American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Headache — Child**

Variant 1: **Primary headache (chronic or recurrent headache including migraine without permanent neurologic signs or signs of increased intracranial pressure).**

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

Variant 2: **Headache with signs of increased intracranial pressure or positive neurological signs.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without IV contrast	8	If lesion is seen, perform a contrast-enhanced scan.	O
MRI head without and with IV contrast	8	Use contrast if appropriate based on noncontrast scan.	O
CT head without IV contrast	7	If MRI is not available.	☢☢☢
CT head with IV contrast	5	If MRI is not available. If noncontrast CT is positive and fever is present.	☢☢☢
MRA head without IV contrast	5	If vascular pathology is suspected based on CT or MRI.	O
MRA head without and with IV contrast	5	If vascular pathology is suspected based on CT or MRI.	O
CT head without and with IV contrast	4	If MRI is not available and if noncontrast CT shows abnormality.	☢☢☢☢
CTA head with IV contrast	3	Consider if SAH is seen on noncontrast CT.	☢☢☢☢
Arteriography cerebral	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 — Child**

Variant 3: **High-intensity headache of abrupt onset (thunderclap headache) suggesting vascular rupture.**

Radiologic Procedure	Rating	Comments	RRL*
CT head without IV contrast	9		☢☢☢
CTA head with IV contrast	7	If SAH is seen on noncontrast CT.	☢☢☢☢
Arteriography cerebral	7	If there is high clinical suspicion or a suspicious imaging finding. If local expertise is available.	☢☢☢☢
MRA head without IV contrast	6	Sensitivity relative to CTA is still uncertain.	O
MRA head without and with IV contrast	6	Sensitivity relative to CTA is still uncertain.	O
MRI head without IV contrast	5	Not a first-line test. Less sensitive than CT for SAH.	O
MRI head without and with IV contrast	5	Not a first-line test. Less sensitive than CT for SAH.	O
CT head with IV contrast	3		☢☢☢
CT head without and 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

HEADACHE — CHILD

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Summary of Literature Review

Introduction

Headache is a common complaint, even in early childhood. The prevalence of headaches increases with age and ranges from 37%-51% for children 7 years of age and gradually increases to 57%-82% by 15 years of age [1,2]. At the age of 16 years, more than 93% of all adolescents have already experienced at least one episode of fierce headache [3]. Prepubertal boys are more affected with headache than girls, whereas after puberty, headaches are found more commonly in girls [4].

The evaluation of a child with headache begins with a thorough medical history and a physical examination with measurement of vital signs including blood pressure, a complete neurologic examination, and examination of the optic fundus. Diagnosis of primary headache disorders of children rests principally on clinical criteria as defined by the International Headache Society. Most children have primary headaches such as migraine or tension headaches, typically chronic or recurrent. Serious intracranial pathology is rare in these children [5]. It is important to recognize that migraine headaches in young children may not meet the usual diagnostic criteria (eg, they are usually of shorter duration than those of adults) [1,6]. Imaging in these patients shows a low rate (0.9%-1.2%) of significant findings [7,8].

Secondary headache is more common in young children [9]. Potential underlying pathologies include brain tumors, meningitis, venous sinus thrombosis, arterial dissection, subarachnoid hemorrhage (SAH), and other disorders that may require prompt management. Brain tumors are rare in children, with an annual incidence approximates only three per 100,000 (0.003%) in children <15 years of age [10].The need to distinguish primary headaches from secondary headaches presents a major challenge.

There is lack of well-designed prospective studies evaluating diagnostic tests in children with headache Most of the studies are retrospective case series, and some represent selective populations of children with headache. Therefore, it is difficult to assess the outcome of early detection of any intracranial pathology.

Primary Headache

According to the International Headache Society, primary headaches include migraine, tension-type headache, cluster headache, and other trigeminal autonomic cephalgias. Others include primary cough headache, primary exertional headache, primary headache associated with sexual activity, hypnic headache, primary thunderclap headache, hemicrania continua, and new daily-persistent headache.

