**American College of Radiology**
**ACR Appropriateness Criteria®**
# Headache

## Variant: 1 Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.

| Procedure | Appropriateness Category | Relative Radiation Level |
|---|---|---|
| CT head without IV contrast | Usually Appropriate | ☢☢☢ |
| CTA head with IV contrast | May Be Appropriate | ☢☢☢ |
| Arteriography cervicocerebral | Usually Not Appropriate | ☢☢☢ |
| MRA head with IV contrast | Usually Not Appropriate | O |
| MRA head without and with IV contrast | Usually Not Appropriate | O |
| MRA head without IV contrast | Usually Not Appropriate | O |
| MRI head with IV contrast | Usually Not Appropriate | O |
| MRI head without and with IV contrast | Usually Not Appropriate | O |
| MRI head without IV contrast | Usually Not Appropriate | O |
| MRV head 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: 2 Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.

| Procedure | Appropriateness Category | Relative Radiation Level |
|---|---|---|
| Arteriography cervicocerebral | Usually Not Appropriate | ☢☢☢ |
| MRA head with IV contrast | Usually Not Appropriate | O |
| MRA head without and with IV contrast | Usually Not Appropriate | O |
| MRA head without IV contrast | Usually Not Appropriate | O |
| MRI head with IV contrast | Usually Not Appropriate | O |
| MRI head without and with IV contrast | Usually Not Appropriate | O |
| MRI head without IV contrast | Usually Not Appropriate | O |
| MRV head 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 | ☢☢☢ |
| 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: 3 Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging.

| Procedure | Appropriateness Category | Relative Radiation Level |
|---|---|---|
| MRI head without and with IV contrast | Usually Appropriate | O |
| MRI head without IV contrast | May Be Appropriate | O |
| Arteriography cervicocerebral | Usually Not Appropriate | ☢☢☢ |
| MRA head with IV contrast | Usually Not Appropriate | O |
| MRA head without and with IV contrast | Usually Not Appropriate | O |
| MRA head without IV contrast | Usually Not Appropriate | O |
| MRI head with IV contrast | Usually Not Appropriate | O |
| MRV head 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 | ☢☢☢ |
| 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: 4 Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). 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 |
| CT head without IV contrast | Usually Appropriate | ☢☢☢ |
| MRV head with 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 | ☢☢☢ |
| Arteriography cervicocerebral | Usually Not Appropriate | ☢☢☢ |
| MRA head with IV contrast | Usually Not Appropriate | O |
| MRA head without and with IV contrast | Usually Not Appropriate | O |
| MRA head without IV contrast | Usually Not Appropriate | O |
| MRI head with IV contrast | Usually Not Appropriate | O |
| CT head with IV contrast | Usually Not Appropriate | ☢☢☢ |
| CT head without and with IV contrast | Usually Not Appropriate | ☢☢☢ |
| CTA head with IV contrast | Usually Not Appropriate | ☢☢☢ |

## Variant: 5 Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.

| Procedure | Appropriateness Category | Relative Radiation Level |
|---|---|---|
| MRI head without and with IV contrast | Usually Appropriate | O |
| MRI thoracic spine with IV contrast | May Be Appropriate (Disagreement) | O |
| MRI thoracic spine without and with IV contrast | May Be Appropriate | O |
| MRI thoracic spine without IV contrast | May Be Appropriate | O |
| Arteriography cervicocerebral | Usually Not Appropriate | ☢☢☢ |

| | | |
|---|---|---|
| MRA head with IV contrast | Usually Not Appropriate | O |
| MRA head without and with IV contrast | Usually Not Appropriate | O |
| MRA head without IV contrast | Usually Not Appropriate | O |
| MRI head with IV contrast | Usually Not Appropriate | O |
| MRI head without IV contrast | Usually Not Appropriate | O |
| MRV head 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 | ☢☢☢ |
| 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: 6 Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**

| Procedure | Appropriateness Category | Relative Radiation Level |
|---|---|---|
| MRI head without IV contrast | Usually Appropriate | O |
| CT head without IV contrast | Usually Appropriate | ☢☢☢ |
| MRV head without IV contrast | May Be Appropriate | O |
| CTV head with IV contrast | May Be Appropriate | ☢☢☢ |
| Arteriography cervicocerebral | Usually Not Appropriate | ☢☢☢ |
| MRA head with IV contrast | Usually Not Appropriate | O |
| MRA head without and with IV contrast | Usually Not Appropriate | O |
| MRA head without IV contrast | Usually Not Appropriate | O |
| MRI head with IV contrast | Usually Not Appropriate | O |
| MRI head without and with IV contrast | Usually Not Appropriate | O |
| MRV head with IV contrast | Usually Not Appropriate | O |
| MRV head without and with IV contrast | Usually Not Appropriate | O |
| CT head with IV contrast | Usually Not Appropriate | ☢☢☢ |
| CT head without and with IV contrast | Usually Not Appropriate | ☢☢☢ |
| CTA head with IV contrast | Usually Not Appropriate | ☢☢☢ |

**Variant: 7 Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. 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 |
| CT head without IV contrast | Usually Appropriate | ☢☢☢ |
| Arteriography cervicocerebral | Usually Not Appropriate | ☢☢☢ |
| MRA head with IV contrast | Usually Not Appropriate | O |
| MRA head without and with IV contrast | Usually Not Appropriate | O |
| MRA head without IV contrast | Usually Not Appropriate | O |

| | | |
|---|---|---|
| MRI head with IV contrast | Usually Not Appropriate | O |
| MRV head 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 | ☢☢☢ |
| CTA head with IV contrast | Usually Not Appropriate | ☢☢☢ |
| CTV head with IV contrast | Usually Not Appropriate | ☢☢☢ |

**Variant: 8 Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-traumatic onset. Initial imaging.**

| Procedure | Appropriateness Category | Relative Radiation Level |
|---|---|---|
| Arteriography cervicocerebral | Usually Not Appropriate | ☢☢☢ |
| MRA head with IV contrast | Usually Not Appropriate | O |
| MRA head without and with IV contrast | Usually Not Appropriate | O |
| MRA head without IV contrast | Usually Not Appropriate | O |
| MRI head with IV contrast | Usually Not Appropriate | O |
| MRI head without and with IV contrast | Usually Not Appropriate | O |
| MRI head without IV contrast | Usually Not Appropriate | O |
| MRV head 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 | ☢☢☢ |
| CT head without IV contrast | Usually Not Appropriate | ☢☢☢ |
| CTA head with IV contrast | Usually Not Appropriate | ☢☢☢ |
| CTV head with IV contrast | Usually Not Appropriate | ☢☢☢ |

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## Summary of Literature Review

### Introduction/Background

Headache is an ancient problem plaguing a large proportion of the population. Data collected in 2013 suggested that 50% of the world's adult population suffered from a "headache disorder." It is most commonly encountered between the ages of 25 to 55 years, with an estimated lifetime

prevalence between 0.2% and 60% [1,2]. At present, headache disorders rank third among the global causes of disability, accounting for more than $78 billion per year in direct and indirect costs in the United States [1]. Although headache comprises a small percentage of overall visits to the emergency department, more than 40% of neurologic cases presenting to the emergency department are related to headache disorders [3]. Although the majority of the headaches are due to benign etiologies and self-limited, a small percentage of these patients may present with potentially life-threatening etiologies. Based on a recent study, the yield of positive findings on a head CT for the indication of headache in the emergency department setting ranged between 7% and 13% depending on the age of the patient [4,5]. Given the prevalence of headache and the wide range of possible etiologies, the goal of this document is to help clarify the most appropriate initial imaging guidelines for headache under 8 clinical scenarios/variants.

The first variant addresses a clinical scenario that can be associated with an immediate life threat: the "thunderclap" headache (TCH). The subsequent variants follow the latest 2018 edition of the International Classification of Headache Disorders (ICHD-3), which uses 3 major categories: primary headaches, secondary headaches, and cranial neuralgias [1]. Variants 2 and 3 address primary headaches, which are independent and are not caused by other disorders and which include migraine, tension-type headache (TTH), and trigeminal autonomic cephalalgias (TACs). Variants 4 to 7 address clinical scenarios that are more likely to be associated with secondary headaches, which are attributed to an underlying causative disorder, such as alteration of intracranial pressure or irritation of meningovascular structures. The addition of variants addressing orthostatic headache and headache in pregnancy facilitates discussion of spinal imaging and venous imaging in those clinical scenarios, respectively. The last variant addresses headache in the absence of new features, neurologic deficit, or other "red flags" for secondary headache.

Given the frequent coexistence of headache with other neurologic, traumatic, infectious, and vascular processes, it is important to acknowledge the overlap of symptoms with other conditions referenced in independent ACR Appropriateness Criteria® documents. For headache in the setting of recent trauma, suspected stroke, rhinosinusitis, or cranial neuralgia (eg, trigeminal neuralgia), please also refer to ACR Appropriateness Criteria® topics on "Cerebrovascular Disease" [6], "Cranial Neuropathy" [7], "Sinonasal Disease" [8], or "Head Trauma" [9].

