Date of origin: 1996
Last review date: 2013

American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Headache**

Variant 1: **Chronic headache. No new features. Normal neurologic examination.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with IV contrast	4		O
MRI head without IV contrast	4		O
CT head without IV contrast	3		☢☢☢
CT head without and with IV contrast	3		☢☢☢
CT head with IV contrast	3		☢☢☢
MRA head without and with IV contrast	2		O
MRA head without IV contrast	2		O
Arteriography cervicocerebral	2		☢☢☢
CTA head with IV contrast	2		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 2: **Chronic headache with new feature or neurologic deficit.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with IV contrast	8		O
MRI head without IV contrast	7		O
CT head without IV contrast	7		☢☢☢
CT head without and with IV contrast	5		☢☢☢
MRA head without and with IV contrast	4		O
MRA head without IV contrast	4	Perform this procedure in selected cases when vascular disease suspected.	O
CTA head with IV contrast	4		☢☢☢
CT head with IV contrast	3		☢☢☢
Arteriography cervicocerebral	2	This procedure is not used as a primary diagnostic tool.	☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition: **Headache**

Variant 3: **Sudden onset of severe headache ("Worst headache of my life", "thunderclap headache").**

Radiologic Procedure	Rating	Comments	RRL*
CT head without IV contrast	9		☢☢☢
CTA head with IV contrast	8		☢☢☢
MRA head without and with IV contrast	7		O
MRA head without IV contrast	7		O
Arteriography cervicocerebral	7		☢☢☢
MRI head without IV contrast	7	This procedure may be helpful after CT depending on CT findings. Include FLAIR and GRE or SWI in this procedure.	O
MRI head without and with IV contrast	6	Include FLAIR and GRE or SWI in this procedure. This procedure may be helpful after CT depending on CT findings.	O
CT head without and with IV contrast	5		☢☢☢
CT head with IV contrast	3		☢☢☢
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Clinical Condition: **Headache**

Variant 4: **Sudden onset of unilateral headache or suspected carotid or vertebral dissection or ipsilateral Horner syndrome.**

Radiologic Procedure	Rating	Comments	RRL*
CTA head and neck with IV contrast	8		☢☢☢
MRA head without IV contrast	8		O
MRA neck without and with IV contrast	8	Include T1 fat-saturated axial images in this procedure.	O
MRI head without and with IV contrast	8	Perform this procedure with DWI sequences.	O
MRI head without IV contrast	8	Perform this procedure with DWI sequences.	O
MRA neck without IV contrast	7	Include T1 fat-saturated axial images in this procedure.	O
CT head without IV contrast	7		☢☢☢
MRA head without and with IV contrast	6		O
MRI neck without and with IV contrast	6	Include T1 fat-saturated axial images in this procedure.	O
Arteriography cervicocerebral	6		☢☢☢
CT head without and with IV contrast	6		☢☢☢
CT head with IV contrast	6		☢☢☢
MRI neck without IV contrast	5	Include T1 fat-saturated axial images in this procedure.	O
MRI cervical spine without and with IV contrast	5		O
MRI cervical spine without IV contrast	4		O
CT neck with IV contrast	4		☢☢☢
CT neck without and with IV contrast	4		☢☢☢
CT neck without IV contrast	3		☢☢☢
US duplex Doppler carotid	3		O
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Clinical Condition: **Headache**

Variant 5: **Headache of trigeminal autonomic origin.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with IV contrast	8		O
MRI head without IV contrast	7		O
CT head without and with IV contrast	6		☢☢☢
CT head without IV contrast	5		☢☢☢
CT head with IV contrast	5		☢☢☢
MRA head without IV contrast	5		O
CTA head with IV contrast	5		☢☢☢
MRA head without and with IV contrast	4		O
Arteriography cervicocerebral	2		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 6: **Headache of skull base, orbital, or periorbital origin.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head and orbits without and with IV contrast	8		O
MRI head and orbits without IV contrast	7		O
CT head and orbits without and with IV contrast	7		☢☢☢
CT head and orbits with IV contrast	7		☢☢☢
CT head and orbits without IV contrast	6		☢☢☢
MRA head without and with IV contrast	5		O
MRA head without IV contrast	5		O
CTA head with IV contrast	5		☢☢☢
Arteriography cervicocerebral	2		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition: Headache

Variant 7: Headache, suspected intracranial complication of sinusitis and/or mastoiditis. (See the ACR Appropriateness Criteria® on "Sinonasal Disease")

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with IV contrast	8		O
MRI head without IV contrast	6		O
CT head without IV contrast	6		☢☢☢
CT head without and with IV contrast	6		☢☢☢
CT head with IV contrast	5		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 8: Headache of oromaxillofacial origin.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with IV contrast	8		O
MRI head without IV contrast	7		O
CT head with IV contrast	6		☢☢☢
CT head without IV contrast	5		☢☢☢
CT head without and with IV contrast	5		☢☢☢
MRA head without IV contrast	3		O
MRA head without and with IV contrast	3		O
CTA head with IV contrast	3		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition: Headache

