American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Headache**

Variant 1: **Worsened chronic headache. History of headache.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with contrast	4		None
CT head without contrast	4		Low
CT head without and with contrast	4		Low
MRI head without contrast	4		None
MRA head	2		None
INV angiography cerebral	2		IP
NUC SPECT head	2		High
CTA head	2		Low
US transcranial	1		None
FDG-PET head	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 2: **Sudden onset of severe headache ("Worst headache of one's life, thunderclap headache").**

Radiologic Procedure	Rating	Comments	RRL*
CT head without contrast	9		Low
CTA head	8		Low
MRA head	8		None
INV angiography cerebral	7		IP
MRI head without contrast	7	May be helpful after CT depending on CT findings.	None
MRI head without and with contrast	6	May be helpful after CT depending on CT findings.	None
CT head without and with contrast	6		Low
US transcranial	2		None
NUC SPECT head	2		High
FDG-PET head	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Clinical Condition: **Headache**

Variant 3: **Sudden onset of unilateral headache, or suspected carotid or vertebral dissection or ipsilateral Horner's syndrome.**

Radiologic Procedure	Rating	Comments	RRL*
CTA head and neck	8	Usage of CT versus MRI depends on local preference and availability.	Low
MRA head and neck	8	Usage of CT versus MRI depends on local preference and availability.	None
MRI head without and with contrast	8	With diffusion-weighted sequences.	None
CT head without contrast	8		Low
MRI head without contrast	8	With diffusion-weighted sequences.	None
INV angiography cerebral	7		IP
CT head without and with contrast	6		Low
US carotid duplex	3		None
NUC SPECT head	2		High
US transcranial	2		None
FDG-PET head	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 4: **Headache, suspected complication of sinusitis and/or mastoiditis.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with contrast	8		None
CT head without contrast	7	Include sinuses.	Low
MRI head without contrast	7		None
CT head without and with contrast	6	Include sinuses.	Low
X-ray skull	4		Min
US transcranial	2		None
NUC SPECT head	1		High
FDG-PET head	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Clinical Condition: **Headache**

Variant 5: **New headache in patient older than age 60. Sedimentation rate higher than 55, temporal tenderness. Suspected temporal arteritis.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without contrast	8	With diffusion-weighed sequences.	None
MRI head without and with contrast	7	With diffusion-weighed sequences.	None
CT head without contrast	6		Low
CTA head and neck	5		Low
MRA head and neck	5		None
CT head without and with contrast	5		Low
INV angiography cerebral	4	If noninvasive imaging unrewarding.	IP
US transcranial	2		None
NUC SPECT head	1		High
FDG-PET head	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 6: **New headache in HIV+ individual.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without contrast	8		None
MRI head without and with contrast	8		None
CT head without contrast	6	If MRI not available.	Low
CT head without and with contrast	5		Low
MRA head	3	If vascular lesion suspected.	None
CTA head	3	If vascular lesion suspected.	Low
US transcranial	2		None
FDG-PET head	2	Useful if indeterminate mass present.	High
NUC SPECT head	2	Useful if indeterminate mass present.	High
INV angiography cerebral	2	If noninvasive imaging non-rewarding.	IP
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Clinical Condition: **Headache**

Variant 7: **New headache in pregnant patient.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without contrast	8		None
CT head without contrast	8		Low
MRI head without and with contrast	5	Pregnancy is a relative contraindication to gadolinium administration. Reserve for urgent medical necessity.	None
MRA head	5	MR venography (MRV) should also be performed.	None
CT head with contrast	3	For urgent medical necessity only.	Low
CTA head	2	If MRI not available, contraindicated or inconclusive.	Low
US transcranial	1		None
NUC SPECT head	1		High
FDG-PET head	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 8: **New headache. Suspected meningitis/encephalitis.**

