



Neuroimaging for Headache

- Neuroimaging is not generally warranted for patients with primary (e.g. migraine or chronic) headaches, but is usually indicated for secondary (i.e. associated with underlying pathology) headaches
- Clinical distinctions between primary and secondary headache are dictated by factors such as headache characteristics, the patient's medical history, and neurological examination findings
- Emergent CT examination is recommended for patients presenting with sudden, severe "thunderclap" headaches or worst headache of life
- CT examination is recommended for patients presenting with secondary headaches in urgent clinical situations; MRI is preferable in non-urgent situations

The vast majority of patients presenting with headaches have primary headache disorders such as migraine, cluster, and tension type headaches. Since primary headache disorders do not result from structural brain abnormalities, head CT or brain MRI is unlikely to be helpful for patients with true primary headaches. However, it is not always easy to rule out a secondary headache caused by an underlying lesion and physicians often err on the side of caution, ordering neuroimaging indiscriminately for all patients with headache. As a result, there is a high referral rate for neuroimaging, most of which results in either normal scans or show incidental abnormalities that, in turn, cause anxiety and lead to unnecessary additional tests.

The overall yield of neuroimaging studies for headache without accompanying neurologic abnormalities is low (Table 1). In a Canadian study investigating the use of CT scans for patients with headache, patient expectations or medicolegal concerns were cited as the primary reason for ordering the scan in 17% of patients. Most of this cohort (85%) had no neurological abnormalities. In 49% of these patients, the referring physician suspected an intracranial tumor. However, the yearly incidence of brain tumors is only 7 per 100,000 in the USA and only about 8% of patients with brain tumors present with an isolated headache as a first and only symptom.

Indications for Neuroimaging

The US Headache Consortium, the American Academy of Neurology, the American College of Emergency Physicians, and the American College of Radiology have published guidelines and practice parameters for neuroimaging in patients with headache, based on

Table 1. Diagnostic yield of neuroimaging for headache with normal neurological exam*

Abnormality found	Incidence (n = 3027)
Brain tumor	0.8%
Arteriovenous malformation	0.2%
Hydrocephalus	0.2%
Aneurysm	0.3%
Sub-dural hematoma	0.2%
Stroke, including chronic ischemic processes †	1.2%

*From Evans, 1996 †Unlikely to be cause of headache

extensive literature reviews. Their recommendations are summarized in Table 2. While these recommendations are followed at Massachusetts General Hospital, we almost always perform neuroimaging for the conditions where "neuroimaging should be considered" in Table 2. We do not encourage neuroimaging in patients with migraine or other chronic headache disorders who have a normal neurological exam and no predisposing factors for brain pathology, such as HIV infection or associated seizures. However, it is important to first make an accurate diagnosis of migraine and distinguish primary from secondary headache disorders. To do so, the physician must elicit an accurate history, perform a thorough neurological examination, and be familiar with the International Headache Society criteria for the diagnosis of headache. Response to analgesics should not be used to make a