Variant 9: New headache in elderly patients. Sedimentation rate higher than 55, temporal tenderness. Suspected temporal arteritis.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with IV contrast	9	Perform this procedure with DWI sequences.	O
MRI head without IV contrast	8	Perform this procedure with DWI sequences.	O
MRA head without and with IV contrast	7		O
MRA head without IV contrast	6		O
MRA neck without and with IV contrast	6		O
MRA neck without IV contrast	5		O
CT head without IV contrast	6		☢☢☢
CTA head and neck with IV contrast	6		☢☢☢
CT head without and with IV contrast	5		☢☢☢
CT head with IV contrast	5		☢☢☢
Arteriography cervicocerebral	4	Perform this procedure if noninvasive imaging is unrewarding.	☢☢☢
FDG-PET/CT whole body	3		☢☢☢☢
US head	3		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 10: New headache in cancer patient or immunocompromised individual.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with IV contrast	9		O
MRI head without IV contrast	7		O
CT head without and with IV contrast	6		☢☢☢
CT head with IV contrast	6		☢☢☢
MRA head without IV contrast	5		O
MRA head without and with IV contrast	5		O
CT head without IV contrast	5	Perform this procedure if MRI is not available.	☢☢☢
CTA head with IV contrast	5		☢☢☢
FDG-PET/CT head	4	This procedure is useful if an indeterminate mass is present.	☢☢☢☢
Thallium-201 SPECT head	3		☢☢☢☢
Arteriography cervicocerebral	2	Perform this procedure if noninvasive imaging is unrewarding.	☢☢☢
Tc-99m HMPAO SPECT head	2	This procedure is useful if an indeterminate mass is present.	☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition: **Headache**

Variant 11: **New headache. Suspected meningitis/encephalitis.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with IV contrast	8		O
MRI head without IV contrast	7		O
CT head with IV contrast	6		☢☢☢
CT head without and with IV contrast	6		☢☢☢
CT head without IV contrast	5	Perform this procedure to rapidly rule out mass lesion prior to lumbar puncture.	☢☢☢
MRA head without and with IV contrast	3		O
MRA head without IV contrast	3		O
CTA head with IV contrast	3		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 12: **New headache in pregnant woman.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without IV contrast	8	MRI is the modality of choice, however use of CT depends on local availability.	O
CT head without IV contrast	7	Use of CT depends on local availability and is helpful if there is a high suspicion for acute intracranial hemorrhage.	☢☢☢
MR venography head without IV contrast	6		O
MRA head without IV contrast	6		O
MRI head without and with IV contrast	5	Pregnancy is a relative contraindication to gadolinium administration. Reserve this procedure for urgent medical necessity only.	O
CT head with IV contrast	3	This procedure is for urgent medical necessity only.	☢☢☢
MRA head without and with IV contrast	3		O
CT head without and with IV contrast	2		☢☢☢
CTA head with IV contrast	2		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition: **Headache**

Variant 13: **New headache. Focal neurologic deficit or papilledema.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with IV contrast	8		O
MRI head without IV contrast	7		O
CT head without IV contrast	7		☢☢☢
MRA head without and with IV contrast	6		O
CT head without and with IV contrast	6		☢☢☢
MRA head without IV contrast	5		O
CT head with IV contrast	5		☢☢☢
CTA head with IV contrast	5		☢☢☢
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Variant 14: **Positional headache.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with IV contrast	8		O
MRI head without IV contrast	7		O
Myelography and post myelography CT spine	7		☢☢☢☢
MRI spine include MR myelography	7		O
CT head without IV contrast	5		☢☢☢
CT head with IV contrast	5		☢☢☢
CT head without and with IV contrast	5		☢☢☢
CTA head with IV contrast	3		☢☢☢
MRA head without IV contrast	3		O
MRA head without and with IV contrast	3		O
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Clinical Condition: **Headache**

Variant 15: **Headache associated with cough, exertion or sexual activity.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with IV contrast	8		O
MRI head without IV contrast	7		O
CT head without IV contrast	7		☢☢☢
MRA head without IV contrast	6		O
MRA head without and with IV contrast	6		O
CT head without and with IV contrast	6		☢☢☢
CT head with IV contrast	5		☢☢☢
CTA head with IV contrast	5		☢☢☢
Myelography and post myelography CT spine	2	Perform this procedure unless spontaneous intracranial hypotension is suspected.	☢☢☢☢
MRI spine include MR myelography	2	Perform this procedure unless spontaneous intracranial hypotension is suspected.	O
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Variant 16: **Post-traumatic headache.**

Radiologic Procedure	Rating	Comments	RRL*
CT head without IV contrast	8		☢☢☢
MRI head without IV contrast	7	Include GRE sequences in this procedure.	O
MRI head without and with IV contrast	7	Include GRE sequences in this procedure.	O
MRA head without IV contrast	5		O
MRA head without and with IV contrast	5		O
CT head without and with IV contrast	5		☢☢☢
CTA head with IV contrast	5		☢☢☢
CT head with IV contrast	4		☢☢☢
Arteriography cervicocerebral	3		☢☢☢
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

HEADACHE

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Summary of Literature Review

Introduction/Background

The cause or type of most headaches can be determined by procuring a careful history and performing a physical examination while focusing on the warning signals that prompt further diagnostic testing. In the absence of worrisome features in the history or examination, the task is then to diagnose the primary headache syndrome based on the clinical features. If atypical features are present or the patient does not respond to conventional therapy, the possibility of a secondary headache disorder should be investigated [1].