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with contrast	8		None
CT head without contrast	8	To exclude intracranial pressure.	Low
MRI head without contrast	6	Needs contrast.	None
MRA head	6	MRV should also be performed.	None
CT head without and with contrast	6	MRI preferable, depending on availability.	Low
CTA head	3	Useful for problem solving or if there is a strong suspicion of vascular disease.	Low
US transcranial	1		None
NUC SPECT head	1		High
FDG-PET head	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Expert Panel on Neurologic Imaging: John E. Jordan, MD[1]; David J. Seidenwurm, MD[2]; Patricia C. Davis, MD[3]; James A. Brunberg, MD[4]; Robert Louis De La Paz, MD[5]; Pr. Didier Dormont[6]; David B. Hackney, MD[7]; John P. Karis, MD[8]; Suresh Kumar Mukherji, MD[9]; Patrick A. Turski, MD[10]; Franz J. Wippold II, MD[11]; Robert D. Zimmerman, MD[12]; Michael W. McDermott, MD[13]; Michael A. Sloan, MD, MS.[14]

Summary of Literature Review

Headache is one of the most frequent ailments of the human race. Studies of the prevalence of headache: of any kind in populations have estimated frequencies of 11%-48% in children [1,2] and 6%-71% in adults [3,4]. As with migraine, age, gender, and case definition may largely account for this variance [5]. However, a higher prevalence of headache has been found by surveys in Europe and North America [6,7] than by those of Asian and South American countries [4,8]. A survey of the Canadian population showed that only about 20% of people there are headache free [9]. Prevalence of migraine shows a clear-cut gender difference, affecting about 15%-18% of women and 6% of men [5,10]. It occurs most commonly in men and women 25-55 years of age. Muscle contraction or tension accounts for most of the nonmigraine headaches encountered in population surveys.

By comparison, the frequency of pathology that can present with headache is rather small. The yearly incidence of brain tumors in the United States is 46 per 100,000. For subarachnoid hemorrhage, the yearly incidence is 9 per 100,000. Arteriovenous malformations (AVMs) are about one-tenth as frequent as saccular aneurysms. Only a subset of these patients presents with isolated headache. In a retrospective review of the presentation of 111 brain tumors, headaches were a symptom in 48%, equally for primary and metastatic brain tumors [11]. 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 only 45% of patients. Other studies have found a higher frequency, but sometimes the headache preceded the diagnosis of brain tumor by several years, bringing up the possibility of an association with this common complaint, rather than causality [12,13]. In children with brain tumors, headache was present in 62%, more often with infratentorial tumors [14]. Because tumors are rare and only about 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 [13].

Several studies have confirmed the low yield of imaging procedures in individuals presenting with isolated headache—that is, headache unaccompanied by other neurological findings [15,16]. Most of them are retrospective reviews. The patients were referred for imaging because the referring physician suspected pathology detectable by imaging or the 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 of them 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 medico-legal concerns [17].

Studies before 1991 on the yield of CT or magnetic resonance imaging (MRI) in patients with headache but normal neurological examination were reviewed by Frishberg [18]. Most of the larger ones were performed with first-generation CT. In addition, he included three more studies in his excellent meta-analysis [19-21]. Of 897 studies in patients with migraine, only four were positive, three for a tumor and one for an AVM, 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 hydrocephalus, 6 AVMs, 5 subdural hematomas, and 3 aneurysms), for a 2.4% yield of potentially treatable lesions. However, two 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 [19,21]. If these two studies are not included among those performed in patients with unspecified headache, the total number of potentially treatable lesions is reduced to three in 725 studies (0.4%) [18]. A potential bias for the early series, however, is that the studies were performed with first-generation equipment, which was likely to have less sensitivity than currently used units.

Of 1,999 scans reported in other series, including mostly CT, only 21 (1%) disclosed treatable lesions [17,22-28].

[1]Review Author, Memrad Medical Group, Inc., Long Beach, Calif; [2]Panel Chair, Radiological Associates of Sacramento, Sacramento, Calif; [3]Vice-Chair, Northwest Radiology Consultants, Atlanta, Ga; [4]University of California-Davis Medical Center, Sacramento, Calif; [5]Columbia University Medical Center, New York, NY; [6]Hôpital de la Salpêtrière, Assistance-Publique-Hôpitaux de Paris, France; [7]Beth Israel Medical Center, Boston, Mass; [8]SW Neuro-Imaging, Phoenix, Ariz; [9]University of Michigan Health System, Ann Arbor, Mich; [10]University of Wisconsin, Madison, Wis; [11]Mallinckrodt Institute of Radiology, Saint Louis, MO; [12]New York Hospital-Cornell University Medical Center, New York, NY; [13]University of California-San Francisco, San Francisco, Calif, American Association of Neurlogical Surgeons; [14]Carolinas Medical Center, Charlotte, NC, American Academy of Neurology.

