Neuroimaging of Adults with Headache

Appropriateness, Utilization, and an Economical Overview

Judith A. Gadde, DO, MBA[a,*], Sarah Cantrell, MD[b], Sumir S. Patel, MD, MBA[a], Mark E. Mullins, MD, PhD[a]

KEYWORDS

• Adult • Appropriateness • Headache • Imaging • Indication • Quality • Safety • Socioeconomics

KEY POINTS

- Attention to quality, safety, utilization, and appropriateness will benefit both patients presenting with headache, as well as the health care system.
- The cost of headache to the individual patient can be large, as can the cost to society.
- Becoming familiar with the workup and treatment of headaches will typically make one a better neuroradiologist.

BACKGROUND AND IMPORTANCE

An approach to thinking about the workup of patients for referral to the Radiology department is nicely phrased in the abstract of an article from Lester and Liu: "When deciding to perform imaging for headache, it is important to consider many factors including the pretest probability, prevalence of diseases, sensitivity of imaging, and implications of treatment."[1] It is hoped that the reader will agree that this approach is not unique to the workup of patients with headache.

This article is meant to complement the others in this issue of *Neuroimaging Clinics of North America* and is organized with attention to quality, safety, utilization, and appropriateness, including socioeconomics. This work is not meant to be all-inclusive because that would likely require the length of 1 or more books. To help with focus, this article attends to adults; as well, the emphasis of this work is on nontraumatic presentations. Health care resources are typically limited; appropriate utilization of resources is paramount to the practice of medicine.

Frequency

Although many of us view headache as a ubiquitous aspect of life, studies demonstrate an estimated overall lifetime prevalence of headache (any kind) between 0.2% and 60%.[2] Headaches are most common between the ages of 25 and 55 years.[2] Hainer and Matheson estimated in 2013 that half of the world's adult population suffered from a "headache disorder."[3]

According to the World Health Organization, headache disorders are estimated to have affected half of all people within the last year.[4] Two to four percent of visits to Emergency Departments (EDs) are due to nontraumatic headaches,

J.A. Gadde and S. Cantrell are co-first authors.

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[a] Department of Radiology, Emory University School of Medicine, 1364 Clifton Road NE, BG 20, Atlanta, GA 30322, USA; [b] Baylor Radiologists, CHI St Lukes, Texas Medical Center, 6720 Bertner Avenue, MC 2-270, Houston, Texas 77030, USA

* Corresponding author.

E-mail address: jagadde@emory.edu

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with more than 800,000 annual ED visits due to migraine.[5–7] Although ED use for the workup and treatment of uncomplicated headache is likely suboptimal for multiple reasons (including but not limited to especially limited resources, long wait times, and characteristic lack of care continuity), approximately 5 million people per year seek headache treatment in the ED.[6]

Epidemiology

Although different types of headaches have typically varying age and gender distribution, headache disorders overall show no clear distinction between gender, race, age, geography, and income.[4,8] Furthermore, headache disorders, including migraine and medication-overuse headache, result in the third highest worldwide cause of disability when measured in years of life with disability.[9,10] Even though there is such a high prevalence of headache, it is estimated that only 50% of migraine sufferers in the United States sought professional (health) care for this issue in the last year.[4]

Appropriateness

In the mid-1980s, the RAND/UCLA Appropriateness Method defined an appropriate procedure as one in which "the expected health benefit exceeds the expected negative consequences by a sufficiently wide margin that the procedure is worth doing, exclusive of cost."[11] The ACR (American College of Radiology) Appropriateness Criteria (ACR AC), which will also be discussed later, assists in determining when and what kind of neuroimaging is appropriate for use in patients presenting with headaches.[2]

Utilization

Imaging services and their costs grew at almost twice the rate of our health care technologies during the early 2000s.[12] Overutilization of imaging services may be defined as when imaging procedures are performed despite the unlikeliness to improve patient outcome. As alluded earlier, resources are, almost by their very nature, limited and we must be good stewards of these. The typical radiology modalities used to evaluate patients with headache are computed tomography (CT) and MR imaging.

Quality

Quality assurance is the act of measuring compliance against standards. Quality improvement is the continuous act of increasing quality efforts. Quality assurance can be performed without quality improvement, but not vice versa. This is the era for the service-focused practice of radiology. Providing excellent quality and service is our goal. Constant attention to quality is necessary and assuming (but not confirming) quality work may be folly. Evaluation of patients with headache is not unique in this regard, but a focus on quality should not be overlooked nonetheless.