**Initial Imaging Definition**

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

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

OR

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

**Discussion of Procedures by Variant**

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.**

Many of the headaches presenting to the emergency department are benign or primary; however, a subset of headaches defined as TCH warrant further investigation. The most important feature of TCH is the abrupt onset of a severe headache that reaches maximum intensity in <1 minute, although for the purposes of this discussion, the term will be used more loosely to encompass the sudden onset of a severe headache that reaches maximum intensity in <1 hour. Initially used in reference to the pain associated with leaking or ruptured intracranial aneurysms, other etiologies of TCH have since been identified [10,11]. Ruptured aneurysm resulting in subarachnoid hemorrhage (SAH) is the primary concern because of significant morbidity and mortality, although it accounts for only 4% to 12% of acute severe headaches [11].

Reversible cerebral vasoconstriction syndrome (RCVS) is the second most common cause of TCH and is the most common cause of TCH without aneurysmal SAH. Associated complications include intracranial hemorrhage and ischemic infarction [12]. RCVS is an important cause of recurrent TCH; half of RCVS headaches can be attributed to a specific trigger [10,12]. Less common causes of TCH include cerebral venous thrombosis (CVT), cervical arterial dissection, posterior reversible encephalopathy syndrome (PRES), spontaneous intracranial hypotension (SIH), pituitary apoplexy, perimesencephalic hemorrhage, arteriovenous malformations (AVM), dural arteriovenous fistulas, and intraventricular colloid cyst. A subset of patients will not have a causative disorder and will be diagnosed as suffering from primary TCH; this is a diagnosis of exclusion [10,11,13].

The Ottawa Subarachnoid Hemorrhage Rule is a clinical decision tool that has been validated as 100% sensitive to capture all patients with SAH; it is applied to patients ≥15 years of age with new severe nontraumatic headache, reaching maximum intensity within 1 hour. Patients require investigation if one or more of the following findings are present: ≥40 years of age, neck pain or stiffness, witnessed loss of consciousness, onset during exertion, TCH, or limited neck flexion on examination. However, the Ottawa Subarachnoid Hemorrhage Rule is not specific and is unable to determine the etiology of the TCH [14,15].

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.**

**A. Arteriography cervicocerebral**

There is no relevant literature to support the use of cervicocerebral arteriography in the initial evaluation of TCH; it may have utility in follow-up evaluation after initial neuroimaging.

Digital subtraction angiography (DSA) can assess vessel diameters as small as 0.4 mm compared with 0.7 mm for CT angiography (CTA). This may be useful for further workup of etiologies such as RCVS, which primarily impacts the smaller vessels and provides the opportunity for intravascular therapy. For example, intraarterial nimodipine has been used to demonstrate reversibility, a diagnostic criterion for RCVS [12]. Likewise, DSA may have a role in the workup of aneurysm rupture associated with SAH, when no aneurysm is detected on the initial multidetector CTA. The American Heart Association and the American Stroke Association guidelines also suggest that DSA may not be necessary if a classic perimesencephalic pattern of hemorrhage is present on CT with a negative CTA. In cases of suspected CVT or AVM based on initial neuroimaging, catheter angiography may be used for further characterization and for endovascular therapy [11].

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour.**

**Initial imaging.**
**B. CT head with IV contrast**

There is no relevant literature to support the use of CT head with intravenous (IV) contrast in the initial imaging evaluation of TCH.

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.**
**C. CT head without and with IV contrast**

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

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.**
**D. CT head without IV contrast**

CT head without IV contrast is useful in the setting of TCH because of its high sensitivity for detecting intracranial hemorrhage. Several studies have demonstrated a high negative predictive value of a noncontrast head CT performed within 6 hours of headache onset in detecting aneurysmal SAH, ranging between 99.9% and 100%. When it is performed within the first 24 hours, the sensitivity ranges between 90% and 100% [16,17]. Ten percent of patients with CVT present with SAH; associated CT abnormalities include venous infarcts, parenchymal edema, or hyperdense thrombus within the occluded sinus. Although SAH is less common in cases of ruptured AVMs, lobar hemorrhage and serpiginous structures representing dilated vasculature can be seen on a noncontrast head CT [11].

In addition, a CTA head with IV contrast may be useful in the setting of TCH when performed in conjunction with a noncontrast head CT (not as an independent initial imaging technique in isolation). There is literature supporting the usefulness of obtaining a head CTA at the same time as a head CT in a patient with TCH, especially when a patient presents with sudden onset severe headache >6 hours, because the sensitivity of head CT for SAH diminishes over time. For suspected cases of RCVS, a noncontrast head CT with special attention to the presence of convexity SAH has been shown to be useful [12]

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.**
**E. CTA head with IV contrast**

CTA head with IV contrast may be useful in the setting of TCH when performed in conjunction with a noncontrast head CT (not as an independent initial imaging technique in isolation). There is literature supporting the usefulness of obtaining a head CTA at the same time as a head CT in a patient with TCH, especially when a patient presents with sudden onset severe headache >6 hours, because the sensitivity of head CT for SAH diminishes over time. For example, a concurrent or follow-up CTA is useful in suspected cases of intracranial aneurysm (ruptured or unruptured), arterial dissection, and RCVS [10-12,18].

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.**
**F. CTV head with IV contrast**

There is no relevant literature to support the use of CT venography (CTV) head with IV contrast in the initial imaging evaluation of TCH. Following initial evaluation with a noncontrast head CT, head

CTV can be useful when there are clinical or imaging findings suspicious for CVT, which is a less common cause of TCH [11,13].

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.**
**G. MRA head with IV contrast**

There is no relevant literature to support the use of MR angiography (MRA) head with IV contrast in the initial imaging evaluation of TCH.

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.**
**H. MRA head without and with IV contrast**

There is no relevant literature to support the use of MRA head without and with IV contrast in the initial imaging evaluation of TCH.

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.**
**I. MRA head without IV contrast**

There is no relevant literature to support the use of MRA head without IV contrast in the initial imaging evaluation of TCH. However, similar to head CTA, brain MRA can be obtained as a follow-up imaging study when there are clinical or imaging findings concerning for aneurysm, dissection, RCVS, or AVM [11].

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.**
**J. MRI head with IV contrast**

There is no relevant literature to support the use of MRI head with IV contrast in the initial imaging evaluation of TCH.

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.**
**K. MRI head without and with IV contrast**

There is no relevant literature to support the use of MRI head without and with IV contrast in the initial imaging evaluation of TCH; it may have utility in follow-up evaluation after initial neuroimaging.

Contrast-enhanced brain MRI can be useful in the diagnosis of SIH, pituitary apoplexy, and intraventricular colloid cyst, which are rare causes of TCH [11].

High-resolution MRI using vessel wall imaging may be useful in differentiating various vasculitides from RCVS and in identifying dissection of the intracranial vessels, compared with standard MRI. For example, recent studies have demonstrated concentric thickening of the vessel wall with minimal or no enhancement in RCVS, compared with more eccentric wall thickening and significant wall enhancement in cases of vasculitis [12]. In addition, vessel wall imaging can be used to help identify the ruptured lesion when initial CTA reveals multiple aneurysms [11].

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.**
**L. MRI head without IV contrast**

There is no relevant literature to support the use of MRI head without IV contrast in the initial imaging evaluation of TCH; it may have utility in follow-up evaluation after initial neuroimaging.

Brain MRI has been shown to have high sensitivity for SAH when using fluid-attenuated inversion recovery (FLAIR) and T2* or susceptibility-weighted images, especially in the acute phase. FLAIR has been demonstrated to be useful for detecting peripheral or sulcal SAH, and T2* has been demonstrated to be useful for detecting cisternal or intraventricular hemorrhage. However, other studies have identified additional causes of sulcal FLAIR hyperintensity, which is therefore not a specific finding for SAH. Brain MRI has higher contrast resolution than head CT, and as a follow-up examination, it can help delineate parenchymal changes from various other non-SAH etiologies of TCH including RCVS, CVT, and pituitary apoplexy [13,19,20].

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.**
**M. MRV head with IV contrast**

There is no relevant literature to support the use of MR venography (MRV) head with IV contrast in the initial imaging evaluation of TCH. Brain MRV can be used as a follow-up imaging study in cases of suspected CVT [11].

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.**
**N. MRV head without and with IV contrast**

There is no relevant literature to support the use of MRV head without and with IV contrast in the initial imaging evaluation of TCH. Brain MRV can be used as a follow-up imaging study in cases of suspected CVT [11].

**Variant 1: Sudden onset severe headache that reaches maximal severity within one hour. Initial imaging.**
**O. MRV head without IV contrast**

There is no relevant literature to support the use of MRV head without IV contrast in the initial imaging evaluation of TCH. Brain MRV can be used as a follow-up imaging study in cases of suspected CVT [11].

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**

In a single year, more than half of the adult population suffers from a headache, most often a primary headache such as TTH and migraine, with a prevalence of 21% and 15%, respectively [21]. Based on the 2016 Global Burden of Diseases study, TTHs and migraines have been ranked in the top 10 causes, with the greatest prevalence. Moreover, migraines are ranked as the second leading cause of years living with disability, especially in high-income, high-middle-income, and middle-socio-demographic index quintile countries. Migraine was also ranked as the second leading cause of years living with disability for women in 35 countries [22]. Two major types of migraines are documented: migraine with aura and migraine without aura. Although less disabling than migraine, TTH has a higher lifetime prevalence of 30% to 78% and, therefore, a high socioeconomic impact. The clinical criteria classify TTH into subtypes based on the frequency of headaches (number of days per month) and the presence or absence of pericranial tenderness [23].