Reprint requests to: Department of Quality & Safety, American College of Radiology, 1891 Preston White Drive, Reston, VA 20191-4397.

Most of the positive cases occurred in the series of Becker et al [17], which included an unspecified number of patients with abnormal neurological findings. If this series is excluded from the analysis, only nine 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 [29].

When considering such a common disorder as headache, the indications for the use of imaging procedures become particularly relevant. This is particularly true in view of the emerging and rapidly evolving technologies in use today [30-33]. In frequent conditions, performing low-yield studies is more likely to result in false positive results, with the consequent risk of causing additional and unnecessary procedures to be performed. As indicated above, the yield of positive studies in patients referred with isolated, nontraumatic headache is about 0.4%. In terms of cost, if one assumes the cost of a CT scan to be $400 and an MRI to be $900, to detect a lesion with CT would cost $100,000 and with MRI, $225,000.

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 the one suffering them, 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 accounted for. While 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 emphasized that costs of detection or screening in imaging headache are always overstated when the value of negative results are not factored into the analysis [16].

Some headache presentations require further discussion. A patient presenting with a sudden, severe headache ("the worst headache of my life", "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 having an SAH, which is more often related to an aneurysm than to an AVM. In a combination of three series, as many as 165 of 350 patients (47%) presenting with thunderclap headache had an SAH [34-36]. If the CT scan is negative, a lumbar puncture should be performed to disclose additional instances of SAH [34,36]. These patients may require magnetic resonance angiography (MRA), computed tomography angiography (CTA), and/or catheter angiography to determine the nature and location of the lesion.

Sudden, severe unilateral headache in a young patient, particularly when it radiates into the neck and is accompanied by ipsilateral Horner's syndrome, may be the result of arterial dissection of the carotid or vertebral arteries [37]. In a series of 161 patients, headache was reported by 68% of them, and, when present, it was the initial manifestation in 47% of those with carotid dissection and in 33% of those with vertebral dissection [38]. Although some of these patients had stroke-like syndromes, others did not, or they developed them several days after an initial presentation with isolated headache. The pattern of radiation will often differ enough to make the patient suspect that this is not a regular headache. In this case, MRI, MRA, CTA and/or catheter angiography are particularly useful to identify the nature of the lesion. Current practice is to anticoagulate these patients to prevent thrombosis at the site of the stenotic lesion. For this reason, identification of the pathology is important.

In 315 children with isolated headache scanned at Boston Children's Hospital, 4% had surgical space-occupying lesions [39]. Sleep-related headache and no family history of migraine were the strongest predictors. The comments made above about selected populations referred to tertiary care centers apply to this example also.

Patients older than 55 years with new onset of headache in the temple regions, particularly when they have tender superficial temporal arteries, should be studied for temporal arteritis [40-42]. Treatment with steroids may forestall vision loss or brainstem strokes.

New onset of headache in populations predisposed to intracranial pathology also results in a much higher yield of findings by CT or MRI. 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 [43]. Patients with known cancer should also be scanned when a headache develops or changes in characteristics [44,45]. In the Andes population, the rate of headache is low, whereas cysticercosis is common. As a result, CT of patients with headache yielded a 33% rate of positive studies [8].

In summary, screening patients with isolated, nontraumatic headache by means of CT or MRI is not warranted. However, for some types of headache or populations at risk these procedures are more likely to be positive. Thunderclap headaches, headaches radiating to the neck, and temporal headaches in an older individual are examples of headaches for which imaging procedures may be helpful. Patients with suspected meningitis and those presenting with headaches in pregnancy also often pose important diagnostic challenges [46-48]. HIV-positive individuals, cancer patients, or other populations at high risk of intracranial disease also should be screened when presenting with new-onset headaches.