Safety

More than 15 years after the release of the Institute of Medicine's report, "To Err is Human: Building a Safer Health System," patient safety remains at the forefront of the radiologists' minds.[13] Apropos of imaging of patients with headache, attention to this in our department includes but is not limited to CT with ionizing radiation exposure, MR imaging compatibility, use of contrast material, imaging of pregnant patients, minimizing patient radiation dose, and so on. Related topics include (but are not limited to) ALARA (As Low As Reasonably Allowable),[14] Image Gently,[15] and Image Wisely.[15] As with the earlier mention of quality, a focus on safety when approaching potentially imaging patients with headache is not unique but, it is thought, remains relevant and important.

SPECTRUM OF HEADACHES IN ADULTS

Classification of headaches into either primary or secondary is essential for proper evaluation and treatment. That being said, the clinical diagnosis of headache is beyond the scope of this article. Herein, the authors mention a few of the salient concepts. An axiom of neuroradiology is that being familiar with relevant workups and treatments outside of the Radiology department typically makes one a better neuroradiologist.

Headache Classification in the Adult

The third edition of the International Classification of Headache Disorders (ICHD), developed by the International Headache Society, is commonly accepted worldwide as an evidence-based guideline for the diagnosis and classification of headache disorders.[15,16] The ICHD-3 classifies headaches into 3 main groups: (1) primary headaches; (2) secondary headaches; and (3) "painful cranial neuropathies," "other facial pains," and other headaches.[15]

Primary headaches are those that are usually benign and include (but are not limited to) migraine with or without aura, tension-type headache, cluster headaches, and less common headache disorders such as cold-stimulus, cough, and exertional headache.[17]

Secondary headaches[18] are those caused by an underlying disease, which includes (but are not limited to) both (usually) benign and sinister causes such as sinusitis and subarachnoid hemorrhage, respectively. Secondary headaches tend to be less common than primary headaches; an article from Ravishankar in 2016 estimated "less than 10%."[19] Secondary headaches are further divided into 7 main groups: traumatic headaches (head and/or neck); cranial or cervical vascular disorders; nonvascular intracranial disorders; substance use or withdrawal; infections; headache or facial pain attributed to disorder of the cranium, neck, eyes, ears, nose, sinuses, teeth, mouth, or other facial or cervical structure; and psychiatric disorder.[15,16] Practically, common causes of secondary headache, which may require prompt treatment, include but are not limited to intracranial hemorrhage, aneurysm, meningitis, venous sinus thrombosis, and idiopathic intracranial hypertension amongst many others. One study by Grant[20] found that approximately 23% of patients with a primary brain tumor presented with a headache as the first symptom. An additional retrospective review found that headache was a symptom in 48% of 111 patients with brain tumor.[21] A commonly stated motivation for imaging patients complaining of headache is that "it could be something *bad*" and, practically speaking, that argument is moving but with limited resources not all patients with headache may be imaged always and routinely, and thus some justice- and medically based approach to utilization seems appropriate. Furthermore, it is not clear that all patients with headache should be imaged given possible ionizing radiation exposure, potential contrast material administration, access issues with MR imaging, etc. even if there are unlimited resources, which obviously are not.

Red Flags in Adult Headache

Although most individuals are eventually diagnosed as having migraine and/or tension-type headaches (examples of primary headaches), eliminating the possibility of treatable and/or dangerous causes of secondary headache is critical.[22] Clinical features that raise concern for secondary headache are commonly called "red flags" and use of some of these, including but not limited to "…paralysis; papilledema; and 'drowsiness, confusion, memory impairment and loss of consciousness,'" has been reported to be statistically significant.[23]

According to Clinch in 2001, "'Red flags' for secondary disorders include sudden onset, onset after 50 years of age, increased frequency or severity, new onset with an underlying medical condition, concomitant systemic illness, focal neurologic signs or symptoms, papilledema and headache subsequent to trauma."[17] In 2013, Hainer and Matheson published that red flags in adult patients with headache include "…focal neurologic signs, papilledema, neck stiffness, an immunocompromised state, sudden onset of the worst headache of the patient's life, personality changes, headache after trauma, and headache that is worse with exercise."[3]