Migraine

By 15 years of age, 3% to 10% of children experience migraine headaches [2,11,12]. Most, but not all, studies report a female predominance. In 1988 the International Headache Society described two types of migraine: migraine with aura (classic), and migraine without aura (common) [13]. Migraine may have many manifestations. If there is a pattern to the headaches it is usually not difficult to diagnose. Children with migraines are symptom-

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free between headaches. If the child has typical migraine with or without aura, most clinicians would recommend no imaging studies [14-18]. No imaging is also recommended in cases of common migraine of more than 6 months duration in patients with a family history of migraine and in nonprogressive migraine attacks. In ophthalmologic migraine with focal neurologic symptoms of unilateral ptosis or complete third-nerve palsy, imaging is recommended to exclude other intracranial abnormalities [16].

In patients with miscellaneous migraine findings or syndromes such as vertigo, basilar artery migraine syndrome, persistent confusion migraine syndrome, progressive chronic headache, or hemiplegic migraine, imaging may be appropriate to exclude an aneurysm, a space-occupying lesion, or other intracranial abnormality.

Because the presenting signs and symptoms of complicated migraines with focal neurologic findings cannot be discriminated from similar presentations related to intracranial neoplasms, imaging is recommended [16]. In a study of 72 patients with brain tumor headaches [19], abnormal physical signs were present in 94%. It is important to note that seizures are one of the most common secondary etiologies for headache other than migraine and often have auras similar to some migraines [20]. If seizures are suspected, magnetic resonance imaging (MRI) should be performed. (See the ACR Appropriateness Criteria® on "Seizures — Child.")

Imaging
The clinical experiences of primary care physicians, pediatricians, and neurologists indicate that neuroimaging studies have a limited role in children with primary headaches [1,4,14,15,18,21-24]. The high prevalence of headaches and the low yield of imaging in pediatric patients presenting with headaches alone bring into question the value of screening for patients with primary headaches.

Secondary Headache

According to the International Headache Society, secondary headaches include those attributed to head and/or neck trauma, cranial or cervical vascular disorder, nonvascular intracranial disorder, a substance or its withdrawal, infection, a disorder of homeostasis, or psychiatric disorder. Secondary headaches or facial pain can also be related to disorders of the cranium, neck, eyes, ears, nose, sinuses, teeth, mouth or other facial or cranial structures.

Headaches with Positive Neurologic Signs or Symptoms of Increased Intracranial Pressure
Major studies addressing the issues of brain tumors and indications for imaging — including the data from 3,291 children described by the Childhood Brain Tumor Consortium [10], 315 children in the Boston Children's review [16], 245 children in Germany [25], and 72 children in the data of Honig and Charney [19] — suggest that nearly all children with intracranial tumors have other symptoms or neurologic signs accompanying their headache. Symptoms depend on the location of the tumor and also on the age of the patients. Increased intracranial pressure leads to an increase of head circumference in the first year of life, which might prevent a rapid development of symptoms [25]. The data from the Childhood Brain Tumor Consortium [10] and the Honig and Charney study [19] showed that 94% of children with brain tumors had abnormal neurologic findings at diagnosis and 60% had papilledema. Other neurological findings included gait disturbance, abnormal reflexes, cranial nerve findings, and altered sensation. Medina et al [16] identified papilledema, nystagmus, and gait disturbances as univariant predictors of brain tumor. Confusion and other assorted abnormal neurological findings were multivariant predictors of brain tumors. These studies stress the need for a meticulous neurological and ophthalmological examination. It would appear appropriate from these retrospective data to consider intracranial imaging in any patient presenting with headache and positive neurologic findings.

Imaging
If there is concern for brain tumor, MRI of the brain with and without contrast is the study of choice. If MRI is not available, and/or there are difficulties with sedation, computed tomography (CT) of the head is indicated. CT without contrast can be performed initially; however a contrast-enhanced study is indicated if it is not possible to get a MRI scan of the brain.

Sudden Severe Headache (Thunderclap Headache)

Sudden severe headaches are more common in adults than in children. These "thunderclap headaches" are associated with subarachnoid and intracranial hemorrhage that may occur with aneurysms or arteriovenous malformations (AVMs). Nausea and vomiting are also seen in the majority. Although childhood intracranial aneurysms are rare, many case reports document severe acute headache as the presenting symptom [26]. AVMs

occur in one per 100,000 children per year and are four times more common than aneurysm in patients <15 years of age [27].

