat imaging is also recommended. Serial follow-up at 3 to 6 months after diagnosis is used to assess for recanalization of the occluded cortical vein/sinuses in stable patients. However, recommendations for duration of anticoagulation are not based on the presence or absence of recanalization [99,105]. In the delayed setting, CVT may be complicated by dural arteriovenous fistula, which may necessitate delayed arterial imaging.

For a discussion of cerebrovascular diseases related to high flow arteriovenous fistulas that may develop after CVT, please see the ACR Appropriateness Criteria® topic on "Cerebrovascular Diseases-Aneurysm, Vascular Malformation, and Subarachnoid Hemorrhage" [5].

Arteriography Cervicocerebral
Catheter-directed cerebral angiography and venography are infrequently necessary in the setting of dural venous sinus thrombosis due to the sensitivity and specificity of CTV and MRV. In the setting of progressive infarct despite adequate medical therapy, catheter-directed angiography and venography may be useful for the identification of endovascular treatment targets or definitive evaluation for dural arteriovenous fistula development, which may complicate CVT.

CT Head Perfusion With IV Contrast
Some studies demonstrate a possible role for perfusion imaging in prognostic evaluation of the ischemic penumbra in the setting of CVT [100]. In ongoing surveillance, however, the role for perfusion imaging is limited.

CT Head With IV Contrast
Contrast-enhanced CT is less commonly performed in surveillance imaging but may demonstrate the thrombus in the form of the "empty delta sign" in some cases, which may allow for assessment of the extent of thrombus. When focused on clot extent, dedicated venous vascular imaging is typically more useful.

CT Head Without and With IV Contrast

Contrast-enhanced CT is less commonly performed in surveillance imaging but may demonstrate the thrombus in the form of the "empty delta sign" in some cases, which may allow for assessment of the extent of thrombus. When focused on clot extent, dedicated venous vascular imaging is typically more useful.

CT Head Without IV Contrast

Serial follow-up noncontrast CT of the head is useful in the patient with persistent or evolving symptoms despite medical treatment or with symptoms suggestive of propagation of thrombus. This is particularly useful in the late acute and subacute phases following initial presentation. Noncontrast CT may show sinus hyperdensity, which may be useful in early evaluation of thrombus extent; however, only 30% of noncontrast head CT examinations are abnormal in the setting of CVT [99].

CTA Head With IV Contrast

Although CTA of the head may be capable of characterizing CVT depending on contrast bolus timing, there is no relevant literature to support the use of CTA of the head in the setting of known CVT. However, CTA of the head may diagnose delayed formation of arteriovenous shunt lesions. For a discussion of cerebrovascular diseases related to high flow arteriovenous fistulas that may complicate CVT, please see the ACR Appropriateness Criteria® topic on "Cerebrovascular Diseases-Aneurysm, Vascular Malformation, and Subarachnoid Hemorrhage" [5].

CTA Neck With IV Contrast

There is no relevant literature to support the use of CTA of the neck in the setting of known CVT.

CTV Head With IV Contrast

In the setting of known CVT, CTV of the head may be useful in assessing thrombus burden; however, there are no data to support its use in determining the duration of anticoagulation. CTV is as accurate in evaluation of CVT as MRV [101,106]. CTV has high spatial resolution and is not affected by typical MRI artifacts that may complicate thrombus imaging. CTV may be useful when MRV is degraded and accurate measurement of thrombus extent is desired or when thrombus involves hypoplastic dural sinuses or cortical branches.

MRA Head Without and With IV Contrast

There is no relevant literature to support the use of contrast-enhanced MRA of the head in the setting of known CVT.

MRA Head Without IV Contrast

There is no relevant literature to support the use of MRA of the head in the setting of known CVT. For a discussion of cerebrovascular diseases related to high flow arteriovenous fistulas that may complicate CVT, please see the ACR Appropriateness Criteria® topic on "Cerebrovascular Diseases-Aneurysm, Vascular Malformation, and Subarachnoid Hemorrhage" [5].

MRA Neck Without and With IV Contrast

There is no relevant literature to support the use of MRA of the neck in the setting of known CVT.

MRA Neck With IV Contrast

There is no relevant literature to support the use of MRA of the neck in the setting of known CVT.

MRI Head Perfusion With IV Contrast

Some studies demonstrate a possible role for perfusion imaging in prognostic evaluation of the ischemic penumbra in the setting of known CVT [100]. CTP is not typically performed, however, in ongoing surveillance imaging in the absence of changes in clinical status.

MRI Head Without and With IV Contrast

MRI of the head is useful in the ongoing evaluation of CVT in evaluating for progressive ischemic and hemorrhagic venous infarct. Contrast is not always required for structural brain imaging but adds to the overall MRI evaluation of venous sinus thrombosis [102] and is commonly administered when MRI is performed together with MRV. Delayed postcontrast imaging can further improve assessment of T1 hyperintense thrombus burden. Noncontrast black blood thrombus imaging may approach the accuracy of contrast-enhanced MRV and negate the need for either MRV or contrast-enhanced examination, but it is less well-validated in clinical practice [103].

MRI Head Without IV Contrast

MRI of the head is useful in the ongoing evaluation of CVT in evaluating for progressive ischemic and hemorrhagic venous infarct. Contrast is not always required for structural brain imaging but adds to the overall MRI evaluation of venous sinus thrombosis [102] and is commonly administered when MRI is performed together with MRV. Delayed postcontrast imaging can further improve assessment of T1 hyperintense thrombus burden. Noncontrast black blood thrombus imaging may approach the accuracy of contrast-enhanced MRV and negate the need for either MRV or contrast-enhanced examination, but it is less well-validated in clinical practice [103].

MRV Head Without and With IV Contrast
Although contrast-enhanced venography is the most accurate means of assessment for CVT, contrast-enhanced and TOF MRV imaging techniques are complementary, in that a contrast-enhanced MRV may provide a better assessment of a hypoplastic dural venous sinus with slow flow and TOF MRV mitigates against T1 isointense thrombus, which may mimic a normal opacification of the sinus on contrast-enhanced MRV [104]. Additionally, T1 hyperintense thrombus can mimic normal flow and enhancement patterns, which necessitates evaluation with noncontrast MRI imaging. Volumetric MRI sequences are essential for contrast-enhanced MRV. Delayed postcontrast imaging can further increase the sensitivity for detection of T1 isointense thrombus.