Headache is one of the most frequent ailments of the human race. Studies have estimated overall lifetime prevalence of 0.2%–60% for headache of any kind [2,3]. In children, prevalence of headache ranges from 8%–83% [4]. As in the case of migraines, characteristics such as age, gender, and case definition may largely account for this variance [3,5,6]. However, a higher prevalence of headache has been found by surveys in South America [7], Europe, and North America [2,8,9] than by those of Asian countries [10]. A survey of the Canadian population showed that only about 20% of people there are headache free [11]. Prevalence studies on migraine show that genetic factors are related to prevalence as well as gender differences, as migraines affect approximately 15%–18% of women and 6% of men [5,12-14]. Headaches occur most commonly between the ages of 25–55 years. Muscle contraction or tension accounts for most of the nonmigraine headaches encountered in population surveys [2].

Several studies have confirmed the low yield of imaging procedures for individuals presenting with isolated headache, ie, headache unaccompanied by other neurological findings [15-21]. Patients were referred for imaging because the referring physician suspected imaging-detected pathology or because patients requested the study to be certain that they did not have a brain tumor. A prospective review of 293 computed tomography (CT) scans ordered in an ambulatory family practice setting disclosed that most scans were ordered because the clinician suspected that a tumor (49%) or a subarachnoid hemorrhage (SAH) (9%) might be present. Fifty-nine (17%) were ordered because of patient expectation or medicolegal concerns [22].

When considering such a common disorder as headache, indications for imaging use become relevant. This is particularly true in the face of emerging and rapidly evolving technologies in use today [23-26]. In frequent conditions, performing low-yield studies is more likely to result in false-positive results, with the consequent risk of additional and unnecessary procedures. The yield of positive studies in patients referred with isolated, nontraumatic headache is approximately 0.4%. Assuming the cost of a CT scan is $400, and a magnetic resonance imaging (MRI) scan is $900, the cost to detect a lesion is $100,000 with CT and $225,000 with MRI.

One should not assume, however, that there is no social benefit in negative imaging studies in the setting of headache. Indeed, headache symptoms can be quite ominous and onerous to those patients, and there can be tremendous costs with respect to productivity and quality-of-life issues. Moreover, health-care providers perceive value in imaging headache when the fear of litigation is taken into account. Although it is beyond the scope of this review to assess the factors and inherent value of negative imaging tests in headache imaging, it must be

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emphasized that the costs of detection or screening in imaging headache are always overstated when the value of negative results is not factored into the analysis [15,19].

Chronic Headache, No New Features and Normal Neurologic Examination

Chronic daily headache represents a range of disorders characterized by the occurrence of long-duration headaches 15 or more days per month. The classification of these disorders continues to undergo revision to be more clinically relevant [27].

In adult and pediatric patients with migraine, with no recent change in attack pattern, history of seizures, or other focal neurological symptoms or signs, the routine use of neuroimaging is usually not warranted [28]. The yield of CT or MRI in patients with headache but normal neurological examination was reviewed by Frishberg [29]. The scans examined in most of the larger studies were performed with first-generation CT equipment. In addition, Frishberg included 3 more studies in his meta-analysis [30-32]. Of 897 studies in patients with migraine, only 4 were positive—3 for a tumor and one for arteriovenous malformations (AVMs)—giving a 0.4% yield of potentially treatable lesions. In patients with unspecified headache, 1,825 scans yielded a total of 43 lesions (21 tumors, 8 cases of hydrocephalus, 6 AVMs, 5 subdural hematomas, and 3 aneurysms), for a 2.4% yield of potentially treatable lesions. However, 2 studies in this group were performed at tertiary referral centers (the Mayo Clinic and the Cleveland Clinic) in the early days of CT and had a 500% higher rate of clinically important findings than more recent prospective studies [30,32]. If these 2 studies are not included among those performed in patients with unspecified headache, the total number of potentially treatable lesions is reduced to 3 in 725 studies (0.4%) [29].

Of 1,999 scans reported in other series, most using CT, only 21 (1%) disclosed treatable lesions [22,33-39]. Most of the positive cases occurred in the Becker et al series [22], which included an unspecified number of patients with abnormal neurological findings. If this series is excluded from the analysis, only 9 out of 1,999 patients (0.5%) had treatable findings. In a retrospective review of charts from 1,074 consecutive emergency department patients who underwent cranial CT, headache was associated with low yield of abnormality [40]. Although the utilization of CT and MRI for the evaluation of headaches in the emergency department increased from 1995–2004 the rate of intracranial pathology remained low over time [41].