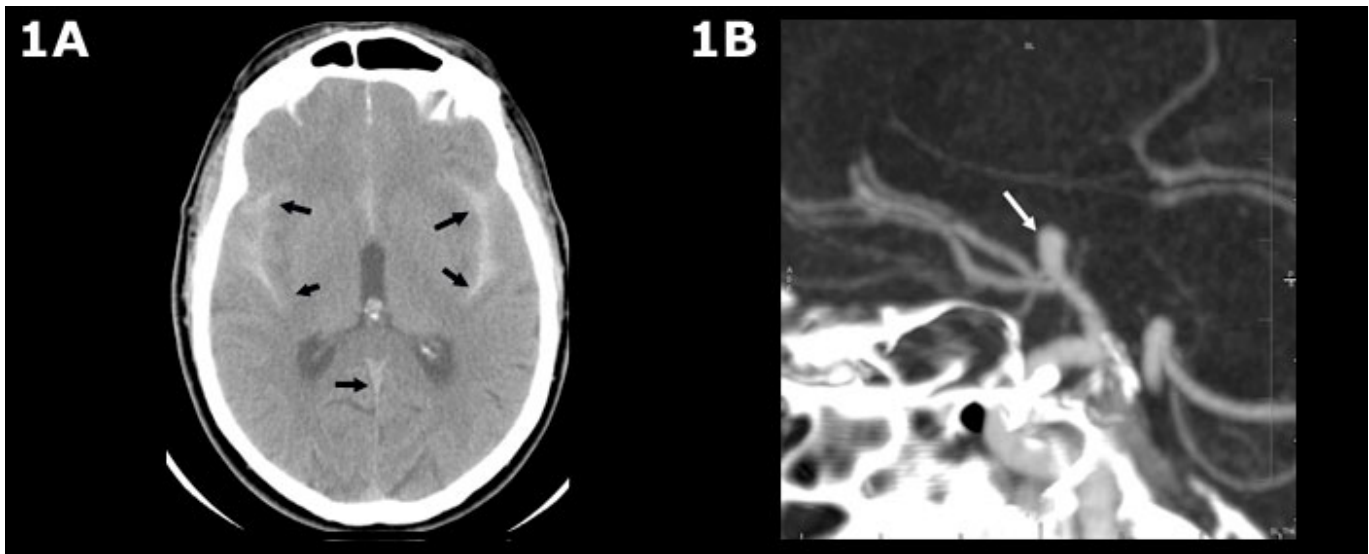


Figure 1. Subarachnoid hemorrhage - 72 year-old man complaining of sudden onset of “worse headache of his life.” Noncontrast CT (A) demonstrates subarachnoid hemorrhage (arrows). Maximal intensity projection (MIP) 3-D reconstruction image (B) from a CT angiogram demonstrates an aneurysm (arrow) from the anterior communicating artery as the cause of the bleed.

Emergent neuroimaging recommended	“Thunderclap” headache with abnormal neurological exam
Neuroimaging recommended to determine if it is safe to do lumbar puncture	Headache accompanied by signs of increased intracranial pressure Headache accompanied by fever and nuchal rigidity
Neuroimaging should be considered	Isolated “thunderclap” headache Headache radiating to neck Temporal headache in an older individual New onset headache in patient who is - HIV positive - has a prior diagnosis of cancer - is in a population at high risk for intracranial disease Headache accompanied by abnormal neurological examination, including papilledema or unilateral loss of sensation, weakness, or hyperflexia
Neuroimaging not usually warranted	Migraine and normal neurological exam
No recommendation (Some evidence for increased risk of intracranial abnormality, not sufficient for recommendation)	Headache worsened by Valsalva maneuver, wakes patient from sleep, or is progressively worsening
No recommendation (insufficient data)	Tension type headache and normal neurological exam

¹ From guidelines developed by US Headache Consortium, the American Academy of Neurology, the American College of Emergency Physicians, and the American College of Radiology.

Choice of Neuroimaging Protocol

While the above guidelines are helpful for selecting patients for neuroimaging tests, they do not guide the choice of imaging modality or the use of contrast or specific imaging sequences, which may increase the diagnostic yield. The algorithm typically followed at Massachusetts General Hospital is presented in Table 3.

In general, MRI is considered superior to CT for evaluating the brain parenchyma, and CT is considered superior to MRI for evaluating subarachnoid hemorrhage. However, because CT is faster and more readily available, it should be performed in emergent evaluation of a patient with a sudden onset, “thunderclap” headache or worst headache of their life.

CT is also used in urgent clinical situations, for example, to exclude midline shift prior to lumbar puncture, or to evaluate for hydrocephalus. In addition, CT angiography may be superior to MR angiography for vascular lesions. In other cases, MRI is generally the preferred modality.