MRV Head Without IV Contrast
Although contrast-enhanced venography is the most accurate means of assessment for CVT [104], TOF and phase-contrast MRV are noncontrast alternatives for the diagnosis of CVT. If the findings on noncontrast MRV are unclear, then further imaging with contrast-enhanced CTV or MRV should be considered.

US Duplex Doppler Carotid Artery
There is no relevant literature to support the use of carotid Doppler in the setting of CVT. However, US assessment of the adjacent venous structures could yield useful information about the extent of the thrombus if extending into the neck.

US Duplex Doppler Transcranial
There is no relevant literature to support the use of transcranial Doppler in the setting of CVT.

Variant 9: Adult. Asymptomatic cervical bruit. Initial imaging.

Cervical carotid bruit is an important diagnostic sign of potential underlying carotid stenosis because patients with carotid bruit are >50% more likely to harbor hemodynamically significant internal carotid stenosis. Although the advent of electronic auscultation has driven the negative predictive value to an all-time high, the positive predictive value is now at an all-time low, in the 30% range, which increases the importance of radiographic evaluation following detection of carotid bruit [107]. In the patient with recent TIA or minor stroke who is a candidate for CEA or stenting, the presence or absence of carotid bruit does not alter the necessity or urgency of evaluating the degree of carotid stenosis (see Variants 1-5). For asymptomatic patients, advances in medical therapy have rendered data from older clinical trials on the benefit of endarterectomy out of date, and thus the value of determining the degree of stenosis in these patients is less clear and currently the subject of a large randomized clinical trial [108-110]. Currently, guidelines from professional societies continue to recommend CEA for certain selected patients with asymptomatic stenosis in which the degree of stenosis is an important deciding factor [111,112].

Arteriography Cervicocerebral
Catheter-directed cerebral angiography has the highest spatial resolution and temporal resolution of any vascular study. Catheter-directed angiography is the most accurate means of delineating the degree of vascular stenosis and can also be useful in the evaluation of collateral circulation. However, the usefulness of this technique for screening is obviated by the invasive nature of the examination. Moreover, there is no literature supporting cerebral angiography as the initial imaging test in evaluation of a carotid bruit. Nonetheless, cerebral angiography may be necessary in some cases after the initial diagnosis of hemodynamically significant carotid stenosis is made on noninvasive imaging.

CT Head Perfusion With IV Contrast
CT head perfusion imaging may help delineate the hemodynamic significance of a known carotid lesion and the collateral support in each distribution. However, there is no literature to support the use of CTP for the initial detection of hemodynamically significant carotid disease in the asymptomatic patient with a carotid bruit.

CT Head With IV Contrast
There is no relevant literature to support the use of contrast-enhanced CT of the head in the evaluation of the asymptomatic patient with a carotid bruit.

CT Head Without and With IV Contrast
There is no relevant literature to support the use of contrast-enhanced CT of the head in the evaluation of the asymptomatic patient with a carotid bruit.

CT Head Without IV Contrast
There is no literature to support noncontrast CT of the head in the initial workup of the asymptomatic patient with a carotid bruit. Noncontrast CT of the head is useful in evaluating for the sequela of known asymptomatic carotid stenosis such as clinically silent strokes or microvascular ischemic changes. However, MRI is much more sensitive in evaluating microvascular ischemic changes or recent strokes. Symptomatic carotid disease should be evaluated relative to the underlying symptoms. Please see Variants 1 to 5 for a discussion of appropriate imaging.

CTA Head With IV Contrast
CTA of the head may be useful in treatment planning for patients with an established diagnosis of asymptomatic carotid stenosis. However, there is no literature to support CTA of the head in the initial workup for the asymptomatic patient with a carotid bruit.

CTA Neck With IV Contrast
CTA of the neck is useful in the initial workup of the asymptomatic patient with a carotid bruit owing to the anatomic assessment of stenosis as well as status of the other cervical vessels. Specifically, CTA of the neck is helpful when multivessel cerebrovascular disease or very severe stenosis is present, which might result in artifactual over or underestimation of the degree of disease by carotid Doppler, respectively [113]. CTA of the neck is also useful for treatment planning [114]. However, CTA of the neck may also underestimate the degree of stenosis in the setting of tortuosity or calcifications similar in density to contrast media [24]. Conversely, CTA may overestimate stenosis in the setting of very severe near occlusive stenosis [115]. Dual-energy CT may help limit overestimation of stenosis in some instances [116]. However, the requirement for iodinated contrast detracts from this examination in comparison to Doppler and MRA.

CTV Head With IV Contrast
There is no relevant literature to support the use of CTV of the head in the evaluation of the asymptomatic patient with a carotid bruit.

MRA Head Without and With IV Contrast
There is no relevant literature to support the use of contrast-enhanced MRA of the head in the evaluation of the asymptomatic patient with a carotid bruit.

MRA Head Without IV Contrast
There is no literature to support MRA of the head in the initial workup of the asymptomatic patient with a carotid bruit. MRA of the head may be useful in treatment planning for patients with an established diagnosis of carotid stenosis. Intracranial collateral characterization may be important when considering proximal embolic protection strategies.

MRA Neck Without and With IV Contrast
MRA of the neck is useful in the initial workup of the asymptomatic patient with a carotid bruit owing to the anatomic assessment of stenosis, which will limit both false-positives and false-negatives. Specifically, MRA of the neck is helpful when multivessel cerebrovascular disease or very severe stenosis is present, which might result in artifactual over- or underestimation of the degree of disease by carotid Doppler, respectively [113]. Noncontrast MRA of the neck may overestimate the degree of stenosis when severe and/or near occlusive. Contrast administration can reduce the degree of overestimation of the degree of stenosis in some cases. However, contrast-enhanced MRA of the neck has a similar sensitivity for the detection of >70% stenosis of the carotid when 2-D and 3-D techniques of TOF are combined [27,117]. MRA of the neck may also be useful for treatment planning. However, the anatomic definition of the surrounding structures may be inadequate for treatment planning in some cases depending on the sequences used [114]. Additionally, composition of carotid plaque including intraplaque hemorrhage on magnetization-prepared rapid acquisition gradient echo images can be useful predictors of future stroke risk, beyond assessing the degree of luminal narrowing [118,119].