Chronic Headache With New Feature or Neurologic Deficit

The frequency of pathology that can present with headache is rather low [17]. In cases with underlying pathology, patients typically present with new features and/or focal neurological symptoms. The incidence of all brain tumors in the United States is 19.9 per 100,000 person-years [42]. For SAH, the yearly incidence is 9 per 100,000. The prevalence of intracranial saccular aneurysms by radiographic and autopsy series is 5% [43]. Brain AVMs occur in approximately 0.01%–0.02% of the population [44,45]. In a retrospective review of the presentation of 111 brain tumors, headache was a symptom in 48%, equally for primary and metastatic tumors [46]. Headaches were similar to tension type in 77%, migraine type in 9%, and other types in 14%. The typical headache was bifrontal but worse ipsilaterally and was the worst symptom in 45% of patients. Other studies have found a higher frequency, but sometimes the headache preceded the diagnosis of brain tumor by several years, raising the possibility of an association with this common complaint rather than causality [47,48]. In children with brain tumors, headache was present in approximately 60% [49,50]. Because tumors are rare, and approximately half of them present with headache, it becomes apparent that if all patients with headache undergo imaging procedures, a large proportion of the studies will be negative [17,47]. In patients with underlying neoplasm or suspected brain tumor, MRI with and without contrast is the study of choice. If there are contraindications to MRI, contrast-enhanced CT is a good alternative. In children, if MRI of the brain is positive for brain tumors, particularly in the posterior fossa, contrast-enhanced MRI of the entire spine is essential to exclude drop metastasis. If there is a suspicion for SAH, gradient echo (GRE), susceptibility-weighted imaging (SWI), and fluid-attenuated inversion recovery (FLAIR) sequences should be included. Alternatively, noncontrast CT imaging may be indicated to exclude acute intracranial hemorrhage.

In nonacute situations, magnetic resonance angiography (MRA) of the brain without contrast is the most commonly performed technique to assess intracranial arteries. It is still controversial whether MRA without or with contrast is more sensitive and accurate for the assessment of intracranial arterial stenosis or occlusion [51,52].

Sudden Onset of Severe Headache—"Thunderclap Headache"

A patient presenting with a sudden, severe headache ("the worst headache of my life" or "thunderclap headache"), particularly if it is not a migraine or if the pattern of the headache is clearly different from the patient's usual headaches, is at a significantly higher risk of an acute SAH, which is more often related to an aneurysm than to an AVM. In a combination of 3 series, as many as 165 of 350 patients (47%) presenting with thunderclap headache had acute SAH [53-55]. The key to SAH diagnosis is the noncontrast head CT [56]. Failure to obtain the head CT accounts for 73% of misdiagnosis [57]. If the CT scan is negative, a lumbar puncture should be performed to disclose additional instances of SAH [54,55]. Patients diagnosed with acute SAH require MRA, computed tomography angiography (CTA), and/or catheter angiography. CTA has gained popularity and is frequently used for its noninvasiveness and sensitivity and specificity comparable to that of cerebral angiography [58]. After aneurysm coil or stent placement, MRA of the brain with and without contrast is usually indicated as the metal in the coils or stent may distort the noncontrast MRA, thus obscuring any residual abnormality. Contrast-enhanced MRA minimizes the distortions and increases the sensitivity of the study. This method allows for noninvasive surveillance of aneurysms that have been treated with coils or stents [59].

Sudden Onset of Unilateral Headache, Suspected Carotid or Vertebral Artery Dissection, or Ipsilateral Horner Syndrome

Sudden, severe unilateral headache in a young patient, particularly when it radiates into the neck and is accompanied by ipsilateral Horner syndrome, may be the result of dissection of the carotid or vertebral arteries [60]. Horner syndrome occurs when there is interruption of the oculosympathetic pathway. Lesions may be located along the preglionic or postganglionic segments of this pathway. In a series of 161 patients, headache was reported by 68% and, when present, it was the initial manifestation in 47% of those with carotid and 33% of those with vertebral artery dissection [59]. Although some of these patients had stroke-like symptoms, others did not, or they developed them several days after an initial presentation with isolated headache. The pattern of radiating pain will often differ enough to make the patient suspect that this is not a regular headache. For first order neuron Horner syndrome, MRI of the brain and brainstem and MRA of the brain are indicated. If there is suspected first order neuron Horner syndrome without brain or brainstem symptoms, MRI of the cervical and upper thoracic spine should first be obtained. Second order neuron Horner syndrome is best imaged with CT or MRI of the soft-tissue of the neck from C2 to approximately T2, with particular attention to the brachial plexus. If postganglionic third order neuron lesion is suspected, imaging is not indicated, as this type of Horner syndrome is usually secondary to a benign condition. If, however, the lesion cannot be localized clinically, and imaging is requested, contrast-enhanced CT or MRI with and without contrast of the face from C3/angle of mandible to the superior margin of the orbit should be performed [61]. The reported sensitivity and specificity of MR techniques and CTA for diagnosis of craniocervical arterial dissection are relatively similar with 83%–99% sensitivity and specificity [62]. MRA of the neck is most commonly performed with gadolinium contrast, whereas MRA of the head is most commonly performed without contrast. MRA of the brain with contrast is generally indicated if embolization coils or intracranial stents have been placed [63].