Despite the clinical and social impact of the 2 most common primary headaches, various studies

have demonstrated very few significant structural abnormalities on neuroimaging in patients presenting to the emergency department and outpatient clinics. The HUNT MRI study performed in middle-aged patients demonstrated that headache sufferers in general demonstrated an increased incidence of intracranial abnormalities, mostly attributed to small nonspecific white matter hyperintensities. This association was near zero when white matter hyperintensities were removed from the analysis [21]. Studies were also conducted examining the incidence of intracranial abnormalities in patients suffering from migraine with and without aura. It was found that patients with migraine with aura were imaged more frequently and demonstrated an increased incidence of minor intracranial abnormalities such as lacunar infarcts and microvascular ischemic changes. No abnormalities were detected that were of major clinical significance [24]. A study performed in China in 2018 examined 1,070 healthy control patients and 1,070 primary headache sufferers; imaging evaluation included either CT or MRI and found no statistical difference in the detection of intracranial abnormalities: 0.58% in patients with headache and 0.78% in healthy controls [25].

The United States Headache Consortium considers ”significant” abnormalities as those that require further action. A study in Spain analyzed the imaging studies of 1,876 patients presenting with primary headaches: 49% of patients presenting with TTH and 53.4% of patients with migraines. This study also demonstrated a very low incidence of "significant” abnormalities: 0.4% in cases of TTH and 0.8% in cases of migraine. The caveat presented in this study was the lack of a screening process for appropriate imaging; the article mentions the impact of patient satisfaction as a factor in the use of diagnostic imaging [26].

The ACR in the Choosing Wisely® campaign (http://www.choosingwisely.org) recommends against imaging for primary headache. For patients meeting criteria of these primary headache syndromes, having no red flags and a normal neurological examination, neuroimaging is not necessary based upon the current available data.

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**
**A. Arteriography cervicocerebral**

There is no relevant literature to support the use of cervicocerebral arteriography in the initial imaging evaluation of primary migraine or TTH with a normal neurologic examination.

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**
**B. CT head with IV contrast**

There is no relevant literature to support the use of CT head with IV contrast in the initial imaging evaluation of primary migraine or TTH with a normal neurologic examination.

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**
**C. CT head without and with IV contrast**

There is no relevant literature to support the use of CT head without and with IV contrast in the initial imaging evaluation of primary migraine or TTH with a normal neurologic examination.

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**
**D. CT head without IV contrast**

There is no relevant literature to support the use of CT head without IV contrast in the initial imaging evaluation of primary migraine or TTH with a normal neurologic examination.

Most studies demonstrate a very low incidence of clinically significant intracranial abnormalities in patients presenting with migraine or TTH and a normal neurological examination [25,26].

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**
**E. CTA head with IV contrast**

There is no relevant literature to support the use of CTA head with IV contrast in the initial imaging evaluation of primary migraine or TTH with a normal neurologic examination.

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**
**F. CTV head with IV contrast**

There is no relevant literature to support the use of CTV head with IV contrast in the initial imaging evaluation of primary migraine or TTH with a normal neurologic examination.

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**
**G. MRA head with IV contrast**

There is no relevant literature to support the use of MRA head with IV contrast in the initial imaging evaluation of primary migraine or TTH with a normal neurologic examination.

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**
**H. MRA head without and with IV contrast**

There is no relevant literature to support the use of MRA head without and with IV contrast in the initial imaging evaluation of primary migraine or TTH with a normal neurologic examination.

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**
**I. MRA head without IV contrast**

There is no relevant literature to support the use of MRA head without IV contrast in the initial imaging evaluation of primary migraine or TTH with a normal neurologic examination.

Brain MRA in primary patients with headache has demonstrated no increased incidence of vascular abnormalities [21].

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**
**J. MRI head with IV contrast**

There is no relevant literature to support the use of MRI head with IV contrast in the initial imaging evaluation of primary migraine or TTH with a normal neurologic examination.

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**
**K. MRI head without and with IV contrast**

There is no relevant literature to support the use of MRI head without and with IV contrast in the

initial imaging evaluation of primary migraine or TTH with a normal neurologic examination.

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**
**L. MRI head without IV contrast**

There is no relevant literature to support the use of MRI head without IV contrast in the initial imaging evaluation of primary migraine or TTH with a normal neurologic examination.

Several studies in primary headache sufferers demonstrated no significant increase in the incidence of major intracranial abnormalities that would require further action or are clinically significant. The most prevalent findings were an increased incidence of small nonspecific white matter hyperintensities, especially in TTH [21,24-26]. Imaging techniques continue to evolve and improve, and recent developments in advanced MRI techniques are allowing the clinical community to better understand the underlying pathophysiology of migraines, which remains less well characterized than the clinical phenotype. Early research with novel structural imaging techniques such as voxel based morphometry and surface based morphometry suggest consistent variations in gray matter volume in regions of the brain responsible for pain processing and modulation in patients with migraine and other chronic pain. White matter hyperintensities have been the most common minor intracranial abnormality in patients with migraine. Recent studies have investigated the correlation of white matter volume changes (eg, corpus callosum) and microstructural alterations on diffusion tensor imaging to symptoms in patients with migraine with and without aura, especially those with a depressive/anxious comorbidity. Functional neuroimaging studies have also been used to investigate the brain activation changes during and between migraine attacks. In addition to functional imaging, research using arterial spin labeling imaging to measure perfusion without necessitating IV contrast is providing useful insignts into the transient perfusion changes during the acute phase of an aura and following an attack. Arterial spin labeling has also proved in separating mirgraine with aura from cerebral ischemia, which can have a direct impact on clinical decision making. This ongoing research may help us understand attack ignition/propagation and provide targets for future therapy [27,28].

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**
**M. MRV head with IV contrast**

There is no relevant literature to support the use of MRV head with IV contrast in the initial imaging evaluation of primary migraine or TTH with a normal neurologic examination.

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**
**N. MRV head without and with IV contrast**

There is no relevant literature to support the use of MRV head without and with IV contrast in the initial imaging evaluation of primary migraine or TTH with a normal neurologic examination.

**Variant 2: Primary migraine or tension-type headache. Normal neurologic examination. Initial imaging.**
**O. MRV head without IV contrast**

There is no relevant literature to support the use of MRV head without IV contrast in the initial imaging evaluation of primary migraine or TTH with a normal neurologic examination.

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging.**

The ICHD-3 describes TACs as attacks of severe, strictly unilateral pain, which are orbital, supraorbital, temporal, or in any combination of these sites, lasting 15 to 180 minutes and occurring from once every other day to 8 times a day. Associated symptoms include ipsilateral conjunctival injection, lacrimation, nasal congestion, rhinorrhea, forehead and facial sweating, miosis, ptosis and/or eyelid edema, with or without restlessness or agitation. This predilection for the ophthalmic nerve (V1) distribution and associated autonomic symptoms help differentiate TACs from trigeminal neuralgia, which is a different disease. They are further classified as chronic or episodic, with 10% to 15% of patients suffering from chronic cluster headaches. Other subtypes include paroxysmal hemicranias (2-30 minutes), short-lasting unilateral neuralgiform headache attacks (1-600 seconds), hemicrania continua, and probable TAC. The short-lasting unilateral headache attacks are further characterized in 2 types: short-lasting unilateral neuralgiform headache attacks with conjunctival injection and tearing and short-lasting unilateral neuralgiform headache attacks with cranial autonomic symptoms [23]. TACs are, as a group, an uncommon primary headache disorder, with cluster headaches being the most common, characterized by a prevalence of 0.1% to 0.4% and a male predominance [29,30].

The exact pathophysiology of TACs is not well understood; current investigations suggest the involvement of the trigeminovascular system, the autonomic nervous system, and the hypothalamus. Recent functional and anatomic neuroimaging studies have demonstrated changes in the pain neuromatrix including the trigeminal nerve, trigeminovascular complex, and general pain system [30]. TACs are a primary headache disorder; however, the differential diagnosis includes structural lesions affecting the trigeminal autonomic reflex and pain pathways. Therefore, it is usually recommended to rule out a secondary cause of these headaches with neuroimaging. The most common structural lesions are primary pituitary lesions. Other reported lesions include parasellar meningiomas, posterior fossa lesions, vascular lesions such as carotid or vertebral artery dissection, cerebral AVMs, and sinus infections. Possible underlying causes of hemicrania continua include CVT and intracranial metastases [30-33].

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging. A. Arteriography cervicocerebral**

There is no relevant literature to support the use of cervicocerebral arteriography in the initial imaging evaluation of TACs.

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging. B. CT head with IV contrast**

There is no relevant literature to support the use of CT head with IV contrast in the initial imaging evaluation of TACs.

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging. C. CT head without and with IV contrast**

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

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging. D. CT head without IV contrast**

There is no relevant literature to support the use of CT head without IV contrast in the initial imaging evaluation of TACs.

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging.**

**E. CTA head with IV contrast**

There is no relevant literature to support the use of CTA head with IV contrast in the initial imaging evaluation of TACs; it may have utility in follow-up evaluation after initial neuroimaging.