MRA Neck Without IV Contrast
MRA of the neck is useful in the initial workup of the asymptomatic patient with a carotid bruit owing to the anatomic assessment of stenosis, which will limit both false-positives and false-negatives. Specifically, MRA of the neck is helpful when multivessel cerebrovascular disease or very severe stenosis is present, which might result

in artifactual over or underestimation of the degree of disease by carotid Doppler, respectively [113]. Noncontrast MRA of the neck may overestimate the degree of stenosis when severe and/or near occlusive. Contrast administration can reduce the degree of overestimation of the degree of stenosis in some cases. However, contrast-enhanced MRA of the neck has a similar sensitivity for the detection of >70% stenosis of the carotid when 2-D and 3-D techniques of TOF are combined [27,117]. MRA of the neck may also be useful for treatment planning. However, the anatomic definition of the surrounding structures may be inadequate for treatment planning in some cases depending on the sequences used [114]. Additionally, composition of carotid plaque including intraplaque hemorrhage on magnetization-prepared rapid acquisition gradient echo images can be useful predictors of future stroke risk, beyond assessing the degree of luminal narrowing [118,119].

MRI Head Perfusion With IV Contrast

Contrast-enhanced MRI head perfusion imaging (or, if available, noncontrast ASL perfusion) may help delineate the hemodynamic significance of a known asymptomatic carotid lesion and the collateral support in each distribution. However, there is no literature to support the use of MRI perfusion in the initial evaluation of the asymptomatic patient with a carotid bruit.

MRI Head Without and With IV Contrast

There is no relevant literature to support the use of contrast-enhanced MRI of the head in the evaluation of the asymptomatic patient with a carotid bruit.

MRI Head Without IV Contrast

There is no literature to support MRI of the head in the initial workup for the asymptomatic patient with a carotid bruit. MRI of the head is useful in evaluating for the sequela of carotid stenosis such as clinically silent strokes or microvascular ischemic changes in the setting of an established diagnosis of asymptomatic carotid stenosis.

MRV Head Without and With IV Contrast

There is no relevant literature to support the use of MRV of the head in the evaluation of the asymptomatic patient with a carotid bruit.

MRV Head Without IV Contrast

There is no relevant literature to support the use of MRV of the head in the evaluation of the asymptomatic patient with a carotid bruit.

US Duplex Doppler Carotid Artery

Duplex carotid Doppler is a very accurate and useful screening test in the evaluation of the extracranial vasculature for carotid stenosis in the asymptomatic patient with a carotid bruit, which stratifies patients into groups of mild (<50%), moderate (50%-69%), and severe (>70%) stenosis. Specifically, carotid Doppler has a 90% sensitivity and a 94% specificity in the identification of clinically significant >70% stenosis, which might warrant surgical intervention [111,112,120]. The lack of need for IV contrast decreases the risk to the patient. However, caution must be observed when evaluating patients with either extremely severe stenosis or multivessel involvement because Doppler can overestimate the degree of stenosis in the setting of contralateral disease or multivessel disease or underestimate the stenosis in the setting of critical high-grade stenosis, which may result in artifactual elevation of velocity or reduction in velocity, respectively. Clinically significant carotid disease may trigger further anatomic imaging to characterize stenosis and exclude confounding multivessel disease; however, there is no consensus on this matter. In otherwise uncomplicated cases, US imaging alone may be the only necessary examination in a patient with carotid bruit.

US Duplex Doppler Transcranial

Transcranial Doppler may be useful, both in the detection of microembolic events and in determining the hemodynamic significance of a known carotid stenosis. However, there is no literature to support transcranial Doppler in the initial workup of the asymptomatic patient with a carotid bruit.

Variant 10: Adult. Asymptomatic carotid stenosis. Surveillance imaging.

Asymptomatic carotid stenosis is an important diagnostic finding, which may progress to symptomatic stenosis. For asymptomatic patients, advances in medical therapy have rendered data from older clinical trials on the benefit of endarterectomy out of date, and thus the value of determining the degree of stenosis in these patients is less clear and currently the subject of a large randomized clinical trial [108-110]. Currently, guidelines from professional societies continue to recommend CEA for certain selected patients with asymptomatic stenosis in which the degree of stenosis is an important deciding factor [111,112]. Surveillance imaging is an important tool in the management of asymptomatic carotid stenosis. From a management prospective, carotid stenosis is divided into 3 categories based on the degree of stenosis including mild (<50%), moderate (50%-69%), and severe (>70%) stenosis, with the latter 2 categories having a higher probability of hemodynamic significance subsequent ipsilateral stroke [121,122]. The risk for progression of carotid stenosis is poorly characterized. In small case-controlled studies, the risk of mild or moderate stenosis to progress is between 30% and 40% within the ensuing 3 years [123]. The type of surveillance imaging indicated is informed by the degree of stenosis and, thereby, concern of the hemodynamic significance of the stenosis. In most cases, surveillance imaging of asymptomatic carotid disease focuses on the area of stenosis guided by the character of the stenosis and presence of involvement of the other cerebrovascular territories. However, if hemodynamically significant stenosis is suspected, parenchymal imaging, physiologic imaging, and invasive imaging may be useful to guide management of asymptomatic carotid disease [112]. For symptomatic carotid disease, please see Variants 1 to 5 for indicated imaging procedures.

Arteriography Cervicocerebral
Catheter-directed cerebral angiography has the highest spatial resolution and temporal resolution of any vascular study. Catheter-directed angiography accurately measures the degree of vascular stenosis and can also be useful in the evaluation of collateral circulation. However, the usefulness of this technique for surveillance imaging is obviated by the invasive nature of the examination and availability of both sensitive and specific noninvasive tests. Although cerebral angiography is not used as routine surveillance imaging for asymptomatic carotid disease, angiography can be useful in some cases of known, hemodynamically significant stenosis to determine appropriate treatment options.

CT Head Perfusion With IV Contrast
CT head perfusion imaging may help delineate the hemodynamic significance of a known asymptomatic carotid lesion and the collateral support in each distribution. More specifically, perfusion imaging may be helpful in cases of moderate stenosis, approaching 70% or severe stenosis [124]. However, there is no literature to support the use of CTP as the initial imaging test in surveillance imaging of asymptomatic carotid disease. The need for IV contrast and relative lack of sensitivity for white matter ischemic changes detracts from the routine use of this study in surveillance imaging.