Headache of Trigeminal Autonomic Origin

Trigeminal autonomic cephalgia is a group of primary headache disorders characterized by pain in unilateral trigeminal distribution in association with ipsilateral cranial autonomic signs and symptoms. Cluster headache is the only relatively common member of this headache disorder family. The others are rare and are characterized by short attacks: paroxysmal hemicrania, hemicrania continua, hypnic headaches, and short, unilateral neuralgiform headache attacks with unilateral conjunctival injection and tearing (SUNCT). SUNCT can occur without the unilateral conjunctival injection and tearing. All of these are diagnosed clinically, but head MRI may be appropriate since secondary causes need to be excluded. Head MRA and CTA are not usually indicated initially. The ophthalmic form of trigeminal neuralgia may be confused with these entities [64-66].

Clusters of severe, strictly unilateral pain lasting a few hours at most characterize a cluster headache. It is often accompanied by ipsilateral Horner syndrome, tearing, and nasal congestion. The pain stays on the same side from attack to attack. The clusters typically last several weeks and recur at varying intervals—approximately once a year or every 2 years is common. Unlike migraine, cluster headaches do not run in families. Although the diagnosis is made clinically, there is an unexplained association with pituitary macroadenomas, which are found in 5%–10% of cluster headache patients. Therefore, brain MRI without and with contrast with attention to the pituitary is indicated at least once in an individual's lifetime. There is no role for head MRA or CTA.

Paroxysmal hemicranias are more frequent, and individual attacks are shorter in duration when compared with cluster headache. MRI of the brain with and without contrast should be performed in all patients with paroxysmal hemicranias.

Trigeminal neuralgia is diagnosed by history, clinical evaluation, and the presence of paroxysmal and shock-like pain with a trigger zone in the distribution of the fifth cranial nerve. For trigeminal neuralgia refractory to medical therapy, neuroimaging is indicated to identify a structural etiology. Neuroimaging is reported to be positive in approximately 15% of patients with trigeminal neuralgia. Contrast-enhanced MRI of the brain, including MR cisternogram, fast inflow with steady-state precession sequences and MRA and CTA of the brain are used to exclude underlying neoplasm, multiple sclerosis, or vascular compression [67-69]. MRI with contrast is preferred because it is better at delineating the full extent of neoplasm [70]. CT with contrast may be useful if MRI is contraindicated.

Headache of Skull Base, Orbital, or Periorbital Origin

There is a wide spectrum of diseases that can affect the skull base, including infectious, inflammatory, benign or malignant, and primary or secondary neoplastic processes. Multiple foramina at the skull base act as a conduit for transmission of pathologies. In addition, the high concentration of nerves at the skull base acts as a source of referred or direct headache. MRI of the brain with and without contrast may be warranted, including focused MRI of the skull base as indicated by the signs and symptoms.

Visual loss, periorbital or facial pain, and ophthalmoplegia are the initial symptoms of orbital apex syndrome, which refers to damage to the oculomotor nerve (III), trochlear nerve (IV), abducens nerve (VI), and ophthalmic branch of the trigeminal nerve (V1) in association with optic nerve dysfunction. The cavernous sinus syndrome may include the features of an orbital apex syndrome with added involvement of the maxillary branch of the trigeminal nerve (V2) and oculosympathetic fibers [1]. Periorbital pain is a diagnostic criterion for Tolosa Hunt syndrome, and painful ophthalmoplegia is a criterion for orbital pseudotumor. Since the underlying pathology may be infectious, inflammatory, vascular, or neoplastic, MRI of the brain and orbits with and without contrast with fat-suppressed postcontrast imaging of the orbits is the preferred procedure for evaluating most lesions. However, CT is indicated in the setting of trauma to evaluate bone involvement or when MRI is contraindicated. If there is a high suspicion for a vascular lesion, MRA or CTA is indicated [71].

Headache of Rhinogenic Origin

"Sinus headaches" are estimated to affect millions of Americans every year. The diagnosis can be made based on clinical symptoms, physical examination, and nasal endoscopy, obviating the need for imaging in most patients [72]. If there is a suspicion for intracranial complications from sinus disease, then MRI of the brain with and without contrast is indicated. However, if MRI is contraindicated, then CT of the head with and/or without contrast may be indicated. In patients with isolated nonfocused headaches, sinusitis accounts for a significant number of etiologies (8%) [73]. In patients with suspected headaches of rhinogenic origin and with endoscopic examinations suggesting sinonasal disease, sinus CT may be appropriate as it may alter treatment decisions [74]. In patients with non–sinusitis-related rhinogenic headache imaging may be indicated to evaluate for various anatomical variations such as contacted mucosa, nasal septal deviations, concha bullosa, and Haller cells that can cause rhinogenic headache [75]. See the ACR Appropriateness Criteria® topic on "Sinonasal Disease."

Headache of Oromaxillofacial Origin

Some oromaxillofacial conditions such as tooth impaction, dental infection, temporomandibular joint (TMJ) disorders, and trigeminal neuralgia present with headache and facial pain. MRI of the brain with and without contrast is generally indicated. Pain of odontogenic origin and neurovascular orofacial pain may present as a "throbbing" headache. Therefore, it is essential to differentiate pain of odontogenic origin from trigeminal neuralgia [76]. With dental caries and periodontal disease referred pain may be present in the absence of primary pain. Infectious odontogenic disease typically presents with pain, and the diagnosis may be made based on examination and history. To exclude other treatable disorders and assess for complications such as abscess and osteomyelitis, contrast-enhanced CT is usually indicated as the results may affect management decisions.