To aid physicians in deciding which patients should proceed to neuroimaging for evaluation of clinically significant lesions causing headache (secondary headache), Dodick (2003) introduced the SNOOP mnemonic for the identification of clinical "red flags," which may help distinguish primary and secondary headache.[24] These criteria were further revised and adapted to the emergency room setting by Nye and Ward to include *S*ystemic Illness (eg, fever, chills, human immunodeficiency virus, history of cancer), *N*eurologic signs (eg, change in mental status, asymmetric reflexes), *O*nset (eg, acute, sudden or split second thunderclap headache), *O*lder patients (eg, >50 years with new or progressive headache), *P*revious headache history (eg, first headache or different headache changing in frequency, severity, or clinical features), headache in children younger than 5 years, and headache worsening under observation.[25] Some investigators also use an additional expression entitled "yellow flags."[26]

ECONOMIC BURDEN OF HEADACHE

The cost of headache to the individual patient may be large; the cost to society is also remarkable. Headaches are estimated to result in health care expenses of more than $1 billion annually in the United States. It is estimated that 113 million workdays each year are lost due to headache, resulting in about a $13 to 19.6 billion loss to the US economy.[27,28] For chronic migraineurs alone, a 2011 study found that these patients spend $1036 every 3 months on direct headache-related costs, including diagnostic imaging.[29] For perspective, the average cost of a noncontrast head CT is estimated to be between $682 and $1390.[30] In addition, the average brain MR imaging is estimated to be between $1000 and $5000.[30] **Table 1** includes published price ranges for both of these examinations. An approach to cost-effectiveness in this workup[31] is clearly indicated.

Although there have been increasing efforts in consumer price transparency for health care costs, including imaging, there remains a broad range of "average" costs. As imaging

Table 1
Price ranges for common imaging examinations in the evaluation of headache (healthcarebluebook.com)[34]

	Low (USD, $)	High (USD, $)
Radiograph—Face	28	675
Radiograph—paranasal sinuses	37	912
CT head without contrast	219	1983
CT head without and with contrast	248	3014
CT angiography of the head (with contrast)	630	3219
MR imaging brain without contrast	468	3397
MR imaging brain without and with contrast	468	5354
MR angiography of the head (without contrast)	468	3269

From CAREOperative. Find Your Fair Price. 2018. Available at: https://www.healthcarebluebook.com/ui/consumerfront. Accessed May 24, 2018.

examinations such as these are usually requested by nonradiologists, a suboptimal grasp on the cost of these examinations may contribute to the economic burden imposed on headache sufferers.

Unfortunately, this ignorance of imaging cost does not seem to be restricted to nonradiology trainees. A 2014 online survey of more than 1000 US radiology trainees demonstrated that almost 50% of respondents incorrectly estimated the cost of every imaging examination tested.[32] Almost 90% of study respondents desired more dedicated education regarding imaging costs.[32] Trainees with an advanced degree in health policy or economics and trainees who received dedicated education in these areas did not perform better than those trainees without the advanced degree or dedicated education.[32]

Another survey of almost 400 trainees at a large academic institution demonstrated similar findings with more than 75% of respondents incorrectly estimating the cost of every imaging examination.[33] More than 75% of study respondents also desired that cost data be incorporated into clinical decision support.[33]

As mentioned briefly earlier, **Table 1** includes published low and high price estimates for common imaging examinations used in the evaluation of headache, as found on healthcarebluebook.com.[34] These price estimates can be found by searching for examination type based on zip code.[34]

Economics of Imaging Headache in the Emergency Department and/or the Primary Cary Setting

The evaluation of both primary and secondary headache may be performed not only in the nonacute/nonemergent but also in the emergent setting. It should be noted that in the absence of an abnormal neurologic examination, headache alone has a lower likelihood of resulting in a causative lesion on imaging[35–37]; this is akin to the subsection of migraine headache mentioned earlier. In classic migraine and tension-type headaches, neuroimaging is considered by some investigators to be unnecessary due to the remarkably decreased expected rate of pathology that is usually identified by imaging in these scenarios.[38] Overall, there is a very low reported rate of identifiable intracranial pathology in patients presenting with headache who receive neuroimaging, with individual pathologic prevalence of subdural hematoma, brain tumors, hydrocephalus, arteriovenous malformations, and aneurysm of less than 1%.[39]