Imaging
Neuroimaging of children with severe or unusual head pain who have a first-degree relative with an aneurysm or AVM is indicated, as these vascular pathologies can be familial [20]. Sudden severe unilateral headaches in the pediatric population and in young adults correlate with carotid or vertebral dissection, especially when associated with neurologic signs and symptoms (eg, Horner's syndrome.) If there is strong concern for arterial dissection, the diagnosis is generally made by MRI or magnetic resonance angiography (MRA) and requires specific neck sequences (T1 fat-saturated and T2 FLAIR axial images) [28]. CT angiography is also commonly employed for this indication. (See the ACR Appropriateness Criteria® on "Cerebrovascular Disease.") In sudden severe headaches, particularly in the absence of a family history of migraine, neuroimaging with a CT scan without contrast is recommended [29].

If subarachnoid or parenchymal hemorrhage is detected, further evaluation for aneurysm or vascular malformation must be performed. This can be accomplished by CT angiography (CTA), conventional angiography with digital subtraction angiography (DSA) techniques, or MRA. Whether to use CTA or DSA as the next study of choice has been and continues to be a topic of much debate. In 2007, Kallmes et al [30] declared that since both negative and positive CTA scans mandate subsequent conventional angiography, the CTA should be dispensed with and patients should proceed directly to DSA. In 2008, Agid et al [31] replied that CTA is faster, safer, and cheaper (ie, better) care. A 2011 meta-analysis by Westerlaan et al [32] concluded that multidetector CTA can be used as a primary examination tool in the diagnostic workup of patients with SAH. In the same journal issue, Moran [33] countered that conventional angiography with DSA is the ideal method for imaging these patients due to its ability to detect aneurysms quickly, reliably, and safely and that it guides the prompt proper therapy. What is clear is that DSA requires a skilled angiographer to be available emergently, and that if one is not available, CTA or possibly MRA should be performed in patients with acute SAH.

Headache Attributed to Infection

Headache can be attributed to either intracranial or extracranial infections. Intracranial infections include meningitis, encephalitis, and brain abscess. Extracranial infections include sinusitis, mastoiditis, and subdural empyema (SDE).

Intracranial Infections
Meningitis is inflammation of the meninges and is commonly viral or bacterial in nature. Symptoms in infants may be nonspecific, including fever, poor feeding, irritability, and lethargy. Seizures are not uncommon in these young children, mostly occurring when the inflammation has progressed to involve the brain parenchyma. Older children may have fever, headache, nausea, vomiting, confusion, stiff neck, and photophobia. Symptoms of viral meningitis can resemble those of the flu. Bacterial meningitis is a medical emergency that must be treated promptly to minimize the risk of serious complications, including death. Diagnosis is made by blood culture and lumbar puncture (LP). MRI or CT may be used in the acute setting to aid in diagnosis. CT is sometimes performed prior to LP to help determine if it is safe to perform the procedure. Neurologic signs and symptoms such as nuchal rigidity or alteration in consciousness may be indications for imaging.

There are known underlying disease processes that predispose patients to intracranial pathology. Children with underlying disease — such as immunocompromised patients, children with known neoplasms, sickle cell patients, children with collagen vascular disease, and patients with coagulopathy or hypertension — are predisposed to intracranial pathology. In high-risk groups, the presence of a severe headache may indicate significant intracranial pathology. It would seem appropriate to consider a lower threshold for imaging in this patient population.

Extracranial Infections
In the study by Lateef et al [1] and many other published reports, the overwhelming majority of acute headaches in children and adolescents were attributable to common, minor, transient conditions, such as upper respiratory illness.

Sinus disease may present with headache or may be associated with it. The diagnosis of acute sinusitis in children is made clinically; however, in children who present with severe and persistent headache as the dominant feature of sinusitis, imaging may be warranted [34-36]. (See the ACR Appropriateness Criteria® on "Sinusitis — Child.") Clinical signs suggesting intracranial abnormality include high fever, confusion, and change in mental status with

and without focal signs. Headache is the most common symptom identified with the intracranial spread of infection resulting from dural irritation and localized encephalitis.

Epidural empyemas are collections of supportive fluid located between the skull and dura. In infants, SDE is most commonly a complication of purulent meningitis, while in older children the source of SDE is typically direct extension of sinusitis or otitis media into the extracranial spaces. The differential diagnosis includes meningitis, subdural and subarachnoid bleeding, and brain abscess.