Internal derangement and inflammation of the TMJ should be considered in patients with unexplained headache and/or facial pain even if mechanical TMJ symptoms such as joint clicking, crepitus, or locking are absent. Although the diagnosis of TMJ disorder is usually made by history and clinical examination, if patients have pain or tenderness localized to at least one TMJ, MRI of the TMJ with surface coil is indicated [77]. CT is used to assess degenerative processes of the TMJ.

New Headache in Elderly Individual With Temporal Tenderness and Elevated Erythrocyte Sedimentation Rate

Patients older than 55 with new-onset headache in the temple regions, particularly with tender superficial temporal arteries, should be studied for temporal (giant cell) arteritis (GCA) [78-80]. GCA is common in elderly patients and affects large- and medium-sized arteries. In the elderly, up to 17% of cases of fever of unknown origin are caused by vasculitis. Prompt diagnosis and treatment are important to prevent serious vascular complications, as treatment with steroids may forestall vision loss or brainstem strokes. The diagnosis of GCA is based on the clinical criteria of the American College of Rheumatology [81] and confirmed by biopsy of the temporal artery. However, because of the segmental nature of histologic lesions, temporal artery biopsy is false-negative in up to 45% of patients [82]. Therefore, imaging procedures play an important role [83]. MRI allows imaging of GCA with high sensitivity and specificity [84]. MRA discloses lumen stenosis [85]. The strength of MRI and MRA is in the detection of small and medium vessel disease such as the superficial cranial arteries. Furthermore, MRI and MRA allow for the detection of aneurysm formation, may be used to identify the most inflamed segments of the vessels for targeted biopsy, and are useful in the diagnosis and follow-up of temporal arteritis [86].

Although ultrasonography (US) may be helpful in diagnosing GCA, its accuracy varies substantially with the skill and experience of the operator. Therefore, the operator's experience should be carefully considered before referring patients for US [87,88]. For patients in whom GCA is only one possible differential diagnosis, especially in fever of unknown origin, fluorine-18-2-fluoro-2-deoxy-D-glucose-positron emission tomography (FDG-PET) appears to be indicated [89] due to its high sensitivity and ability to screen all large arteries in a single step (standardized whole-body scanning).

New Headache in Immunosuppressed Individuals or Cancer Patients

Immunosuppressed individuals are at increased risk of infection, lymphoma, leukemia, and complications of immunosuppressive therapy. For instance, a series of 49 HIV-positive individuals had an 82% yield of positive pathology. Although cryptococcal meningitis was most common (39%), toxoplasmosis was a close second (16%), and a number of patients had other mass lesions identified by CT [90]. MRI or CT of the brain with and without contrast is indicated when infection or neoplasm is suspected. Noncontrast CT and/or MRI may be helpful if there is contraindication to contrast (see "Anticipated Exceptions"), a high suspicion of hemorrhage, or side effects of immunosuppressive therapy, such as posterior reversible encephalopathy syndrome. Thallium 201 imaging of the brain is useful to distinguish infection from neoplasm in this population.

Patients with known cancer should also be scanned when a headache develops or if there is a change in headache characteristics. Although single-photon emission CT (SPECT) and PET are not currently routinely used in the evaluation of patients with headache, PET and SPECT may be useful in differentiating tumor from infection in high-risk patients [28]. The comments above regarding selected populations referred to tertiary care centers also apply to patients with known cancer [91,92].

New Headache, Suspected Meningitis, and Encephalitis

Patients with suspected meningitis often pose important diagnostic challenges [93,94]. Headaches, fever, and alteration of consciousness or behavior, all with or without nuchal rigidity are symptoms of central nervous system infections such as meningitis, encephalitis, and intracranial abscesses, but history and physical examination are insufficient to make a diagnosis. Lumbar puncture is essential if meningitis is suspected. In general, a CT scan is performed before lumbar puncture to determine if there is elevated intracranial pressure. In a study of 301 patients, Hasbun et al [95] found that in the absence of an underlying immunocompromised state, history of central nervous system mass, stroke, or focal infection, or specific abnormal neurologic examination, CT had a negative likelihood ratio of 0.1. According to the Infectious Diseases Society of America [96], when any underlying condition is present, blood cultures should first be obtained, then empiric antimicrobial therapy instituted, followed by CT of the brain without and with contrast to look for contraindications to lumbar puncture.

Encephalitis is an inflammatory process of the brain associated with neurologic deficit. MRI of the brain is more sensitive and specific than CT for detecting encephalitis and complications of meningitis. Therefore, if encephalitis is suspected, MRI of brain with and without contrast is the study of choice. CT of the brain with and without contrast should only be performed if MRI is contraindicated or unavailable [97]. Imaging with diffusion-weighted sequence (DWI) is important to obtain, as it is sensitive for the detection of early changes of encephalitis [98]. MRI is also helpful for detecting postinfectious immune-mediated disorders of the brain such as acute disseminated encephalomyelitis. FDG-PET is not generally indicated for evaluation of suspected encephalitis or meningitis.