CT Head With IV Contrast
There is no relevant literature to support the use of contrast-enhanced CT of the head in the surveillance imaging of asymptomatic carotid stenosis.

CT Head Without and With IV Contrast
There is no relevant literature to support the use of contrast-enhanced CT of the head in the surveillance imaging of asymptomatic carotid stenosis.

CT Head Without IV Contrast
There is no literature to support noncontrast CT of the head in the routine surveillance imaging of asymptomatic carotid disease. Noncontrast CT of the head is useful in evaluating for the sequela of carotid stenosis such as clinically silent strokes or microvascular ischemic changes in the setting of an established diagnosis of carotid stenosis, which is particularly important in cases of hemodynamically significant stenosis. However, MRI is much more sensitive in evaluating microvascular ischemic changes or recent strokes. Symptomatic carotid disease should be evaluated relative to the underlying symptoms. Please see Variants 1 to 5 for a discussion of appropriate imaging.

CTA Head With IV Contrast
There is no literature to support CTA of the head in routine surveillance imaging of known asymptomatic carotid disease with no future treatment plans. CTA of the head may be useful in treatment planning for patients with an established diagnosis of hemodynamically significant asymptomatic carotid stenosis. Specifically, intracranial collateral characterization may be important when considering both the initial decision to treat and treatment involving proximal embolic protection strategies.

CTA Neck With IV Contrast
CTA of the neck is useful in the surveillance imaging of some patients with asymptomatic carotid stenosis owing to the anatomic assessment of stenosis. Specifically, CTA of the neck is helpful when multivessel cerebrovascular disease or very severe stenosis is present, which might result in artifactual over or underestimation of the degree of disease by carotid Doppler, respectively [113]. CTA of the neck is also useful for treatment planning [114]. However, CTA of the neck may also underestimate the degree of stenosis in the setting of tortuosity or calcifications similar in density to contrast media [80]. Conversely, CTA may overestimate stenosis in the setting of very severe

near occlusive stenosis [115]. Dual-energy CT may help limit the overestimation of stenosis in some instances [116].

CTV Head With IV Contrast
There is no relevant literature to support the use of CTV of the head in the surveillance imaging of asymptomatic carotid stenosis.

MRA Head Without and With IV Contrast
There is no relevant literature to support the use of contrast-enhanced MRA of the head in the surveillance imaging of asymptomatic carotid stenosis.

MRA Head Without IV Contrast
There is no literature to support MRA of the head as in ongoing routine surveillance imaging of known asymptomatic carotid disease. MRA of the head may be useful in treatment planning for patients with an established diagnosis of asymptomatic carotid stenosis. Specifically, intracranial collateral characterization may be important when considering both the initial decision to treat and treatment involving proximal embolic protection strategies.

MRA Neck Without and With IV Contrast
MRA of the neck is useful in the surveillance imaging of some patients with asymptomatic carotid stenosis owing to the anatomic assessment of stenosis and can be useful for treatment planning. Specifically, MRA of the neck is helpful when multivessel cerebrovascular disease or very severe stenosis is present, which might result in artifactual over or underestimation of the degree of disease by carotid Doppler, respectively [113]. Noncontrast MRA of the neck may overestimate the degree of stenosis when severe and/or near occlusive. Contrast administration can reduce the degree of overestimation of the degree of stenosis in some cases. However, contrast-enhanced and TOF MRA of the neck have similar sensitivity for the detection of >70% stenosis of the carotid when 2-D and 3-D techniques of TOF are combined [27,117]. MRA of the neck may also be useful for treatment planning. However, the anatomic definition of the surrounding structures may be inadequate for treatment planning in some cases depending on the sequences used [114]. Additionally, anatomical features of carotid plaque including intraplaque high-intensity signal on 3-D TOF source images can be useful predictors of future stroke risk, beyond assessing the degree of luminal narrowing [85,118,119].

MRA Neck Without IV Contrast
MRA of the neck is useful in the surveillance imaging of some patients with asymptomatic carotid stenosis owing to the anatomic assessment of stenosis and can be useful for treatment planning. Specifically, MRA of the neck is helpful when multivessel cerebrovascular disease or very severe stenosis is present, which might result in artifactual over- or underestimation of the degree of disease by carotid Doppler, respectively [113]. Noncontrast MRA of the neck may overestimate the degree of stenosis when severe and/or near occlusive. Contrast administration can reduce the degree of overestimation of the degree of stenosis in some cases. However, contrast-enhanced and TOF MRA of the neck have a similar sensitivity for the detection of >70% stenosis of the carotid when 2-D and 3-D techniques of TOF are combined [27,117]. MRA of the neck may also be useful for treatment planning. However, the anatomic definition of the surrounding structures may be inadequate for treatment planning in some cases depending on the sequences used [114]. Additionally, anatomical features of carotid plaque including intraplaque high-intensity signal on 3-D TOF source images can be useful predictors of future stroke risk, beyond assessing the degree of luminal narrowing [85,118,119].

MRI Head Perfusion With IV Contrast
Contrast-enhanced MRI head perfusion imaging (or, if available, noncontrast ASL perfusion) may help delineate the hemodynamic significance of a known asymptomatic carotid lesion and the collateral support in each distribution. More specifically, perfusion imaging may be helpful in cases of moderate stenosis, approaching 70% or severe stenosis [124].

MRI Head Without and With IV Contrast
There is no relevant literature to support the use of contrast-enhanced MRI of the head in the surveillance imaging of asymptomatic carotid stenosis.

MRI Head Without IV Contrast
MRI of the head is useful in evaluating for the sequela of carotid stenosis such as clinically silent strokes or microvascular ischemic changes in the setting of an established diagnosis of carotid stenosis, which is particularly important in cases of hemodynamically significant stenosis. There may be a role for noncontrast MRI of the head

when monitoring patients with risk factors for stroke or known carotid stenosis. However, symptomatic carotid disease should be evaluated relative to the underlying symptoms. Please see Variants 1 to 5 for a discussion of appropriate imaging.

MRV Head Without and With IV Contrast
There is no relevant literature to support the use of MRV of the head in the surveillance imaging of asymptomatic carotid stenosis.