Vascular lesions including carotid/vertebral dissections, AVMs, and aneurysms are a rare, secondary cause of TACs [30,31,33]. The European Headache Federation recommends vascular imaging especially when 3 consecutive preventative treatments fail [34].

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging. F. CTV head with IV contrast**

There is no relevant literature to support the use of CTV head with IV contrast in the initial imaging evaluation of TACs. Brain CTV can be used as a follow-up imaging study in cases of suspected CVT, which is in the differential diagnosis for TACs, especially hemicrania continua. [30,31,33,34].

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging. G. MRA head with IV contrast**

There is no relevant literature to support the use of MRA head with IV contrast in the initial imaging evaluation of TACs.

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging. H. MRA head without and with IV contrast**

There is no relevant literature to support the use of MRA head without and with IV contrast in the initial imaging evaluation of TACs.

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging. I. MRA head without IV contrast**

There is no relevant literature to support the use of MRA head without IV contrast in the initial imaging evaluation of TACs; it may have utility in follow-up evaluation after initial neuroimaging. Vascular lesions including carotid/vertebral dissections, AVMs, and aneurysms are a rare, secondary cause of TACs [30,31,33]. The European Headache Federation recommends vascular imaging especially when 3 consecutive preventative treatments fail [34].

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging. J. MRI head with IV contrast**

There is no relevant literature to support the use of MRI head with IV contrast in the initial imaging evaluation of TACs; the most common recommendation for initial imaging evaluation is MRI head without and with IV contrast.

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging. K. MRI head without and with IV contrast**

MRI head without and with IV contrast is the most common recommendation for initial imaging evaluation of TACs; it is useful to help exclude a secondary headache due to a sellar region or posterior fossa mass.

Structural lesions, especially originating from the pituitary gland, remain the most common secondary cause of TACs, especially cluster headaches. In addition, posterior fossa lesions may also mimic the symptoms of TACs. Brain MRI including dedicated imaging through the sellar region may be useful to exclude pituitary causes of TACs. In addition, routine brain MRI will also be useful to exclude other structural lesions such as intracranial neoplasms (meningiomas) and AVMs, which

are in the differential diagnosis for TACs [30,31,33,34]. Balanced steady-state–free precession sequences can be considered as part of the structureal analysis for TAC and to evaluate potential mass effect on the trigeminal nerve. Short-lasting unilateral neuralgiform headache attacks with conjunctival injection and tearing may be difficult to differentiate from V1 trigeminal neuralgia, and dedicated high-resolution imaging through the brain stem and cranial nerves may also be useful to evaluate for trigeminal nerve compression or other pathology [34].

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging. L. MRI head without IV contrast**

There is no relevant literature to support the use of MRI head without IV contrast in the initial imaging evaluation of TACs; the most common recommendation for initial imaging evaluation is MRI head without and with IV contrast.

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging. M. MRV head with IV contrast**

There is no relevant literature to support the use of MRV head with IV contrast in the initial imaging evaluation of TACs. Brain MRV can be used as a follow-up imaging study in cases of suspected CVT, which is in the differential diagnosis for TACs, especially hemicrania continua [30,31,33,34].

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging. N. MRV head without and with IV contrast**

There is no relevant literature to support the use of MRV head without and with IV contrast in the initial imaging evaluation of TACs. Brain MRV can be used as a follow-up imaging study in cases of suspected CVT, which is in the differential diagnosis for TACs, especially hemicrania continua [30,31,33,34].

**Variant 3: Primary trigeminal autonomic cephalalgias (eg, cluster headache). Initial imaging. O. MRV head without IV contrast**

There is no relevant literature to support the use of MRV head without IV contrast in the initial imaging evaluation of TACs. Brain MRV can be used as a follow-up imaging study in cases of suspected CVT, which is in the differential diagnosis for TACs, especially hemicrania continua [30,31,33,34].

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**

Headache attributed to increased cerebrospinal fluid (CSF) pressure can be accompanied by nausea/vomiting and exacerbated by the Valsalva maneuver (inhibits venous return) or by lying down (redistributes CSF into head). Elevated intracranial pressure can be due to various secondary etiologies such as structural lesions including mass, hydrocephalus, and venous sinus thrombosis [35]. Primary idiopathic intracranial hypertension (IIH), also known previously as pseudotumor cerebri, is characterized as an elevation of intracranial pressure with no identifiable cause. The etiology remains unknown. IIH predominantly impacts women, especially obese women of childbearing age. The prevalence of IIH in the general population ranges between 0.5 and 2 per 100,000. Due to the overlap of symptoms with several other primary headache syndromes, IIH is likely underdiagnosed. Headache is present in 90% of patients with IIH and is commonly the presenting symptom. The diagnostic criteria as per the ICHD-3 includes a documentation of intracranial pressure exceeding 250 mm $H_2O$ (or 280 mm $H_2O$ in obese children). A lumbar puncture to document opening pressure remains a required diagnostic tool for the diagnosis of

IIH. Physical examination findings such as papilledema is a cardinal feature of IIH. Recognition of IIH and treatment is predominantly aimed preserving vision. The role of neuroimaging is mostly to exclude secondary causes of elevated intracranial pressure and to aid in the diagnosis of IIH [23,35,36]. It can also identify venous outflow problems, which can contribute to elevated intracranial pressure in both primary and secondary intracranial hypertension.

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**
**A. Arteriography cervicocerebral**

There is no relevant literature to support the use of cervicocerebral arteriography in the initial imaging evaluation of headache with features of intracranial hypertension.

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**
**B. CT head with IV contrast**

There is no relevant literature to support the use of CT head with IV contrast in the initial imaging evaluation of headache with features of intracranial hypertension.

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**
**C. CT head without and with IV contrast**

There is no relevant literature to support the use of CT head without and with IV contrast in the initial imaging evaluation of headache with features of intracranial hypertension.

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**
**D. CT head without IV contrast**

CT head without IV contrast can be useful in the initial imaging evaluation of headache with features of intracranial hypertension. Papilledema is an indicator for elevated intracranial pressure and is one of the "red flags" that has been demonstrated to be a strong predictor of abnormal imaging findings including structural lesions. Noncontrast head CT can be useful to promptly evaluate for a secondary cause of intracranial hypertension, such as mass, edema, or hydrocephalus [37].

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**
**E. CTA head with IV contrast**

There is no relevant literature to support the use of CTA head with IV contrast in the initial imaging evaluation of headache with features of intracranial hypertension.

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**
**F. CTV head with IV contrast**

Theories regarding the pathophysiology of IIH include venous outflow obstruction leading to increased intracranial pressure, which can compress and narrow the distal transverse sinuses. Several studies have demonstrated a finding of venous sinus stenosis or thrombosis in patients with suspected IIH and patients with chronic headaches, which reinforces the value of venous imaging for unexplained headaches, especially when there are features of intracranial hypertension [38-40]. Several studies have also demonstrated the increased utility of CTV with IV contrast when

compared with time-of-flight MRI techniques [36,38].

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**
**G. MRA head with IV contrast**

There is no relevant literature to support the use of MRA head with IV contrast in the initial imaging evaluation of headache with features of intracranial hypertension.

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**
**H. MRA head without and with IV contrast**

There is no relevant literature to support the use of MRA head without and with IV contrast in the initial imaging evaluation of headache with features of intracranial hypertension.

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**
**I. MRA head without IV contrast**

There is no relevant literature to support the use of MRA head without IV contrast in the initial imaging evaluation of headache with features of intracranial hypertension.

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**
**J. MRI head with IV contrast**

There is no relevant literature to support the use of MRI head with IV contrast in the initial imaging evaluation of headache with features of intracranial hypertension; in most situations, both precontrast and postcontrast imaging will be performed when contrast is administered ("without and with IV contrast").

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**
**K. MRI head without and with IV contrast**

Brain MRI can be useful to detect imaging signs that are associated with primary IIH and to help exclude secondary causes of elevated intracranial pressure, including structural abnormalities such as mass, edema, or hydrocephalus [37]. Although IV contrast is not required to visualize the structural alterations associated with IIH or mass/hydrocephalus, it can be useful for characterization of an intracranial mass and for depiction of the venous sinuses.

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**
**L. MRI head without IV contrast**

MRI head without IV contrast can be useful in the initial imaging evaluation of headache with features of intracranial hypertension. For example, brain MRI can evaluate for secondary causes of elevated intracranial pressure, including structural abnormalities such as mass, edema, or hydrocephalus. In addition, brain MRI can detect subtle findings that have been described in the literature that are associated with primary IIH. Based on a 2011 study including patients with elevated intracranial pressure, 6 signs were more prevalent in patients with IIH: partially empty sella, posterior displacement of the pituitary stalk, flattening of the posterior globe, optic nerve head protrusion, optic nerve sheath distension, and optic nerve sheath tortuosity. Three of the above signs were shown to be highly specific for IIH: partially empty sella, flattening of the

posterior globe, and optic nerve head protrusion [35,41]. A small-scale study has shown the potential utility of semiautomated volumetric evaluation of the optic nerve sheath and hypophysis to help diagnose IIH [42].