Additional neuroimaging may be warranted based upon the initial imaging findings. For example, if subarachnoid or intraparenchymal hemorrhage is found, CT angiography is recommended for suspected vascular malformations or aneurysms and CT venography for suspected cerebral venous sinus thrombosis. In addition, transfemoral angiography may

be considered for arteriovenous malformations or cerebral vasculitis; transcranial Doppler ultrasound for stroke; and positron emission tomography (PET) for neoplasms.

Ultimately, the choice of imaging modality and imaging protocol should be based on clinical suspicion, and determined after consultation with a neuroradiologist. The choice is complex, especially for MRI, because

there are several specific MRI sequences, each of which can be helpful for certain diagnoses. For example, contrast injection may be considered for inflammatory, infectious, neoplastic, and demyelinating conditions; gradient echo sequences for intracranial hemorrhage; MR-angiography for vascular diseases; fat-suppressed T1 axial images for cerebral artery dissection; and MR-spectroscopy for brain neoplasms.

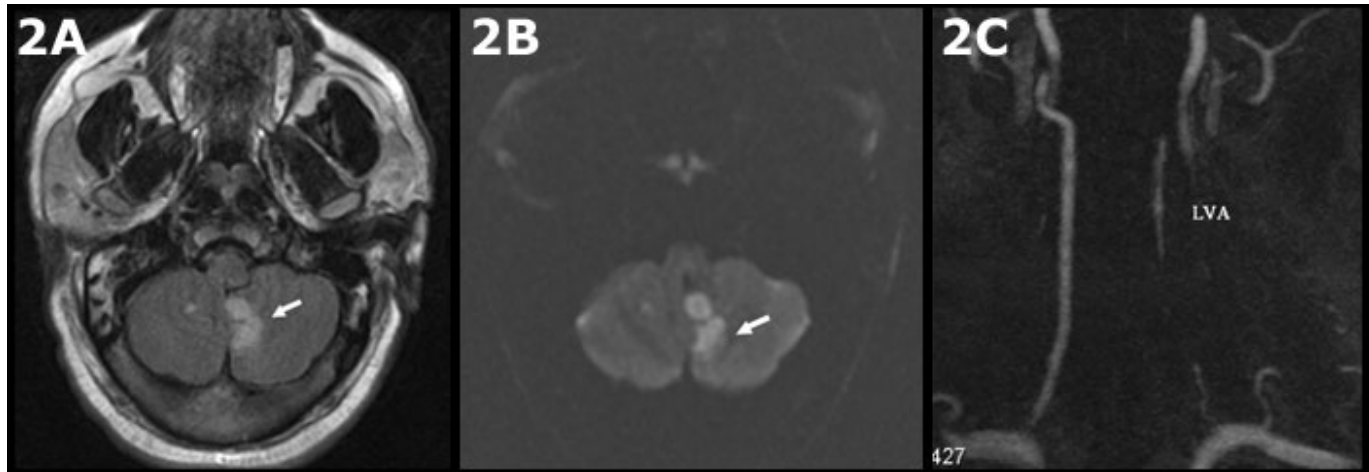


Figure 2. Cerebellar stroke from vertebral artery dissection - 51 year-old man with headache and vertigo. Axial MR (A) and diffusion weighted (B) images demonstrate abnormal signal in the left cerebellum consistent with a subacute infarction. MRA (C) demonstrates loss of flow-related signal in the left vertebral artery (LVA) corresponding to a dissection.

Table 3. MGH Algorithm for Neuroimaging Modality Choice in Patients with Headache

FOR PATIENTS PRESENTING WITH:

- *Worst headache of life*
- *Sudden, severe "thunderclap" headache*

An emergent non-contrast head CT scan should be obtained. If it shows:

- Subdural hematoma, patient requires surgical evaluation.
- Subarachnoid or intraparenchymal hemorrhage, further neuroimaging is warranted.
 - CT angiography for suspected vascular malformations or aneurysms.
 - MRI for suspected cerebral amyloid angiopathy or brain neoplasms.
 - CT venography for suspected cerebral venous sinus thrombosis.
- A mass lesion, proceed with a brain MRI.
- No lesion to explain the headache, obtain an MRI. Consider additional tests such as CT angiography, MR angiography, transcranial Doppler ultrasound, or lumbar puncture.