MRV Head Without IV Contrast
There is no relevant literature to support the use of MRV of the head in the surveillance imaging of asymptomatic carotid stenosis.

US Duplex Doppler Carotid Artery
Duplex carotid Doppler is a very accurate and useful test in the evaluation of the extracranial vasculature in the setting of carotid stenosis, which stratifies patients into groups of mild (<50%), moderate (50%-69%), and severe (>70%) stenosis. Specifically, carotid Doppler has a 90% sensitivity and a 94% specificity in the identification of clinically significant >70% stenosis, which might warrant surgical intervention [120]. The lack of need for IV contrast decreases the risk to the patient. However, caution must be observed when evaluating patients with either extremely severe stenosis or multivessel involvement because Doppler can overestimate the degree of stenosis in the setting of contralateral disease or multivessel disease or underestimate the stenosis in the setting of critical high-grade stenosis, which may result in artifactual elevation of velocity or reduction in velocity, respectively. In the absence of suspected confounding factors that might result in Doppler error or active treatment plan, US imaging may be the only indicated examination in a patient with carotid bruit.

US Duplex Doppler Transcranial
Transcranial Doppler may be useful, both in the detection of microembolic events and in determining the hemodynamic significance of a known carotid stenosis. However, there is no literature to support transcranial Doppler in the surveillance imaging of asymptomatic carotid stenosis.

Variant 11: Adult. Suspected cervical vascular dissection or injury. Initial imaging.

Cervical cerebrovascular dissections are an important stroke etiology across all age ranges with an incidence of 2 per 100,000, accounting for 15% of all strokes [125]. The indications for neurologic imaging in suspected vascular dissection vary based on the underlying suspected etiology, severity of injuries, and presenting symptoms. Potential etiologies include but are not limited to traumatic, iatrogenic, spontaneous, and connective tissue disorder–associated dissections. High-energy trauma is the most common indication for cerebrovascular imaging in the setting of suspected dissection. Cerebrovascular dissections associated with major nonpenetrating trauma are typically graded on the Biffl scale, which is in most cases colloquially referred to as the Denver grading scale. Higher-grade dissections are more likely to result in ischemic complications [126]. For indicated imaging in patients with focal neurological deficits relative to cervical dissections, please see Variants 1 to 5 for additional indicated imaging procedures. Dissection may be suspected based on known or suspected connective tissue disorder in the setting of new unexplained neck pain or new focal neurological deficit. Regardless, the initial imaging of suspected dissections primarily focuses on both rapid initial diagnosis and grading the dissection. However, in some cases of severe presenting symptoms, evaluation of collateral circulation supporting the at-risk territory, intracranial extension, and embolic intracranial complications also becomes important.

For a discussion of suspected vascular dissection of injury due to penetrating trauma, please see the ACR Appropriateness Criteria® topic on "Penetrating Neck Injury" [4].

Arteriography Cervicocerebral
Catheter-directed cerebral angiography has the highest spatial resolution and temporal resolution of any vascular study. As such, catheter-directed angiography is the most accurate means of grading a cervical dissection, delineating the degree of associated stenosis, and may also be useful in assessment of collateral circulation. Additionally, some subtle dissections may be more apparent due to higher spatial resolution. However, the usefulness of this technique in screening for dissection is obviated by the invasive nature of the test. There is no literature supporting cerebral angiography as the initial imaging test for suspected cervical vascular dissection. Cervicocerebral angiography may influence treatment options after the initial diagnosis of dissection in patients with severe presenting symptoms such as focal neurological deficits [126]; however, the degree of stenosis may not influence the rate of further stroke [127,128].

CT Head Perfusion With IV Contrast
There is no literature to support the use of CTP in the initial imaging of suspected cervical vascular dissection or injury.

CT Head With IV Contrast
There is no relevant literature to support the use of contrast-enhanced CT of the head in the initial imaging of suspected cervical vascular dissection or injury.

CT Head Without and With IV Contrast
There is no relevant literature to support the use of contrast-enhanced CT of the head in the initial imaging of suspected cervical vascular dissection or injury.

CT Head Without IV Contrast
Noncontrast CT may be useful in the setting of a known dissection to evaluate for complications such as hemorrhagic conversion, mass effect, and herniation or in the exclusion of ICH before the initiation of anticoagulation or antiplatelet therapy for a known dissection. However, MRI is much more sensitive in evaluating recent strokes.

CTA Head With IV Contrast
CTA of the head may be useful in the evaluation for intracranial extension of a known cervical dissection. CTA of the head may also be useful for evaluation of intracranial collaterals of the circle of Willis and excluding associated intracranial LVO, which is important in stroke risk stratification and treatment strategies. As such, although a CTA of the head may be necessary in the workup of a known cervical artery dissection, there is no literature to support CTA of the head in the initial screening examination for a suspected cervical artery dissection.

CTA Neck With IV Contrast
CTA of the neck is useful in the initial screening examination for suspected cervical vascular dissection owing to rapid acquisition and high spatial resolution of the examination. Rapid examination is important in the evaluation for suspected cervical dissection due to the stroke risk associated with treatment delays. The high resolution of CTA neck allows for the detection of fairly subtle dissections with high sensitivity for both cervical carotid and vertebral artery dissections with a sensitivity and specificity approaching 98% [129]. CTA neck can rapidly and accurately grade the degree of luminal narrowing, vessel irregularity, wall thickening/hematoma, pseudoaneurysm, and intimal flap, which may make it preferable to MRA [130]. CTA neck also allows for fairly accurate grading of dissections comparable to digital subtraction angiography, which may be helpful in clinical management [131]. The potential detractors from CTA of the neck are the requirements for iodinated contrast and ionizing radiation.

CTV Head With IV Contrast
There is no relevant literature to support the use of CTV of the head in the initial imaging of suspected cervical vascular dissection or injury.

MRA Head Without and With IV Contrast
There is no relevant literature to support the use of contrast-enhanced MRA of the head in the initial imaging of suspected cervical vascular dissection or injury.

MRA Head Without IV Contrast
MRA of the head may be useful in evaluation for intracranial extension of a known cervical dissection. MRA of the head may also be useful for evaluation of intracranial collaterals of the circle of Willis, which is important in stroke risk stratification and treatment strategies. As such, although an MRA of the head may be useful in the workup of a known cervical dissection, there is no literature to support MRA of the head in the initial imaging of suspected cervical arterial dissection.