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**
**M. MRV head with IV contrast**

Venous outflow obstruction either by an intraluminal thrombus or an extrinsic stenosis has been shown to be associated with elevated intracranial pressure and IIH; therefore, venous imaging such as brain MRV can be useful in the imaging evaluation of headache with features of intracranial hypertension. The decision to use noncontrast (eg, time-of-flight or phase-contrast) versus contrast techniques may depend on the preferences of different institutions. The use of IV contrast helps clearly delineate the venous sinus lumen and avoids some of the flow-related artifacts encountered in noncontrast MRV techniques, which can be more prone to misinterpretation [36,38]. Therefore, noncontrast brain MRV should be interpreted with attention to possible artifacts related to slow or turbulent flow and in conjunction with brain MRI, if previously performed.

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**
**N. MRV head without and with IV contrast**

Venous outflow obstruction either by an intraluminal thrombus or an extrinsic stenosis has been shown to be associated with elevated intracranial pressure and IIH; therefore, venous imaging such as brain MRV can be useful in the imaging evaluation of headache with features of intracranial hypertension. The decision to use noncontrast (eg, time-of-flight or phase-contrast) versus contrast techniques may depend on the preferences of different institutions. The use of IV contrast helps clearly delineate the venous sinus lumen and avoids some of the flow-related artifacts encountered in noncontrast MRV techniques, which can be more prone to misinterpretation [36,38]. Therefore, noncontrast brain MRV should be interpreted with attention to possible artifacts related to slow or turbulent flow and in conjunction with brain MRI, if previously performed.

**Variant 4: Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.**
**O. MRV head without IV contrast**

Venous outflow obstruction either by an intraluminal thrombus or an extrinsic stenosis has been shown to be associated with elevated intracranial pressure and IIH; therefore, venous imaging such as brain MRV can be useful in the imaging evaluation of headache with features of intracranial hypertension. The decision to use noncontrast (eg, time-of-flight or phase-contrast) versus contrast techniques may depend on the preferences of different institutions. The use of IV contrast helps clearly delineate the venous sinus lumen and avoids some of the flow-related artifacts encountered in noncontrast MRV techniques, which can be more prone to misinterpretation [36,38]. Therefore, noncontrast brain MRV should be interpreted with attention to possible artifacts related to slow or turbulent flow and in conjunction with brain MRI, if previously performed.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**

Headache attributed to low CSF pressure, as defined by the International Headache Society's ICHD-3, is primarily characterized by an orthostatic headache, which is worse when upright (redistributes CSF into spine) and which can be accompanied by neck pain, tinnitus, changes in

hearing, photophobia, or nausea. The diagnostic criteria includes either low opening pressure (<60 mm CSF) or evidence of CSF leak on imaging [23]. It should be noted that because of compensatory mechanisms, patients with chronic symptomatic "intracranial hypotension" do not always have low opening pressure (ie, CSF hypovolemia without hypotension). CSF leaks can result from iatrogenic dural defects such as lumbar punctures or other spinal procedures; diagnosing the cause of a new orthostatic headache in this setting is fairly straightforward. In contrast, the diagnosis of SIH can be more difficult and underrecognized. SIH is rare and has a female predominance; it is estimated to affect 5 in 100,000 people per year. It is caused by a spontaneous spinal CSF leak, which has been classified by some authors as follows: type 1, a ventral dural tear due to a disc herniation or endplate osteophyte; type 2, a lateral dural tear at the proximal nerve root sleeve; type 3, a CSF-venous fistula at the distal nerve root sleeve; and type 4, a slow CSF leak at the distal nerve root sleeve [43,44]. Brain imaging in this scenario can be useful to help identify SIH as the cause of a patient's orthostatic headaches, because the symptoms may be unclear or underrecognized due to the rarity of SIH. Spine imaging is also useful in cases of SIH to look for an extradural fluid collection, usually at the level of the thoracic spine, that would be consistent with a dural tear (type 1 or type 2 CSF leak) [45].

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**A. Arteriography cervicocerebral**

There is no relevant literature to support the use of cervicocerebral arteriography in the initial imaging evaluation of headache with features of intracranial hypotension.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**B. CT head with IV contrast**

There is no relevant literature to support the use of CT head with IV contrast in the initial imaging evaluation of headache with features of intracranial hypotension; although some findings of SIH can be detected on noncontrast head CT, contrast-enhanced brain MRI is needed to evaluate for pachymeningeal enhancement.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**C. CT head without and with IV contrast**

There is no relevant literature to support the use of CT head without and with IV contrast in the initial imaging evaluation of headache with features of intracranial hypotension.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**D. CT head without IV contrast**

There is no relevant literature to support the use of CT head without IV contrast in the initial imaging evaluation of headache with features of intracranial hypotension.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**E. CTA head with IV contrast**

There is no relevant literature to support the use of CTA head with IV contrast in the initial imaging evaluation of headache with features of intracranial hypotension.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when**

**upright, better when lying down). Initial imaging.**
**F. CTV head with IV contrast**

There is no relevant literature to support the use of CTV head with IV contrast in the initial imaging evaluation of headache with features of intracranial hypotension.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**G. MRA head with IV contrast**

There is no relevant literature to support the use of MRA head with IV contrast in the initial imaging evaluation of headache with features of intracranial hypotension.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**H. MRA head without and with IV contrast**

There is no relevant literature to support the use of MRA head without and with IV contrast in the initial imaging evaluation of headache with features of intracranial hypotension.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**I. MRA head without IV contrast**

There is no relevant literature to support the use of MRA head without IV contrast in the initial imaging evaluation of headache with features of intracranial hypotension.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**J. MRI head with IV contrast**

There is no relevant literature to support the use of MRI head with IV contrast in the initial imaging evaluation of headache with features of intracranial hypotension; in most situations, both precontrast and postcontrast imaging will be performed when contrast is administered ("without and with IV contrast").

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**K. MRI head without and with IV contrast**

MRI head without and with IV contrast is useful in the initial imaging evaluation of headache with features of intracranial hypotension. The most common brain MRI findings include pachymeningeal enhancement (reported in 83% of patients), subdural fluid collections, brain/brainstem sagging, downward displacement of cerebellar tonsils, distension of venous structures/sinuses, and enlargement of the pituitary gland. Orbital findings include a collapsed optic nerve sheath and a straightened optic nerve angle. It should be noted that the venous sinus, pituitary gland, and optic nerve sheath findings are opposite of what is seen in IIH or intracranial hypertension, as expected. It should also be noted that these need to be interpreted in the appropriate clinical context of orthostatic headaches, because there are other diseases with overlapping imaging findings: downward displacement of cerebellar tonsils in Chiari type 1 malformation, subdural fluid collections due to trauma, and diffuse dural thickening due to inflammatory conditions such as immunoglobulin G4-related disease and neurosarcoidosis [43-45].

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**

**L. MRI head without IV contrast**

There is no relevant literature to support the use of MRI head without IV contrast in the initial imaging evaluation of headache with features of intracranial hypotension; although some findings of SIH can be detected on noncontrast brain MRI, contrast-enhanced brain MRI is needed to evaluate for pachymeningeal enhancement.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**M. MRI thoracic spine with IV contrast**

Although the primary purpose of spine imaging is to look for an extradural fluid collection that would be consistent with a dural tear, which does not require contrast, there may be scenarios where postcontrast imaging of the spine is reasonable, for example, when contrast is being administered for concurrent brain MRI or when contrast is needed to differentiate enhancing epidural venous distension from nonenhancing epidural fluid collection.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**N. MRI thoracic spine without and with IV contrast**

Although the primary purpose of spine imaging is to look for an extradural fluid collection that would be consistent with a dural tear, which does not require contrast, there may be scenarios where postcontrast imaging of the spine is reasonable, for example, when contrast is being administered for concurrent brain MRI or when contrast is needed to differentiate enhancing epidural venous distension from nonenhancing epidural fluid collection.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**O. MRI thoracic spine without IV contrast**

MRI spine without IV contrast is useful in the initial imaging evaluation of headache with features of intracranial hypotension. The primary purpose is to look for an extradural fluid collection in the spinal canal, usually at the level of the thoracic spine, that would be consistent with a dural tear (type 1 or type 2 CSF leak). Identification of such a fluid collection can help to guide further management or to confirm a diagnosis of SIH in rare cases in which brain MRI is normal. Other spine MRI findings that have been reported in SIH include dural enhancement, distension of epidural veins, and abnormal visualization of nerve root sleeves. Although some patients with a spinal CSF leak will respond to horizontal bedrest and/or nontargeted epidural blood patches in the lumbar spine, others will have refractory symptoms and require spinal CSF leak localization for targeted therapy.

Heavily T2-weighted MR myelography without the use of intrathecal contrast is an emerging noninvasive technique for detecting CSF leaks without the need for a lumbar puncture and radiation exposure. This technique can also be used to guide targeted epidural blood patches. A study conducted in Korea replaced CT myelography with heavily T2-weighted MR myelography (performed on a 3T MRI) for 26 patients who presented with headache attributed to low CSF pressure. This study demonstrated CSF leak detection in 80.8% of the patients. The findings of heavily T2-weighted MR myelography was used to plan epidural blood patches placement; complete relief of symptoms was achieved in 82.4% of patients in whom a CSF leak was seen using heavily T2-weighted MR myelography [46].