References

1. Abu-Arefeh I, Russell G. Prevalence of headache and migraine in schoolchildren. *BMJ* 1994; 309(6957):765-769.
2. Brattberg G. The incidence of back pain and headache among Swedish school children. *Qual Life Res* 1994; 3(Suppl 1):S27-S31.
3. Gobel H, Petersen-Braun M, Soyka D. The epidemiology of headache in Germany: a nationwide survey of a representative sample on the basis of the headache classification of the International Headache Society. *Cephalalgia* 1994; 14(2):97-106.
4. Wong TW, Wong KS, Yu TS, Kay R. Prevalence of migraine and other headaches in Hong Kong. *Neuroepidemiology* 1995; 14(2):82-91.
5. Lipton RB, Stewart WF. The epidemiology of migraine. *Eur Neurol* 1994; 34(suppl 2):6-11.
6. Kryst S, Scherl E. A population-based survey of the social and personal impact of headache. *Headache* 1994; 34(6):344-350.
7. Merikangas KR, Whitaker AE, Isler H, Angst J. The Zurich Study: XXIII. Epidemiology of headache syndromes in the Zurich cohort study of young adults. *Eur Arch Psychiatry Clin Neurosci* 1994; 244(3):145-152.
8. Cruz ME, Cruz I, Preux PM, Schantz P, Dumas M. Headache and cysticercosis in Ecuador, South America. *Headache* 1995; 35(2):93-97.
9. O'Brien B, Goeree R, Streiner D. Prevalence of migraine headache in Canada: a population-based survey. *Int J Epidemio*l 1994; 23(5):1020-1026.
10. Russell MB, Rasmussen BK, Thorvaldsen P, Olesen J. Prevalence and sex ratio of the subtypes of migraine. *Int J Epidemiol* 1995; 24(3):612-618.
11. Forsyth PA, Posner JB. Headaches in patients with brain tumors: a study of 111 patients. *Neurology* 1993; 43(9):1678-1683.
12. Suwanwela N, Phanthumchinda K, Kaoropthum S. Headache in brain tumor: a cross-sectional study. *Headache* 1994; 34(7):435-438.
13. Purdy RA, Kirby S. Headaches and brain tumors. *Neurol Clin* 2004; 22(1):39-53. Review.
14. The epidemiology of headache among children with brain tumor. Headache in children with brain tumors. The Childhood Brain Tumor Consortium. *J Neurooncol* 1991; 10(1):31-46.
15. Tsushima Y, Endo K. MR imaging in the evaluation of chronic or recurrent headache. *Radiology* 2005; 235(2):575-579. Review.
16. Jordan JE, Ramirez GF, Bradley WG, Chen DY, Lightfoote JB, Song A. Economic and outcomes assessment of magnetic resonance imaging in the evaluation of headache. *J Natl Med Assoc* 2000; 92(12):573-578.
17. Becker LA, Green LA, Beaufait D, Kirk J, Froom J, Freeman WL. Use of CT scans for the investigation of headache: a report from ASPN, Part 1. *J Fam Pract* 1993; 37(2):129-134.
18. Frishberg BM. The utility of neuroimaging in the evaluation of headache in patients with normal neurologic examinations. *Neurology* 1994; 44(7):1191-1197.
19. Mitchell CS, Osborn RE, Grosskreutz SR. Computed tomography in the headache patient: is routine evaluation really necessary? *Headache* 1993; 33(2):82-86.
20. Osborn RE, Alder DC, Mitchell CS. MR imaging of the brain in patients with migraine headaches. *AJNR* 1991; 12(3):521-524.
21. Weingarten S, Kleinman M, Elperin L, Larson EB. The effectiveness of cerebral imaging in the diagnosis of chronic headache. *Arch Intern Med* 1992; 152(12):2457-2462.
22. Akpek S, Arac M, Atilla S, Onal B, Yucel C, Isik S. Cost-effectiveness of computed tomography in the evaluation of patients with headache. *Headache* 1995; 35(4):228-230.
23. Cull RE. Investigation of late-onset migraine. *Scott Med J* 1995; 40(2):50-52.
24. Demaerel P, Boelaert I, Wilms G, Baert AL. The role of cranial computed tomography in the diagnostic work-up of headache. *Headache* 1996; 36(6):347-348.
25. Dumas MD, Pexman JH, Kreeft JH. Computed tomography evaluation of patients with chronic headache. *CMAJ* 1994; 151(10):1447-1452.