MRA Neck Without and With IV Contrast
MRA of the neck is useful in the initial screening examination for suspected cervical vascular dissection owing to high tissue contrast, especially incorporating fat-saturated T1-weighted sequences, which may be helpful in delineation of subtle intramural hematomas improving visibility to the examiner. The sensitivity of MRI neck is similar to CTA neck for cervical carotid dissections. However, the sensitivity for detection of cervical vertebral artery dissections is significantly reduced compared with CTA neck to as low as 60%, with some variability depending on the technique and sequences employed [129]. Limitations of MRA neck include longer acquisition times and lower spatial resolution, which may delay care or miss subtle intimal irregularities associated with suspected cervical vascular dissections, particularly those involving the vertebral artery. Additionally, an

unenhanced MRA of the neck may also overestimate the degree of stenosis in more severe dissections, and the anatomic definition of the surrounding structures may be inadequate for treatment planning in some cases depending on the sequences used. Contrast administration can reduce the degree of overestimation of the degree of stenosis in many cases [132].

MRA Neck Without IV Contrast
MRA of the neck is useful in the initial screening examination for suspected cervical vascular dissection owing to high tissue contrast, especially incorporating fat-saturated T1-weighted sequences, which may be helpful in the delineation of subtle intramural hematomas, improving visibility to the examiner. The sensitivity of MRI neck is similar to CTA neck for cervical carotid dissections. However, the sensitivity for the detection of cervical vertebral artery dissections is significantly reduced compared with CTA neck to as low as 60%, with some variability depending on the technique and sequences employed [129]. Limitations of MRA neck include longer acquisition times and lower spatial resolution, which may delay care or miss subtle intimal irregularities associated with suspected cervical vascular dissections, particularly those involving the vertebral artery. Additionally, an unenhanced MRA of the neck may also overestimate the degree of stenosis in more severe dissections, and the anatomic definition of the surrounding structures may be inadequate for treatment planning in some cases depending on the sequences used. Contrast administration can reduce the degree of overestimation of the degree of stenosis in many cases [132].

MRI Head Perfusion With IV Contrast
There is no literature to support the use of MRI head perfusion as the initial imaging test in the detection of a suspected cervical artery dissection.

MRI Head Without and With IV Contrast
There is no relevant literature to support the use of contrast-enhanced MRI of the head in the initial imaging of suspected cervical vascular dissection or injury.

MRI Head Without IV Contrast
MRI of the head may be useful in evaluating strokes in the setting of a known dissection or in the exclusion of ICH before the initiation of anticoagulation or antiplatelet therapy for a known dissection. As such, although an MRI of the head may be useful in the workup of a known dissection, there is no literature to support an MRI of the head in the initial screening examination for a suspected cervical artery dissection.

MRV Head Without and With IV Contrast
There is no relevant literature to support the use of MRV of the head in the initial imaging of suspected cervical vascular dissection or injury.

MRV Head Without IV Contrast
There is no relevant literature to support the use of MRV of the head in the initial imaging of suspected cervical vascular dissection or injury.

US Duplex Doppler Carotid Artery
There is no literature that supports duplex Doppler examination of the carotid in the initial imaging of suspected cervical vascular dissection or injury.

US Duplex Doppler Transcranial
Transcranial Doppler may be useful, both in the detection of microembolic events and in determining the hemodynamic significance of a known cervical vascular dissection. However, there is no literature to support transcranial Doppler in the initial imaging of suspected cervical vascular dissection or injury.

Variant 12: Adult. Known cervical vascular dissection or injury. Surveillance imaging.

Cervical cerebrovascular dissections are an important stroke etiology across all age ranges with an incidence of 2 per 100,000, accounting for 15% of all strokes [125]. The indications for neurologic imaging in the surveillance of vascular dissection vary based on the cause and severity of dissection, stability of the patient, and presence of ongoing or worsening symptoms. Cerebrovascular dissections associated with major nonpenetrating trauma are typically graded on the Biffl scale, which is in most cases colloquially referred to as the Denver grading scale. Higher-grade dissections are more likely to result in ischemic complications [126]. For these dissections associated with major nonpenetrating trauma, repeat imaging with CTA neck is recommend at 7 days and again at 3 months [133]. For patients with minor or no trauma, outcome is not correlated with the degree of subsequent recanalization so a role of follow-up imaging has not been established [134-136]. The subsequent surveillance imaging of cervical vascular dissections centers on the evaluation of healing of the dissection, risk stratification, and development for ongoing ischemic and hemorrhagic complications. Surveillance imaging is less focused on screening for intracranial complication of known dissection beyond the early stages of vascular injury. For indicated imaging in patients with focal neurological deficits relative to cervicocerebral dissections, please see Variants 1 to 5 for additional indicated imaging procedures. Dissection may also be the result of suspected connective tissue disorder, which may also warrant further imaging workup.

Arteriography Cervicocerebral
Catheter-directed cerebral angiography may be useful in the surveillance imaging of some selected cases of known vascular dissection. Specifically, assessment for complete healing of a previously symptomatic dissection or assessment of progression of a known dissection with new or ongoing focal neurological symptom may be more completely assessed by catheter-directed angiography owing to higher spatial and temporal resolution compared with other vascular studies.

CT Head Perfusion With IV Contrast
For indicated imaging in patients with focal neurological deficits relative to cervicocerebral cervical dissections, please see Variants 1 to 5 for additional indicated imaging procedures. However, there is no literature to support the use of CTP as a routine surveillance imaging test in the ongoing evaluation of cervical artery dissections.

CT Head With IV Contrast
There is no relevant literature to support the use of contrast-enhanced CT of the head in the surveillance imaging of cervical vascular dissection.

CT Head Without and With IV Contrast
There is no relevant literature to support the use of contrast-enhanced CT of the head in the surveillance imaging of cervical vascular dissection.

CT Head Without IV Contrast
In the absence of ongoing symptoms, there is no literature to support routine surveillance imaging of the brain parenchyma in the setting of cervical vascular dissection. Noncontrast CT may be useful in the setting of a known dissection in the patient with ongoing or new symptoms to evaluate for new ischemic stroke and complications such as hemorrhagic conversion, mass effect, and herniation or in the exclusion of ICH in the setting of ongoing medical treatment of vascular dissections. However, MRI is much more sensitive in evaluating recent strokes.