Minimally invasive methods for spinal CSF leak localization include conventional CT myelography, dynamic CT myelography, digital subtraction myelography, and MR myelography with intrathecal injection of contrast. These techniques are, therefore, useful in the follow-up imaging evaluation of headache with features of intracranial hypotension, when refractory to nontargeted therapy. The choice between spinal CSF leak localization techniques may depend on the suspected CSF leak type (dural tear versus distal nerve root sleeve) and also on the preferences of different institutions. Although radioisotope cisternography can be used in some scenarios to help confirm the presence of a spinal CSF leak, it has insufficient spatial resolution for precise leak localization.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**P. MRV head with IV contrast**

There is no relevant literature to support the use of MRV head with IV contrast in the initial imaging evaluation of headache with features of intracranial hypotension.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**Q. MRV head without and with IV contrast**

There is no relevant literature to support the use of MRV head without and with IV contrast in the initial imaging evaluation of headache with features of intracranial hypotension.

**Variant 5: Headache with features of intracranial hypotension (eg, positional, worse when upright, better when lying down). Initial imaging.**
**R. MRV head without IV contrast**

There is no relevant literature to support the use of MRV head without IV contrast in the initial imaging evaluation of headache with features of intracranial hypotension.

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**

Thirty-five percent of pregnant women and 40% of postpartum women experience headache. Although migraine headaches are common, evidence shows that during the second trimester, migraine symptoms typically improve. More than a third of pregnant women presenting to the hospital can have a secondary headache [47-49].

Total blood volume increase (by 40% at term) and rising progesterone levels in the third trimester can contribute to increased venous compliance. These are factors that can explain some of the neurological complications in pregnancy [49]. A study at an urban medical center conducted over a 5-year period examining 140 pregnant women presenting with acute headache demonstrated an incidence of secondary headaches in 35%. Within this group, hypertensive disorder of pregnancy was most common, predominated by preeclampsia [47].

Various secondary headaches are more likely to occur during pregnancy, which may be related to hypercoagulability, hormonal factors, and anesthesia for labor. Pregnancy-induced hypercoagulability is an adaptive physiologic mechanism that reduces the risk of hemorrhage but increases the risk of thromboembolism; this risk extends into the postpartum period, which is defined as the first 6 weeks following delivery. Conditions related to the hypercoagulability and endothelial dysfunction include cerebral venous sinus thrombosis and RCVS. A subset of pregnancy-related RCVS is postpartum angiopathy, which is an important cause of headache in

these patients and which may be underdiagnosed. Intracranial hypotension from iatrogenic CSF leak is another important consideration in postpartum patients, which may follow spinal anesthesia or inadvertent dural puncture during epidural anesthesia (also refer to Variant 5) [12,49].

The incidence of primary malignant tumors in pregnant women is slightly lower than in nonpregnant women; however, studies have shown that both tumor volume and growth increase during pregnancy, especially with respect to gliomas. Lesions such as meningiomas express progesterone receptors and are known to regress after pregnancy. These gestational tumoral changes also correlated with clinical worsening and increased frequency of seizure that may precipitate obstetrical emergencies [50]. Breast cancer and choriocarcinoma are 2 of the most common types of cancers that can metastasize to the brain in pregnancy [49].
Pituitary disorders are also a cause of symptoms during pregnancy. The adenohypophysis increases in volume by 30% in pregnancy. Prolactinomas are the most common pituitary tumors occurring during pregnancy, and a small percentage of microadenomas show signs of tumor enlargement. Lymphocytic hypophysitis is a rare inflammatory autoimmune disorder of the pituitary gland/stalk that can occur in the postpartum period or in the third trimester. Typically, these lesions can present with visual symptoms due to impingement of the optic chiasm in addition to symptoms of headache and hypopituitarism. Pituitary apoplexy can present similarly in the setting of postpartum hemorrhage (Sheehan syndrome) [49].

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**
**A. Arteriography cervicocerebral**

There is no relevant literature to support the use of cervicocerebral arteriography in the initial imaging evaluation of new headache during pregnancy or peripartum period.

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**
**B. CT head with IV contrast**

There is no relevant literature to support the use of CT head with IV contrast in the initial imaging evaluation of new headache during pregnancy or peripartum period.

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**
**C. CT head without and with IV contrast**

There is no relevant literature to support the use of CT head without and with IV contrast in the initial imaging evaluation of new headache during pregnancy or peripartum period.

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**
**D. CT head without IV contrast**

CT head without IV contrast can be useful in the initial imaging evaluation of new headache during pregnancy or peripartum period, especially when the headache is acute or "thunderclap” in nature. For pregnant or postpartum patients presenting with new TCH, it is essential to exclude SAH, which has a 20-fold increase in incidence in the immediate postpartum period [51]. As discussed in Variant 1, several studies have demonstrated the negative predictive value of a head CT performed within 6 hours of headache onset in detecting aneurysmal SAH ranging between 99.9% and 100% when interpreted by qualified radiologists. When performed within the first 24 hours, the sensitivity

ranges between 90% and 100% [16,17]. This patient population is also at an increased risk for RCVS, and for suspected cases of RCVS, a noncontrast CT head with special attention to the presence of convexity SAH can be beneficial [12]. CVT is an additional diagnosis that this demographic is at an increased risk for because of the hypercoagulability seen in pregnancy. A noncontrast head CT may be useful to visualize hyperattenuating thrombus within a dural venous sinus or hypoattenuating parenchymal edema related to venous ischemia, especially if the patient presents with a focal neurologic defect [11].

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**
**E. CTA head with IV contrast**

There is no relevant literature to support the use of CTA head with IV contrast in the initial imaging evaluation of new headache during pregnancy or peripartum period, unless there is TCH and suspicion for aneurysmal SAH or RCVS (also refer to Variant 1). Overall, the risk of intracerebral hemorrhage in pregnant women is rare; however, the risk of SAH rises dramatically in the postpartum period. As such, these patients may present with a classic TCH, and etiologies for SAH should be considered. Other conditions such as arterial dissections are also seen in pregnancy and are usually associated with preeclampsia [51]. After an initial head CT, a concurrent or follow-up CTA is useful in suspected cases of intracranial aneurysm (ruptured or unruptured), arterial dissection, and RCVS, which can occur within the first month of pregnancy and most often within 10 days [10-12,18,49].

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**
**F. CTV head with IV contrast**

CTV head with IV contrast can be useful in the initial imaging evaluation of new headache during pregnancy or peripartum period, as this patient demographic is at a higher risk for thromboembolic complications such as CVT, especially in the postpartum period [12,49]. In pregnant patients requiring contrast-enhanced evaluation of the dural venous sinuses, CTV is the modality of choice because iodinated contrast agents are generally considered safer than gadolinium-based contrast agents (GBCA) with regard to potential effects on the fetus. After an initial head CT, a concurrent or follow-up CTV is useful in suspected cases of venous thrombosis.

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**
**G. MRA head with IV contrast**

There is no relevant literature to support the use of MRA head with IV contrast in the initial imaging evaluation of new headache during pregnancy or peripartum period; the recommendation is to avoid administering IV GBCA during pregnancy.

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**
**H. MRA head without and with IV contrast**

There is no relevant literature to support the use of MRA head without and with IV contrast in the initial imaging evaluation of new headache during pregnancy or peripartum period; the recommendation is to avoid administering IV GBCA during pregnancy.

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**

**I. MRA head without IV contrast**

There is no relevant literature to support the use of MRA head without IV contrast in the initial imaging evaluation of new headache during pregnancy or peripartum period. In some scenarios, brain MRA may be useful following or in conjunction with brain MRI when evaluating for cerebrovascular etiologies of headache such as RCVS [12,52].

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**

**J. MRI head with IV contrast**

There is no relevant literature to support the use of MRI head with IV contrast in the initial imaging evaluation of new headache during pregnancy or peripartum period; the recommendation is to avoid administering IV GBCA during pregnancy.

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**

**K. MRI head without and with IV contrast**

There is no relevant literature to support the use of MRI head without and with IV contrast in the initial imaging evaluation of new headache during pregnancy or peripartum period; the recommendation is to avoid administering IV GBCA during pregnancy.

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**

**L. MRI head without IV contrast**

MRI head without IV contrast can be useful in the initial imaging evaluation of new headache during pregnancy or peripartum period. There are multiple etiologies that can cause secondary headaches in pregnant women. For TCH, there is the possibility of arterial pathologies such as aneurysmal SAH or RCVS, especially in the postpartum period (also refer to Variant 1). Structural lesions include intracranial neoplasms and lesions originating from the pituitary gland. Another condition to consider is intracranial hypertension, especially in an obese female (also refer to variant 4). Preeclampsia and eclampsia are diseases of pregnancy that can present with headache and with findings of PRES on neuroimaging [47,49-51]. Brain MRI is the study of choice to evaluate for vasogenic edema due to endothelial dysfunction in PRES. It is best seen on FLAIR and T2-weighted imaging, which is more sensitive for abnormalities in the posterior fossa than head CT, which is abnormal in 45% of patients with PRES. In the setting of headache with new onset seizures, MRI can potentially detect the causative mass/lesion or PRES to support a diagnosis of eclampsia. [49,50]. Lesions originating from the pituitary gland are also readily detectable on MRI [30,49].

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**

**M. MRV head with IV contrast**

There is no relevant literature to support the use of MRV head with IV contrast in the initial imaging evaluation of new headache during pregnancy or peripartum period; the recommendation is to avoid administering IV GBCA during pregnancy.