New Headache in Pregnant Woman

In general, pregnancy favorably impacts the course of migraine, but patients presenting with headache in pregnancy have higher yields of a pathologic etiology. A recent study found a 27% underlying etiology for headache in pregnant patients presenting to the emergency department [99]. Although the cornerstones of the workup are history, physical examination, and laboratory tests, brain imaging is an important complement. MRI of the brain without gadolinium is the preferred modality to evaluate for secondary headaches in pregnancy. Iodinated and gadolinium contrast agents should not be routinely used in *pregnant* patients (see "Safety Considerations in Pregnant Patients"). If there is a high suspicion for venous/sinus thrombosis, MR venography should be considered. A CT scan is useful to exclude acute intracranial hemorrhage [100]. However, MRI of the brain that includes SWI, GRE, and FLAIR sequences can assess for hemorrhage without radiation exposure.

New Headache With Focal Neurologic Deficit or Papilledema

Headache is a cardinal symptom of increased intracranial pressure and is frequently accompanied by nausea and vomiting, which is usually worst in the mornings. In the setting of headache, the presence of bilateral papilledema indicates increased intracranial pressure that is transmitted to the optic nerve sheath. As such, the differential diagnosis for headache in the setting of papilledema is quite broad. It includes any mass such as abscess, primary or metastatic tumors, hematoma, cerebral edema, communicating or obstructive hydrocephalus, idiopathic intracranial hypertension (IIH), dural venous sinus thrombosis, and entities that result in increased cerebrospinal fluid (CSF) production [101]. MRI of the head with and without contrast is the imaging study of choice. CT of the head with contrast may be appropriate if MRI is contraindicated or not available.

New-onset headache in populations predisposed to intracranial pathology, such as those with neoplasms, those in prothrombotic states, those who live in endemic regions, or individuals with focal neurologic deficits, also results in a much higher yield of findings with neuroimaging. The population living in the Andes, the South American mountain range has a low rate of headache, whereas cysticercosis is common. As a result, CT scans of patients with headache yielded a positive study rate of 33% [102].

Cerebral venous sinus thrombosis is a potentially lethal disorder with variable clinical manifestations. However, with early diagnosis and institution of therapy, prognosis may be improved. The predisposing factors to this condition are mainly genetically acquired prothrombotic states, and infection. Headaches may be accompanied by seizures, visual disturbance, papilledema, focal neurologic deficits, and altered consciousness. The incidence of cerebral venous sinus thrombosis in children and neonates has been reported to be as high as 7 cases per million, whereas in adults the incidence is 3–4 cases per million. A combination of MRI, noncontrast CT, time-of-flight MR venography, and contrast-enhanced CT venography are particularly useful techniques for detecting cerebral venous and brain parenchymal changes that may be related to venous sinus thrombosis [103-105].

Patients with IIH are usually obese females of childbearing age. The headache is usually positional and of a throbbing nature. Characteristic findings of IIH on MRI include flattening of the posterior sclera, distension of perioptic subarachnoid space, enhancement and protrusion of the intraocular optic nerve, and an empty sella. If the neuroimaging study reveals no structural etiology for IIH, a lumbar puncture is performed. In addition to measuring the opening pressure, the CSF is analyzed for cell count and differential, glucose, protein, and sensitivity to microbial agents [106]. In individuals with contraindication to MRI (eg, claustrophobia or obesity), noncontrast CT is generally helpful to assess for the presence of mass, acute intracranial hemorrhage, midline shift, effacement of basal cisterns, or hydrocephalus.

Positional Headache

Spontaneous intracranial hypotension is probably an under-reported cause of headache and other neurological symptoms. It is typically manifested by orthostatic headache and low opening pressure on lumbar puncture. Manifestations of spontaneous intracranial hypotension are variable [107-111]. Currently in many practices, if MRI of the head confirms the clinical suspicion of spontaneous intracranial hypotension, epidural blood patching or conservative treatment consisting of bed rest, oral hydration, and oral caffeine is recommended. Spinal imaging is recommended if such treatments fail or if MRI of the head is normal. Comprehensive diagnostic criteria encompassing the varied clinical and radiographic manifestations of spontaneous intracranial hypotension was proposed by Schievink et al in 2008. These criteria are based on symptoms, brain and spine imaging, lumbar puncture, and response to epidural blood patch [112].

The main diagnostic criteria of spontaneous intracranial hypotension are the demonstration of extrathecal CSF with CT or MRI of the entire spine, which should include MR myelography sequence [110,112]. If no extrathecal CSF is present, then MRI showing spontaneous intracranial hypotension changes and the presence of at least one of the following should indicate a diagnosis of spontaneous intracranial hypotension: low opening pressure on lumbar puncture, meningeal diverticulum, or improvement of symptoms with epidural blood patch.