CTA Head With IV Contrast
There is no literature to support CTA of the head in the routine surveillance of known dissections isolated to the cervical vasculature. CTA of the head may be useful in the surveillance of cervical vascular dissections that are known to extend into the intracranial vasculature. CTA of the head may also be useful for the evaluation of intracranial collaterals of the circle of Willis and excluding associated intracranial LVO in patients with ongoing symptoms, which is important in stroke risk stratification and treatment strategies.

CTA Neck With IV Contrast
CTA of the neck is useful in ongoing surveillance imaging of cervical vascular dissection owing to high spatial resolution of the examination. The high resolution of CTA allows for the detection of subtle dissections with high sensitivity for both cervical carotid and vertebral artery dissections with a sensitivity and specificity approaching 98%, which informs the usefulness of CTA in follow-up surveillance imaging [129]. CTA can rapidly and accurately grade the degree of luminal narrowing, vessel irregularity, wall thickening/hematoma, pseudoaneurysm, and intimal flap, which may make it preferable to MRA [130]. CTA also allows for accurate grading of dissections comparable to digital subtraction angiography, which may be helpful in clinical management [131]. The potential detractors from CTA of the neck are the requirements for iodinated contrast and ionizing radiation.

CTV Head With IV Contrast
There is no relevant literature to support the use of CTV of the head in the surveillance imaging of cervical vascular dissection.

MRA Head Without and With IV Contrast
There is no relevant literature to support the use of contrast-enhanced MRA of the head in the surveillance imaging of cervical vascular dissection.

MRA Head Without IV Contrast
There is no literature to support MRA of the head in the routine surveillance of known dissections isolated to the cervical vasculature. MRA of the head may be useful in the surveillance of cervical vascular dissections that are known to extend into the intracranial vasculature. MRA of the head may also be useful for the evaluation of intracranial collaterals of the circle of Willis and excluding associated intracranial LVO in patients with ongoing symptoms, which is important in stroke risk stratification and treatment strategies.

MRA Neck Without and With IV Contrast
MRA of the neck may be useful in the surveillance imaging of known cervical vascular dissections owing to high tissue contrast, especially incorporating fat-saturated T1-weighted sequences, which may better demonstrate subtler intramural hematomas that may not be visible on other noninvasive studies. However, some dissections may be too subtle to follow by MRA of the neck due to lower spatial resolution compared with CTA. Specifically, the sensitivity of MRI is similar to CTA for cervical carotid dissections; however, the sensitivity for the detection of cervical vertebral artery dissections is significantly reduced compared with CTA to as low as 60% with some variability depending on the technique and sequences employed [129]. Unenhanced MRA of the neck may also overestimate the degree of stenosis in more severe dissections, and the anatomic definition of the surrounding structures may be inadequate for treatment planning in some cases depending on the sequences used. Contrast administration can reduce the degree of overestimation of the degree of stenosis in many cases [132].

MRA Neck Without IV Contrast
MRA of the neck may be useful in the surveillance imaging of known cervical vascular dissections owing to high tissue contrast, especially incorporating fat-saturated T1-weighted sequences, which may better demonstrate subtler intramural hematomas that may not be visible on other noninvasive studies. However, some dissections may be too subtle to follow by MRA of the neck due to lower spatial resolution compared with CTA. Specifically, the sensitivity of MRI is similar to CTA for cervical carotid dissections; however, the sensitivity for detection of cervical vertebral artery dissections is significantly reduced compared with CTA to as low as 60% with some variability depending on the technique and sequences employed [129]. Unenhanced MRA of the neck may also overestimate the degree of stenosis in more severe dissections, and the anatomic definition of the surrounding structures may be inadequate for treatment planning in some cases depending on the sequences used. Contrast administration can reduce the degree of overestimation of the degree of stenosis in many cases [132].

MRI Head Perfusion With IV Contrast
There is no literature to support the use of MRI head perfusion in the surveillance imaging of cervical vascular dissection.

MRI Head Without and With IV Contrast
There is no relevant literature to support the use of contrast-enhanced MRI of the head in the surveillance imaging of cervical vascular dissection.

MRI Head Without IV Contrast
There is no literature to support an MRI of the head in the surveillance imaging of cervical vascular dissection. MRI of the head may be useful in the setting of a known dissection in the patient with ongoing or new symptoms to evaluate for new ischemic stroke and complications such as hemorrhagic conversion, mass effect, and herniation or in the exclusion of ICH in the setting of ongoing medical treatment of vascular dissections.

MRV Head Without and With IV Contrast
There is no relevant literature to support the use of MRV head in the surveillance imaging of cervical vascular dissection.

MRV Head Without IV Contrast
There is no relevant literature to support the use of MRV head in the surveillance imaging of cervical vascular dissection.

US Duplex Doppler Carotid Artery
Limited studies have used US in follow-up of known cervical carotid dissection [137]. There is no relevant literature to support the use of US duplex Doppler examination of the carotid in the surveillance imaging of cervical vascular dissection.

US Duplex Doppler Transcranial

Transcranial Doppler may be useful, both in the detection of microembolic events and in determining the hemodynamic significance of a known cervical vascular dissection. However, there is no literature to support transcranial Doppler in the surveillance imaging of cervical vascular dissection.