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**

**N. MRV head without and with IV contrast**

There is no relevant literature to support the use of MRV head without and with IV contrast in the

initial imaging evaluation of new headache during pregnancy or peripartum period; the recommendation is to avoid administering IV GBCA during pregnancy.

**Variant 6: Headache with new onset or pattern during pregnancy or peripartum period. Initial imaging.**
**O. MRV head without IV contrast**

MRV head without IV contrast can be useful in the initial imaging evaluation of new headache during pregnancy or peripartum period, because this patient demographic is at a higher risk for thromboembolic complications such as CVT, especially in the postpartum period [12,49]. After an initial brain MRI, a concurrent or follow-up MRV is useful in suspected cases of venous thrombosis. Because the recommendation is to avoid administering IV GBCA during pregnancy, this is typically performed using a noncontrast technique such as time-of-flight or phase-contrast imaging.

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. Initial imaging.**

The use of a list of "red flags" can help to triage patients that benefit most from imaging and are more likely to have a secondary cause of headache. This process can help to decrease the indiscriminate use of imaging and expedite the need for imaging in certain patients. Several studies have demonstrated an increased incidence of a secondary cause of headache in patients screened for "red flags" when compared with patients without concerning symptoms. One of the earliest studies to establish a screening tool for patients presenting with headache was published in the *British Journal of Radiology* in 2003. The study looked at 111 patients who complained of headache, and 20 red flags were selected for analysis. There was a significant correlation between the presence of a secondary headache and 5 of the red flags: papilledema, impaired consciousness, asymmetric pupillary response, progressive visual or neurological response, and paralysis [37]. This study included age over 50 as one of the red flags.

Over the course of the last 2 decades, several studies have demonstrated a higher incidence of neuropathology for selected patients with certain red and orange flags. For example, a British literature review demonstrated that in the primary care setting, the risk of a brain tumor with a headache presentation is 0.09%; however, when the headache was associated with abnormal findings on neurologic examination, with aggravation by exertion, with vomiting, or with focal symptoms or worsening headaches, there was a higher risk of tumor. The same review also suggested an increased risk of neoplasm with older age [53]. Another study following 530 new patients presenting to an outpatient headache service over 5 years demonstrated intracranial abnormalities in 1.2% of those diagnosed with migraines, 0.9% of those diagnosed with TCH, and 5.5% of those who were "flagged" based on a screening tool [54]. A list of common "red flags" were selected for this variant; however, they are not exhaustive. Several other evidence-based studies included the SNOOP and the more lengthy "SNNOOP10" acronym of red and orange flags for secondary headaches: Systemic symptoms including fever, Neoplasm history, Neurologic deficit including decreased consciousness, sudden or abrupt Onset, Older age, etc [55]. Many of these red flags, including sudden onset or positional headache or papilledema or pregnancy, have been discussed in previous variants.

Posttraumatic onset headaches are defined as those that develop within a 7-day interval of trauma by the ICHD-3; this subset of headaches is defined as chronic or persistent if they persist beyond 3 months [23,55].

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. Initial imaging.**
**A. Arteriography cervicocerebral**

There is no relevant literature to support the use of cervicocerebral arteriography in the initial imaging evaluation of headache with one or more of the listed "red flags."

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. Initial imaging.**
**B. CT head with IV contrast**

There is no relevant literature to support the use of CT head with IV contrast in the initial imaging evaluation of headache with one or more of the listed "red flags."

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. Initial imaging.**
**C. CT head without and with IV contrast**

There is no relevant literature to support the use of CT head without and with IV contrast in the initial imaging evaluation of headache with one or more of the listed "red flags."

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. Initial imaging.**
**D. CT head without IV contrast**

CT head without IV contrast can be useful in the initial imaging evaluation of headache with one or more of the listed "red flags," which are associated with a higher likelihood of intracranial neuropathology. Patients presenting with acute neurologic or mental status deficits and patients presenting in the setting of recent trauma would benefit from head CT as an initial study to exclude intracranial hemorrhage as a cause of secondary headache [55,56].

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. Initial imaging.**
**E. CTA head with IV contrast**

There is no relevant literature to support the use of CTA head with IV contrast in the initial imaging evaluation of headache with one or more of the listed "red flags." For patients presenting with TCH, please refer to the discussion in Variant 1 [56].

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. Initial imaging.**
**F. CTV head with IV contrast**

There is no relevant literature to support the use of CTV head with IV contrast in the initial imaging evaluation of headache with one or more of the listed "red flags." Following initial evaluation with a noncontrast head CT, head CTV can be useful when there are clinical or imaging findings suspicious for CVT. For example, a history of cancer may indicate a hypercoagulable state, which would present an increased risk for CVT [55,57].

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. Initial imaging.**
**G. MRA head with IV contrast**

There is no relevant literature to support the use of MRA head with IV contrast in the initial imaging evaluation of headache with one or more of the listed "red flags." For patients presenting with TCH, please refer to the discussion in Variant 1 [56].

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. Initial imaging.**
**H. MRA head without and with IV contrast**

There is no relevant literature to support the use of MRA head without and with IV contrast in the initial imaging evaluation of headache with one or more of the listed "red flags."

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. Initial imaging.**
**I. MRA head without IV contrast**

There is no relevant literature to support the use of MRA head without IV contrast in the initial imaging evaluation of headache with one or more of the listed "red flags."

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. Initial imaging.**
**J. MRI head with IV contrast**

There is no relevant literature to support the use of MRI head with IV contrast in the initial imaging evaluation of headache with one or more of the listed "red flags"; in most situations, both precontrast and postcontrast imaging will be performed when contrast is administered ("without and with IV contrast").

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. Initial imaging.**
**K. MRI head without and with IV contrast**

MRI head without and with IV contrast can be useful in the initial imaging evaluation of headache with one or more of the listed "red flags," which are associated with a higher likelihood of intracranial neuropathology. The literature examining the usefulness of "red flags" as indicators to proceed to neuroimaging considers both CT and MRI as appropriate initial options. No specific data are currently available to favor one imaging modality over another at this time, especially given the wide range of potential etiologies. Given the higher soft tissue resolution of MRI when compared with CT, MRI may be the preferred initial imaging modality, especially outside of the acute setting. Much of the literature includes both CT and MRI as the initial imaging modalities considered [37,53,55,58]. In patients with headaches and one or more of the listed "red flags," the addition of IV contrast can be useful in the diagnosis of neoplastic or inflammatory diseases, in which there is breakdown of the blood-brain barrier [59].

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age**

**(>50 years) of onset, or posttraumatic onset. Initial imaging.**
**L. MRI head without IV contrast**

MRI head without IV contrast can be useful in the initial imaging evaluation of headache with one or more of the listed "red flags," which are associated with a higher likelihood of intracranial neuropathology. The literature examining the usefulness of "red flags" as indicators to proceed to neuroimaging considers both CT and MRI as appropriate initial options. No specific data are currently available to favor one imaging modality over another at this time, especially given the wide range of potential etiologies. Given the higher soft tissue resolution of MRI when compared with CT, MRI may be the preferred initial imaging modality, especially outside of the acute setting. Much of the literature includes both CT and MRI as the initial imaging modalities considered [37,53,55,58].

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. Initial imaging.**
**M. MRV head with IV contrast**

There is no relevant literature to support the use of MRV head with IV contrast in the initial imaging evaluation of headache with one or more of the listed "red flags." Following initial evaluation with a brain MRI, brain MRV can be useful when there are clinical or imaging findings suspicious for CVT. For example, a history of cancer may indicate a hypercoagulable state, which would present an increased risk for CVT [55,57].

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. Initial imaging.**
**N. MRV head without and with IV contrast**

There is no relevant literature to support the use of MRV head without and with IV contrast in the initial imaging evaluation of headache with one or more of the listed "red flags." Following initial evaluation with a brain MRI, brain MRV can be useful when there are clinical or imaging findings suspicious for CVT. For example, a history of cancer may indicate a hypercoagulable state, which would present an increased risk for CVT [57,59].

**Variant 7: Headache with one or more of the following "red flags": increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset. Initial imaging.**
**O. MRV head without IV contrast**

There is no relevant literature to support the use of MRV head without IV contrast in the initial imaging evaluation of headache with one or more of the listed "red flags." Following initial evaluation with a brain MRI, brain MRV can be useful when there are clinical or imaging findings suspicious for CVT. For example, a history of cancer may indicate a hypercoagulable state, which would present an increased risk for CVT [57,59].

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-traumatic onset. Initial imaging.**

Headaches can carry significant morbidity for affected patients. Several clinical decision support

guidelines advise against routine imaging for many of these headaches. Most of these headaches are primary headaches such as migraine headaches and TTHs. Several studies have demonstrated a low yield of positive neuroimaging findings that require a change in management for these headaches. A study in China examining 1,070 patients with primary headaches and 1,070 asymptomatic patients demonstrated a rate of significant neuroimaging abnormalities in 0.58% of primary headache sufferers versus 0.73% of healthy controls [25]. Likewise, a study by Sempere et al [26] with neuroimaging for 1,876 consecutive patients with headache found a 1.2% incidence of significant lesions. Another study conducted over a 2-year period looked at 402 patients receiving an MRI for a primary complaint of headache with duration >3 months, no other neurologic symptoms, and evaluation by a neurologist. This study documented a major abnormality in 3.7% of patients: 0.6% of patients with migraine, 1.4% of patients with TTH, and 14.1% of patients with atypical headaches, which are defined as those that do not fit into any of 15 categories of headaches classified by the International Headache Society. Another predictor of abnormal imaging findings in this study was age, with an incidence of abnormalities of 2.2% in patients between 18 to 39 years of age, 8.3% in patients 40 to 59 years of age, and 2.6% of those >60 years of age [60].