Imaging

Imaging is decisive and aids treatment. CT and MRI have been the mainstays of imaging diagnosis of SDE. Contrast enhancement can increase the conspicuousness of a subtle collection. MRI is preferable for diagnosing epidural empyemas because of its ability to distinguish between different types of fluid, and the use of diffusion-weighted imaging is recommended to aid in the diagnosis and follow-up of children with suspected inflammatory subdural collections [37]. Venous sinus thrombosis is another possible complication of sinusitis and mastoiditis, and if suspected, MR venography is considered the technique of choice for diagnosis and follow-up. In certain cases, MRI could be superior, as it shows the thrombus itself and not just the absence of signal as seen on MR venography [38]. If MRI is not feasible or in cases in which the results of MRI are ambiguous, imaging with CT venography has been found to be a fast, widely accessible, and cost-effective alternative approach with high sensitivity and specificity in detecting venous sinus thrombosis [39].

Headache Attributed to Head and Neck Trauma

Clearly, intracranial imaging plays a critical role in the evaluation of the acutely injured patient; however, because headache is rarely a major indication for imaging, in the context of this Appropriateness Criteria® topic we will consider only the evaluation of headache related to subacute or remote trauma. (See the ACR Appropriateness Criteria® on "Head Trauma.")

Patients who have a history of subacute or remote trauma may present with headaches. Post-traumatic headache is defined as a headache that begins within 2 weeks of a closed head injury. A recent prospective study of children admitted with a closed head injury (minor 79%, major 21%) found that 7% of children reported chronic post-traumatic headaches, 4% had episodic tension-type headaches, and 2.5% had migraine without aura [40]. Studies that correlate neurologic signs and symptoms with imaging findings in children with closed head injuries are lacking; however, studies of adults reveal that the complaint of headache has been associated with an increased risk of intracranial injury, even in patients suffering minor head trauma with Glasgow coma scores >13. Certainly it would be prudent to consider imaging of patients in whom neurologic signs or symptoms are positive, whose headaches are associated with vomiting, or whose headaches are increasing in frequency, duration, or severity, regardless of the severity of the initial trauma.

Summary

- Primary headache
  - No imaging is indicated for typical migraine.
  - In ophthalmologic migraine with focal neurologic symptoms of unilateral ptosis or complete third-nerve palsy, MRI is recommended.
  - MRI is also recommended for patients with miscellaneous findings such as vertigo, basilar artery migraine syndrome, persistent confusion migraine syndrome, progressive chronic headache, or hemiplegic migraine.
  - MRI should be performed for patients with seizures and postictal headaches.
- Secondary headache
  - If neurologic signs or symptoms of increased intracranial pressure are present, MRI is recommended. If MRI is not available or there are problems with sedation, CT should be performed.
  - CT of the head without intravenous contrast is recommended for sudden severe headaches (thunderclap headaches).
  - If subarachnoid hemorrhage is detected, CT or conventional angiography should be performed. MRA is also appropriate but is generally considered less sensitive in detecting small aneurysms.
  - If intracranial hemorrhage is present, MRI of the brain should be performed if possible. Obtaining a concomitant MRA is recommended.

- If infarction is present, and there is concern for possible arterial dissection, CTA or conventional angiography should be performed. MRA is also appropriate; however, its sensitivity for detecting dissection is generally considered lower than that of CT or conventional angiography.

- Headache attributed to infection
  - If there is concern for meningitis or encephalitis, CT can be performed prior to LP to exclude impending herniation related to increased intracranial pressure.
  - MRI or CT may be appropriate to evaluate the brain, leptomeninges, and extra-axial spaces in patients with suspected meningitis, encephalitis, or brain abscess. MRI is the study of choice.
  - CT is usually appropriate for evaluating for sinusitis or mastoiditis.
  - CT or MRI is usually appropriate for imaging patients with SDE. If there is concern for venous sinus thrombosis, either CT or MR venography is usually appropriate.
- Headache attributed to trauma
  - If there are headaches with neurologic signs or symptoms following head trauma including vomiting, or headaches that are increasing in frequency, duration, or severity, CT is usually the initial imaging modality of choice in the acute clinical setting.
  - See the ACR Appropriateness Criteria® on "Head Trauma."

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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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.