26. Maytal J, Bienkowski RS, Patel M, Eviatar L. The value of brain imaging in children with headaches. *Pediatrics* 1995; 96(3 Pt 1):413-416.
27. McAbee GN, Siegel SE, Kadakia S, Cantos E. Value of MRI in pediatric migraine. *Headache* 1993; 33(3):143-144.
28. Sotaniemi KA, Rantala M, Pyhtinen J, Myllyla VV. Clinical and CT correlates in the diagnosis of intracranial tumors. *J Neurol Neurosurg Psychiatry* 1991; 54(7):645-647.
29. Reinus WR, Erickson KK, Wippold FJ II. Unenhanced emergency cranial CT: optimizing patient selection with univariate and multivariate analyses. *Radiology* 1993; 186(3):763-768.
30. Medina LS, D'Souza B, Vasconcellos E. Adults and children with headache: evidence-based diagnostic evaluation. *Neuroimaging Clin N Am* 2003; 13(2):225-235. Review.
31. Sandrini G, Friberg L, Janig W, et al. Neurophysiological tests and neuroimaging procedures in non-acute headache: guidelines and recommendations. *Eur J Neurol* 2004; 11(4):217-224.
32. Cohen AS, Goadsby PJ. Functional neuroimaging of primary headache disorders.Curr *Neurol Neurosci Rep* 2004; 4(2):105-110.
33. Aurora SK. Imaging chronic daily headache. *Curr Pain Headache Rep* 2003; 7(3):209-211. Review.
34. Lledo A, Calandre L, Martinez-Menendez B, Perez-Sempere A, Portera-Sanchez A. Acute headache of recent onset and subarachnoid hemorrhage: a prospective study. *Headache* 1994; 34(3):172-174.
35. Linn FH, Wijdicks EF, van der Graaf Y, Weerdesteyn-van Vliet FA, Bartelds AI, van Gijn J. Prospective study of sentinel headache in aneurysmal subarachnoid hemorrhage. *Lancet* 1994; 344(8922):590-593.
36. van der Wee N, Rinkel GJ, Hasan D, van Gijn J. Detection of subarachnoid haemorrhage on early CT: is lumbar puncture still needed after a negative scan? *J Neurol Neurosurg Psychiatry* 1995; 58(3):357-359.
37. Biousse V, D'Anglejan-Chatillon J, Massiou H, Bousser MG. Head pain in non-traumatic carotid artery dissection: a series of 65 patients. *Cephalalgia* 1994; 14(1):33-36.
38. Silbert PL, Mokri B, Schievink WI. Headache and neck pain in spontaneous internal carotid and vertebral artery dissections. *Neurology* 1995; 45(8):1517-1522.
39. Medina LS, Pinter JD, Zurakowski D, Davis RG, Kuban K, Barnes PD. Children with headache: clinical predictors of surgical space-occupying lesions and the role of neuroimaging. *Radiology* 1997; 202(3):819-824.
40. Caselli RJ, Hunder GG, Whisnant JP. Neurologic disease in biopsy-proven giant cell (temporal) arteritis. *Neurology* 1988; 38(3):352-359.
41. Wilkinson IM, Russell RW. Arteries of the head and neck in giant cell arteritis. A pathological study to show the pattern of arterial involvement *Arch Neurol* 1972; 27(5):378-391.
42. Husein AM, Haq N. Cerebral arteritis with unusual distribution. *Clin Radiol* 1990; 41(5):353-354.
43. Lipton RB, Feraru ER, Weiss G, et al. Headache in HIV-1-related disorders. *Headache* 1991; 31(8):518-522.
44. Sze G, Johnson C, Kawamura Y, et al. Comparison of single- and triple-dose contrast material in the MR screening of brain metastases. *AJNR* 1998; 19(5):821-828.
45. Yokoi K, Kamiya N, Matsuguma H, et al. Detection of brain metastasis in potentially operable non-small-cell lung cancer: a comparison of CT and MRI. *Chest* 1999; 115(3):714-719.
46. Silberstein SD. Headaches in pregnancy. *Neurol Clin* 2004; 22(4):727-756. Review.
47. Kastrup O, Wanke I, Maschke M. Neuroimaging of infections. *NeuroRx* 2005; 2(2):324-332.Castillo M. Imaging of meningitis. *Semin Roentgenol* 2004; 39(4):458-464.
48. Castillo M. Imaging of meningitis. *Semin Roentgenol* 2004; 39(4):458-464.