Given the overall low incidence of significant neuroimaging findings, the ACR in the Choosing Wisely campaign (http://www.choosingwisely.org) advocates no imaging for uncomplicated headaches. For headache in the setting of suspected rhinosinusitis, please also refer to ACR Appropriateness Criteria® topic on "Sinonasal Disease" [8].

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-traumatic onset. Initial imaging.**
**A. Arteriography cervicocerebral**

There is no relevant literature to support the use of cervicocerebral arteriography in the initial imaging evaluation of headache without any "red flags."

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-traumatic onset. Initial imaging.**
**B. CT head with IV contrast**

There is no relevant literature to support the use of CT head with IV contrast in the initial imaging evaluation of headache without any "red flags."

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-traumatic onset. Initial imaging.**
**C. CT head without and with IV contrast**

There is no relevant literature to support the use of CT head without and with IV contrast in the initial imaging evaluation of headache without any "red flags."

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-traumatic onset. Initial imaging.**
**D. CT head without IV contrast**

There is no relevant literature to support the use of CT head without IV contrast in the initial imaging evaluation of headache without any "red flags." Several studies have demonstrated a low yield of positive imaging findings in patients without concerning "red flags" [25,26,60]. The American Headache Society specifically advises against neuroimaging studies in patients with stable headaches that meet criteria for migraine headaches; it also advises the use of MRI over head CT when MRI is available [61].

One study examining 3,630 patient records noted clinically significant abnormal noncontrast CT scans in 7 patients who had a normal neurologic examination. In this study, these 7 patients described their headaches as severe and nonremitting. The study concludes that noncontrast head CT may be useful for patients suffering from severe and unremitting headaches [62].

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-traumatic onset. Initial imaging.**
**E. CTA head with IV contrast**

There is no relevant literature to support the use of CTA head with IV contrast in the initial imaging evaluation of headache without any "red flags."

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-traumatic onset. Initial imaging.**
**F. CTV head with IV contrast**

There is no relevant literature to support the use of CTV head with IV contrast in the initial imaging evaluation of headache without any "red flags."

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-traumatic onset. Initial imaging.**
**G. MRA head with IV contrast**

There is no relevant literature to support the use of MRA head with IV contrast in the initial imaging evaluation of headache without any "red flags."

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-**

**traumatic onset. Initial imaging.**
**H. MRA head without and with IV contrast**

There is no relevant literature to support the use of MRA head without and with IV contrast in the initial imaging evaluation of headache without any "red flags."

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-traumatic onset. Initial imaging.**
**I. MRA head without IV contrast**

There is no relevant literature to support the use of MRA head without IV contrast in the initial imaging evaluation of headache without any "red flags."

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-traumatic onset. Initial imaging.**
**J. MRI head with IV contrast**

There is no relevant literature to support the use of MRI head with IV contrast in the initial imaging evaluation of headache without any "red flags."

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-traumatic onset. Initial imaging.**
**K. MRI head without and with IV contrast**

There is no relevant literature to support the use of MRI head without and with IV contrast in the initial imaging evaluation of headache without any "red flags."

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-traumatic onset. Initial imaging.**
**L. MRI head without IV contrast**

There is no relevant literature to support the use of MRI head without IV contrast in the initial imaging evaluation of headache without any "red flags." A study specifically examining MRI findings in patients with patheadache found major abnormalities in 0.6% of those with migraine headaches and 1.4% in those patients with TTH [60]. The current guidelines do not support routine neuroimaging in patients with stable chronic headache without atypical features that would be concerning for secondary headache.

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-**

**traumatic onset. Initial imaging.**
**M. MRV head with IV contrast**

There is no relevant literature to support the use of MRV head with IV contrast in the initial imaging evaluation of headache without any "red flags."

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-traumatic onset. Initial imaging.**
**N. MRV head without and with IV contrast**

There is no relevant literature to support the use of MRV head without and with IV contrast in the initial imaging evaluation of headache without any "red flags."

**Variant 8: Headache without any of the following "red flags": sudden onset ("thunderclap"), features of intracranial hypertension or hypotension, new onset or pattern during pregnancy or peripartum period, increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (greater than 50 years of age) of onset, or post-traumatic onset. Initial imaging.**
**O. MRV head without IV contrast**

There is no relevant literature to support the use of MRV head without IV contrast in the initial imaging evaluation of headache without any "red flags."

**Summary of Highlights**

This is a summary of the key recommendations from the variant tables. Refer to the complete narrative document for more information.

- **Variant 1**: In the setting of sudden onset severe headache that reaches maximal severity within 1 hour, CT head without IV contrast is usually appropriate as the initial imaging study. A complementary examination is a CTA head with IV contrast, which may be appropriate when performed in conjunction with noncontrast head CT, particularly in the setting of a thunderclap headache presenting with sudden onset severe headache >6 hours.
- **Variant 2**: In the setting of a primary migraine or TTH with normal neurologic examination, imaging is usually not appropriate. Despite the clinical and social impact of the 2 most common primary headaches, studies have demonstrated very few significant structural abnormalities on neuroimaging in this patient group.
- **Variant 3**: In the setting of primary TACs or cluster headaches, MRI head without and with IV contrast is appropriate as the initial imaging examination. TACs are a primary headache disorder; however, the differential diagnosis includes structural lesions involving the pituitary gland (most commonly) and the posterior fossa. Therefore, it is usually recommended to rule out a secondary cause of these headaches with neuroimaging.
- **Variant 4**: In the setting of headache with features of IIH, imaging is useful to exclude secondary causes of elevated intracranial pressure. CT head without IV contrast, MRI head without IV contrast, and MRI head without and with IV contrast are all appropriate alternative initial imaging examinations. Venous outflow obstruction has been shown to be associated with elevated intracranial pressure and IIH; therefore, venous imaging techniques such as MRV or CTV may be appropriate as complementary examinations in selected clinical settings.

- **Variant 5**: In the setting of headache with features of intracranial hypotension (SIH), MRI head without and with IV contrast is usually appropriate as the initial imaging study. Imaging showing typical imaging findings can help clarify SIH as the cause of a orthostatic headaches given the rarity of SIH. Spine imaging may be useful in cases of SIH to look for an extradural fluid collection, usually at the level of the thoracic spine. MRI thoracic spine without IV contrast or MRI thoracic spine with and without IV contrast may be appropriate as complementary alternative imaging examinations to brain MRI.
- **Variant 6**: In the setting of new onset or new pattern of headache during pregnancy or the peripartum period, MRI without IV contrast or CT without IV contrast are usually appropriate as complementary initial imaging studies. Pregnant women are at a higher risk of thromboembolic complications such as CVT; therefore, an MRV head without IV contrast or a CTV with IV contrast are alternate examinations that may be appropriate given the specific clinical scenario.
- **Variant 7**: In the setting of headache with one or more of the following "red flags"—increasing frequency or severity, fever or neurologic deficit, history of cancer or immunocompromise, older age (>50 years) of onset, or posttraumatic onset—imaging is useful to identify patients with secondary cause of headache. CT head without IV contrast, MRI head without IV contrast, or an MRI head without and with IV contrast are usually appropriate as initial imaging choices. No specific data is currently available to favor one imaging modality over another at this time, especially given the wide range of potential etiologies. As such, these examinations may be either complementary or alternative depending on the clinical context.
- **Variant 8**: In the setting of headache without any "red flags," imaging is usually not appropriate. Most of these headaches are primary headaches such as migraine headaches and TTHs. Several studies have demonstrated a low yield of positive neuroimaging findings that require a change in management for these headaches; as such, clinical decision support guidelines advise against routine imaging for many of these headaches.

**Supporting Documents**

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

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

**Safety Considerations in Pregnant Patients**

Imaging of the pregnant patient can be challenging, particularly with respect to minimizing radiation exposure and risk. For further information and guidance, see the following ACR documents:

· ACR–SPR Practice Parameter for the Safe and Optimal Performance of Fetal Magnetic Resonance Imaging (MRI)

· ACR-SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Patients with Ionizing Radiation

· ACR-ACOG-AIUM-SMFM-SRU Practice Parameter for the Performance of Standard

Diagnostic Obstetrical Ultrasound
- ACR Manual on Contrast Media
- ACR Manual on MR Safety

**Appropriateness Category Names and Definitions**

| Appropriateness Category Name | Appropriateness Rating | Appropriateness Category Definition |
|---|---|---|
| Usually Appropriate | 7, 8, or 9 | The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients. |
| May Be Appropriate | 4, 5, or 6 | The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal. |
| May Be Appropriate (Disagreement) | 5 | The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned. |
| Usually Not Appropriate | 1, 2, or 3 | The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable. |

**Relative Radiation Level Information**

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

**Relative Radiation Level Designations**

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

☢☢☢☢☢ 30-100 mSv 10-30 mSv

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

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**Disclaimer**

The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

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