Headache Associated With Cough, Exertion, or Sexual Activity

Benign cough headache, benign exertional headache, and headache associated with sexual activity are very uncommon and may be a primary headache syndrome or may herald potentially serious underlying disease. Primary cough headache is provoked by coughing or straining in the absence of any intracranial disorder; it affects people older than 40, is sudden in onset and bilateral in distribution, and lasts less than 30 minutes. Primary cough headaches are not associated with sound or light sensitivity, nausea, vomiting, rhinorrhea, conjunctival injection, or lacrimation. Neuroimaging, preferably with MRI, is a prerequisite for making the diagnosis of primary cough headache, as the possibility of an underlying structural abnormality must first be excluded [113]. GRE, SWI, and FLAIR sequences should be included. Pathologies associated with cough headache include Chiari 1 malformation, posterior fossa lesions, aneurysm, intracranial hypotension, hypervolemia, or unilateral carotid artery occlusion.

It is sometimes difficult to distinguish primary cough headache from primary exertional headache because valsalva maneuvers frequently occur in the context of many forms of physical exertion. However, several clinical differences between benign cough and benign exertional headache aid in distinguishing the 2 disorders [114]. Exertional headache is very uncommon, ranging from 1%–12% prevalence [115,116]. It is characterized by episodes of pulsatile head pain that occur during or after physical exercise. As neuroimaging techniques have improved, the proportion of symptomatic headaches relative to primary headaches has increased, with imaging studies revealing pathology in 9.7%–43% of cases of headaches associated with cough, exertion, or sexual activity [117]. Patients with exercise-induced headache should be evaluated with brain MRI and MRA to rule out vascular abnormalities or other structural causes, especially if the headaches are of new onset, occur after age 40, last beyond a few hours, or are accompanied by vomiting or focal neurologic symptoms. Any symptoms suggestive of SAH, including rapid onset, alteration in consciousness, or meningeal symptoms, argue for emergent neuroimaging, including noncontrast CT of the brain.

Similarly, headaches associated with sexual activity may represent a primary benign disorder, or they may signal underlying pathologies such as SAH, intratumoral hemorrhage, meningitis, encephalitis, pheochromocytoma, or nonhemorrhagic stroke. In such cases, a thorough neurologic evaluation is indicated. Because of these possible underlying causes evaluation with a head CT examinaton to exclude intracranial hemorrhage or with MRI, to include GRE or SWI sequences, is usually indicated for more thorough assessment [118].

Post-traumatic Headache

Post-traumatic headache (PTH) is defined by the 2nd edition of the *International Classification of Headache Disorders* as headache that begins within a week of trauma. Both acute (APTH) and chronic (CPTH) begin within 7 days of the injury, and CPTH persists for more than 3 months. Headache is among the most prominent of the symptoms that may linger after mild traumatic brain injury (TBI). The Centers for Disease Control reports that TBI results in nearly 1.4 million emergency room visits, 275,000 hospitalizations, and 52,000 deaths per year. Mild TBI accounts for most of the nonlethal events, and motor vehicle accidents are the most common cause of injury [119]. PTH often has features of one of the primary headache syndromes. Its biology is poorly understood and whether it merely represents the expression of the primary headache or has a distinct pathogenesis remains unclear. The frontal lobe is often affected in traumatic head injury. Its dysfunction can cause an array of clinical consequences that have an impact on the patient's symptomatology and therapeutic outcome [120]. Within the first 72 hours of trauma, thorough neurological examination is indicated to identify red flags. Neuroimaging is indicated if there is skull fracture, focal neurologic deficit, or progression of symptoms. With acute head trauma, noncontrast head CT is the primary imaging procedure of choice. See the ACR Appropriateness Criteria® topic on "Head Trauma" for more information. MRI with GRE, FLAIR, SWI, and DWI are reserved for severe acute head trauma and in cases where the patient is much worse on clinical examination than can be explained by CT results. MRI is the primary imaging modality for evaluating delayed effects of brain injury. Furthermore, if MRI and CT are negative but neuropsychological evaluation identifies impairment of mood, executive function, or cognitive endurance, then diffusion tensor imaging might be indicated [119,120].

Summary

- Definitive diagnosis of primary headache syndrome is usually achieved by procuring a detailed history and by performing a detailed physical and neurologic examination and, as such, screening with CT or MRI in patients who present with isolated, nontraumatic headache is usually not warranted.
- The history and physical and neurologic examination may elicit critical features that warrant further investigation with CT or MRI to exclude secondary causes of headache.
- For some types of headache or populations at risk, neuroimaging procedures are more likely to be positive. Examples of headaches for which imaging procedures may be helpful include headaches associated with head and neck trauma; new, worse, or abrupt-onset headache; thunderclap headache; headache radiating to the neck; trigeminal autonomic cephalgia, persistent positional headache; and temporal headache in older individuals. Pregnant patients, immunocompromised individuals, cancer patients, and patients with papilledema or systemic illnesses, including hypercoagulable disorders usually benefit from imaging.
- In some patients who present to the otorhinolaryngologist with suspected headaches of skull base, rhinogenic, odontogenic, or maxillofacial origin imaging may be helpful in management decisions and for detecting intracranial complications.
- Unlike most headaches, those associated with cough, exertion, or sexual activity usually require neuroimaging with MRI of the brain with and without contrast to exclude potentially underlying pathology before a primary headache syndrome is diagnosed.

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 Practice Guideline for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation
- ACR-ACOG-AIUM Practice Guideline for the Performance of Obstetrical Ultrasound
- ACR Manual on Contrast Media
- ACR Guidance Document for Safe MR Practices

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

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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