Summary of Highlights

- **Variant 1: Clinical transient ischemic attack (TIA). Symptoms resolved. Initial imaging.** In the setting of TIA with resolution of symptoms, imaging workup is used to exclude true stroke and identify high-risk lesions of the carotid arteries, which could be a source of stroke. As such, both CT head without IV contrast and MRI head without IV contrast were considered usually appropriate as both alternate and complementary initial imaging examinations. Rapidly acquired CTA head and neck as well as noninvasive US duplex of the carotid arteries were also usually appropriate.
- **Variant 2: Focal neurologic deficit. Clinically suspected acute ischemic stroke. Initial imaging.** Recent onset of acute stroke demands imaging to define the extent of infarct and evaluate for hemorrhage. Rapid vascular imaging is needed to guide the next steps in interventional workup. As such, both CT head without IV contrast and MRI head without IV contrast were considered usually appropriate as both alternate and complementary initial imaging examinations. Rapidly acquired CTA head and neck was also usually appropriate. In the setting of recent ischemic infarct <24 hours (Variant 3), less rapid vascular imaging with MRA neck and head were usually appropriate.
- **Variant 3: Recent ischemic infarct; less than 24 hours. Initial imaging.** Recent onset of acute stroke demands imaging to define the extent of infarct and evaluate for hemorrhage. Rapid vascular imaging is needed to guide the next steps in interventional workup. As such, both CT head without IV contrast and MRI head without IV contrast were considered usually appropriate as both alternate and complementary initial imaging examinations. Rapidly acquired CTA head and neck was also usually appropriate. In the setting of recent ischemic infarct <24 hours (Variant 3), less rapid vascular imaging with MRA neck and head were usually appropriate.
- **Variant 4: Recent ischemic infarct; greater than 24 hours. Initial imaging.** Recent onset of acute stroke demands imaging to define the extent of infarct and evaluate for hemorrhage. Rapid vascular imaging is needed to guide the next steps in interventional workup. As such, both CT head without IV contrast and MRI head without IV contrast were considered usually appropriate as both alternate and complementary initial imaging examinations. Rapidly acquired CTA head and neck was also usually appropriate. In the setting of recent ischemic infarct <24 hours (Variant 3), less rapid vascular imaging with MRA neck and head were usually appropriate.
- **Variant 5: Prior ischemic infarct. Surveillance imaging.** In the setting of surveillance imaging after an initial ischemic injury is defined, the focus is on complications such as hemorrhage and mass effect. As such, CT head without IV contrast was usually appropriate. Other imaging modalities may be appropriate based on patient-specific factors and findings on prior imaging.
- **Variant 6: Known intraparenchymal hemorrhage. No history of trauma. Follow-up imaging study.** With known atraumatic IPH, there is a need to monitor for complications that could require emergent neurosurgical intervention and assess for potential etiologies through vascular imaging and advanced parenchymal imaging. As such, CT head without IV contrast, MRI head without IV contrast, or MRI head with and without IV contrast, and CTA head are all usually appropriate for follow-up. Other imaging modalities may be appropriate based on patient-specific factors and findings on prior imaging.
- **Variant 7: Suspected venous sinus thrombosis. Initial imaging.** For initial imaging evaluation of suspected venous sinus thrombosis or for surveillance imaging of known venous sinus thrombosis, imaging focuses the direct identification of clot, as well as the assessment for complications such as venous infarction and hemorrhage. CT head without IV contrast and MRI head without or with IV contrast and MRI head without IV contrast are alternative procedures for direct parenchymal assessment. Direct venous vascular imaging with CTV or MRV are usually appropriate alternatives. MRI head with and without IV contrast is also usually appropriate and can accomplish both parenchymal and vascular assessment. CT head with IV contrast may be appropriate for initial imaging in the setting of suspected venous sinus thrombosis (Variant 7), but direct venous imaging with CTV or MRV is preferred for surveillance of a known thrombus (Variant 8).

- **Variant 8: Known venous sinus thrombosis. Surveillance imaging.** For initial imaging evaluation of suspected venous sinus thrombosis or for surveillance imaging of known venous sinus thrombosis, imaging focuses the direct identification of clot, as well as the assessment for complications such as venous infarction and hemorrhage. CT head without IV contrast and MRI head without or with IV contrast and MRI head without IV contrast are alternative procedures for direct parenchymal assessment. Direct venous vascular imaging with CTV or MRV is usually an appropriate alternative. MRI head with and without IV contrast is also usually appropriate and can accomplish both parenchymal and vascular assessment. CT head with IV contrast may be appropriate for initial imaging in the setting of suspected venous sinus thrombosis (Variant 7), but direct venous imaging with CTV or MRV is preferred for surveillance of a known thrombus (Variant 8).
- **Variant 9: Asymptomatic cervical bruit. Initial imaging.** In the setting of asymptomatic cervical bruit, imaging is focused on identifying potentially significant carotid stenosis. As such, either US duplex Doppler carotid artery, CTA neck, MRA neck without IV contrast, or MRA neck without and with IV contrast is usually appropriate as an alternative initial imaging procedure. If findings are unclear using one examination, other examinations may also be a useful complementary problem-solving procedure.
- **Variant 10: Asymptomatic carotid stenosis. Surveillance imaging.** In the setting of known, asymptomatic carotid stenosis, surveillance is focused on early identification of stenosis progression. As such, either US duplex Doppler carotid artery, CTA neck, MRA neck without IV contrast, or MRA neck without and with IV contrast is usually appropriate as an alternative surveillance imaging procedure. If findings are unclear using one examination, other examinations may also be a useful complementary problem-solving procedure. There was disagreement as to whether parenchymal imaging with MRI head without IV contrast may be helpful or not as a tool to identify potentially significant silent progression of parenchymal disease.
- **Variant 11: Suspected cervical vascular dissection or injury. Initial imaging.** In the setting of suspected cervical vascular dissection or injury, imaging focuses primarily on rapid diagnosis and grading of dissection. Initial imaging with either CTA neck, MRA neck without and with IV contrast, and MRA neck without IV contrast is usually an appropriate alternative examination. CT head without IV contrast is usually appropriate for parenchymal evaluation for embolic intracranial complications, although MRI head without IV contrast may be appropriate. Evaluation for intracranial extension and collateral circulation may be appropriate using MRA head without IV contrast or CTA head, performed concurrent with any other initial imaging study is used for the neck.
- **Variant 12: Known cervical vascular dissection or injury. Surveillance imaging.** For subsequent surveillance imaging of cervical vascular dissections, imaging focuses primarily on healing of the dissection. CTA neck, MRA neck without and with IV contrast, and MRA neck without IV contrast are usually appropriate imaging alternates. These examinations are also usually appropriate as complementary examinations for problem-solving purposes; cervicocerebral arteriography may be appropriate as a complementary imaging examination. Surveillance imaging is less focused on screening for intracranial complication of known dissection beyond the early stages of vascular injury. As such, CTA head and MRA head without IV contrast may be appropriate, depending on the clinical context.

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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 go to www.acr.org/ac.

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 [138].

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 (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."		

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