Evaluation of Headache in the Emergency Department

Evaluation of headache in the ED typically differs from evaluation in the clinic due to the emphasis on excluding immediately life-threatening causes, the need for efficient management in the ED,[17] and the potential for lack of clinical follow-up by the patient, either in the ED or in the clinic.[40] The consequent sense of urgency and need to initiate potentially life-saving treatment make CT a popular choice of initial test due to its availability, rapid acquisition, and the oftentimes high sensitivity of CT in the evaluation of acutely life-threatening causes. Chillingly, amongst the most common misdiagnosed neurologic complaints in the ED is patients who subsequently follow-up with neurologists for headache.[40]

Challenges related to the clinical setting (ED vs clinic) include, but are not limited to, patient anxiety and desire for imaging as well as fear of

litigation; these typically further add to the heterogeneity of imaging workup of headache. An article by Jordan and colleagues[41] noted that "…incremental cost per clinically significant case detected in the ED was $50078." and they concluded that "…emergent CT imaging of nonfocal headache…has limited cost efficacy." It is also of note that some investigators have reported low utilization of neurology consultation in this setting, including Young and colleagues[26] in 2018.

CURRENT (AS OF THE TIME OF THIS WRITING) EVIDENCE-BASED GUIDELINES REGARDING IMAGING OF HEADACHE

American Academy of Neurology Guidelines

Per the report of the Quality Standards Subcommittee of the American Academy of Neurology Evidence-Based Guidelines for Migraine Headache, neuroimaging was not usually warranted in patients with migraine and a normal neurologic examination.[42]

International Headache Society Guidelines

Similarly, the European Headache Federation Consensus on Technical Investigation for Primary Headache Disorders suggested that no imaging is characteristically required in workup of migraine without aura.[43]

National Clinical Guideline Centre

The National Clinical Guideline Centre on behalf of the National Institute for Health and Clinical Excellence states that patients with tension-type headache, migraine, cluster headache, or medication overuse headache should not be imaged for reassurance purposes only.[44]

US Headache Consortium

A 14-member consortium led by the American Academy of Neurology with members from the American Academy of Family Physicians, the American Headache Society, the American College of Emergency Physicians, the American College of Physicians, the American Osteopathic Association, and the National Headache Foundation has produced 5 evidence-based practice guidelines including recommendations for neuroimaging of patients with nonacute headache.[45] These evidence-based guidelines are thus far apparently inadequately used, despite wide availability.[45]

Grade A recommendations are those based on multiple clinical trials with consistent relevant findings.[45] Grade B recommendations are those with some supportive evidence, although the amount of evidence is suboptimal.[45] Grade C recommendations are those without sufficient evidence but developed by a consensus of the US Headache Consortium.[45] No recommendation (Grade C recommendation) is given regarding the comparative sensitivities of CT versus MR imaging.[45]

Some investigators have published that neuroimaging is not warranted in adult patients with migraine, no history of seizures, no change in recent headache patterns, and no focal neurologic sign or symptom (presumably Grade B).[46]

The US Headache Consortium stated that neuroimaging is usually not indicated in patients with a normal neurologic examination in the setting of migraine (also presumably Level B).[45]

American College of Radiology Appropriateness Criteria

It is our understanding that the ACR AC are evidence-based guidelines initially developed in the early 1990s primarily for referring physicians and other providers in an attempt to reduce inappropriate utilization of radiologic services.[47] These guidelines include genres of diagnostic imaging selection, image-guided interventional procedures, and radiotherapy protocols.

There are 16 ACR AC variants currently listed under the clinical condition of headache, including (but not limited to) chronic headaches, sudden onset of headache, and new headaches.[2] A rating system is used to rank each radiologic procedure for each clinical variant. A rating of 1, 2, or 3 is given for procedures that are usually not appropriate for the specific variant.[2] A rating of 4, 5, or 6 suggests the procedure may be appropriate.[2] A rating of 7, 8, or 9 is given for those procedures that are usually appropriate.[2] For example, currently, a CT head with intravenous (IV) contrast is given a rating of 3 for sudden onset of severe headache versus a CT head without IV contrast in this same scenario, which receives a rating of 9.[2]

A comments section is also available for each variant, when clinically relevant. For example, the ACR AC suggest that an MR imaging head without IV contrast may be helpful for sudden onset of severe headache depending on the CT findings.[2]

As well, a relative radiation level is given for each radiologic procedure when pertinent. This level may assist referring physicians in deciding which examination is best for patients, as well as answer questions that patients may have in regard to relative radiation risk or dose. Of note, these provided level assessments are not numeric but more of general guides.