FOR PATIENTS PRESENTING WITH:

- *New headache with focal neurological symptoms or abnormal neurological exam.*
- *Headache with fever and/or nuchal rigidity.*
- *Headache with signs of increased intracranial pressure.*
- *Progressively worsening headache.*
- *New onset headache in patients with known underlying brain lesion or systemic illness that predisposes to intracranial pathology (e.g. HIV, TB, cancer).*

CT scan is performed only for urgent clinical indications to:

- Exclude midline shift prior to lumbar puncture.
- Evaluate for hydrocephalus.

MRI is the preferred modality; discuss with neuroradiologist to optimize protocol.

- Intravenous contrast for inflammatory, infectious, neoplastic, and demyelinating conditions.
- Gradient echo sequences for intracranial hemorrhage.
- MR-angiography for vascular diseases.
- Fat-suppressed T1 axial images for cerebral artery dissection.
- MR-spectroscopy for brain neoplasms.

Additional neuroimaging may be warranted based upon the initial imaging findings.

Scheduling

If emergency neuroimaging is warranted, the patient should be sent to the Emergency Department at MGH, where a CT will be performed. In other cases, neuroimaging can be performed at Mass General West Imaging in Waltham, Mass General Imaging in Chelsea or the main MGH campus. Neuroimaging can be ordered online via the Radiology Order Entry (<http://mghroe/>) or by calling 4-XRAY (617-724-9729).

Further Information

For further questions on neuroimaging for headache, please contact [Pamela W. Schaefer, M.D.](#), Associate Radiologist in the Neuroradiology Division (617-726-8320), or [Aneesh B. Singhal, M.D.](#), Assistant Professor of Neurology (617-726-8459 x 4).

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References

- Evans RW. (1996) *Diagnostic testing for the evaluation of headaches*. *Neurol Clin* 14:1-26.
- Frischberg B, Rosenberg J, Matchar D, et al. (2000) *Evidence based guidelines in the primary care setting: Neuroimaging in patients with nonacute headache*. <http://www.aan.com/professionals/practice/pdfs/g10088.pdf>: National Headache Consortium.
- Silberstein SD. (2000) *Practice parameter: evidence-based guidelines for migraine headache (an evidence-based review): report of the Quality Standards Subcommittee of the American Academy of Neurology*. *Neurology*. 55: 754-62.
- Lewis D, Ashwal S, Hershey A, Hirtz D, Yonker M, Silberstein S. (2004). American Academy of Neurology Quality Standards Subcommittee; Practice Committee of the Child Neurology Society. *Practice parameter: pharmacological treatment of migraine headache in children and adolescents: report of the American Academy of Neurology Quality Standards Subcommittee and the Practice Committee of the Child Neurology Society*. *Neurology* 63:2215-24.
- American College of Emergency Physicians (2002). *Clinical policy: critical issues in the evaluation and management of patients presenting to the emergency department with acute headache*. *Ann Emerg Med* 39:108-22.
- Expert Panel on Neurologic Imaging. (2006) ACR Appropriateness Criteria. http://www.acr.org/s_acr/bin.asp. Reston, VA: American College of Radiology.
- Headache Classification Committee of the International Headache Society (2004). *The International Classification of Headache Disorders*. *Cephalalgia*. 2004; 24: 1–160
- Schwedt TJ, Matharu MS, Dodick DW. (2006) *Thunderclap headache*. *Lancet Neurol*. 5:621-31.

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Janet Cochrane Miller, D. Phil., Author
Susanna I. Lee, M.D., Ph.D., Editor