An article entitled "ACR Appropriateness Criteria Headache" by Douglas and colleagues[48]

in 2014 suggests that imaging may be "useful" for the following patients with headache: "…associated with trauma; new, worse, or abrupt onset; thunderclap; radiating to the neck; due to trigeminal autonomic cephalgia; persistent and positional; and temporal in older individuals." These investigators go on to also mention that "Pregnant patients, immunocompromised individuals, cancer patients, and patients with papilledema or systemic illnesses, including hypercoagulable disorders may benefit from imaging."[48]

Use of Guidelines

Young and colleagues[26] reported in 2018 that "An estimated 35% of patients were imaged against guidelines" in their study regarding outpatients with headache. An article published in 2015 by Rosenberg and colleagues[49] noted a decrease in imaging of patients with headache from 14.9% to 13.4% in their system, which was a statistically significant change; they attributed this change to Image Wisely. Thought-provokingly, Lester and Liu reminded us via an article in 2013 that "…value of negative imaging should not be underestimated in the cost-benefit analysis…"[1]

COMPUTED TOMOGRAPHY VERSUS MR IMAGING

When considering the choice of CT versus MR imaging, it is imperative to ensure that one can expect the clinical question to likely be answered with the chosen modality. If the clinical question cannot be expected to be answered sufficiently, it is characteristically the job of the Radiologist to suggest the more appropriate imaging examination, if one exists. To this end, excellent communication between referring providers and radiologists is essential to outstanding patient care. CT is typically more (geographically) available, faster, and cheaper. MR imaging typically provides more information. In the authors' experience, it is commonly said by nonradiologists that CT is superior to MR imaging at identification of intracranial hemorrhage; however, this has not been what they have found in their practice, at least anecdotally. That being said, time is usually of the essence when intracranial hemorrhage is suspected and in this setting CT is usually preferable.

For example, an MR imaging of the head with and without contrast material is a highly rated examination of choice (rating of 8 in ACR AC) in the setting of new-onset headache with focal neurologic deficit or papilledema.[2] On the other hand, a CT head with contrast has a lower rating of 5 but might be useful if MR imaging is not available or is contraindicated.[2]

Some investigators have communicated for a "two-tiered approach" to MR imaging including focused MR sequences as an approach to the cost-effective workup of patients with headache.[50]

An article by Douglas and colleagues[48] in 2014 about the ACR AC regarding headache notes that "Unlike most headaches, those associated with cough, exertion, or sexual activity usually required neuroimaging with MRI of the brain with and without contrast…"

A local approach to this is to promote CT if there is anything urgent, emergent, or acute about the clinical scenario and to promote MR imaging otherwise, if the patient may receive either examination. Advanced neuroimaging (eg, functional MR imaging or MR spectroscopy) is not usually helpful for the workup of headache in the setting of a normal conventional MR imaging. Anecdotally, the authors have also not found a benefit to use of 3 T MR imaging scanners over 1.5 T versions for the workup of uncomplicated headache. One way to optimize utilization of resources is to look for all of the already-made available diagnoses on the scans interpreted, especially noting those that may answer the clinical question, for example, imaging findings of an enlarged, partially empty sella and papilledema that may explain headache via idiopathic intracranial hypertension (**Fig. 1**). Overlooking diagnoses on neuroimaging of patients with headache that may explain the presentation but are not "acute intracranial pathology" is not a good use of resources. A few commonly (in our experience) overlooked diagnoses that may explain headache include intracranial increased or decreased pressure abnormalities, sinusitis, middle ear and/or mastoid air cell disease, and temporomandibular joint disease. Of note, contraindications, relative or absolute, may affect this decision-making process.

CONTRAST MATERIAL

The decision of whether or not to use contrast material for CT or MR imaging is another consideration when choosing the appropriate examination. For example, if a patient presents with a sudden onset of severe headache (eg, "worst headache of life"), a CT head without contrast is the preferred initial examination with an ACR AC rating of 9.[2] This step is usually crucial to search for subarachnoid hemorrhage, especially in the appropriate clinical setting. In contradistinction, CT scan of the head with contrast is given a rating of 3, ostensibly because the intravenous contrast could obscure subarachnoid hemorrhage.[2]

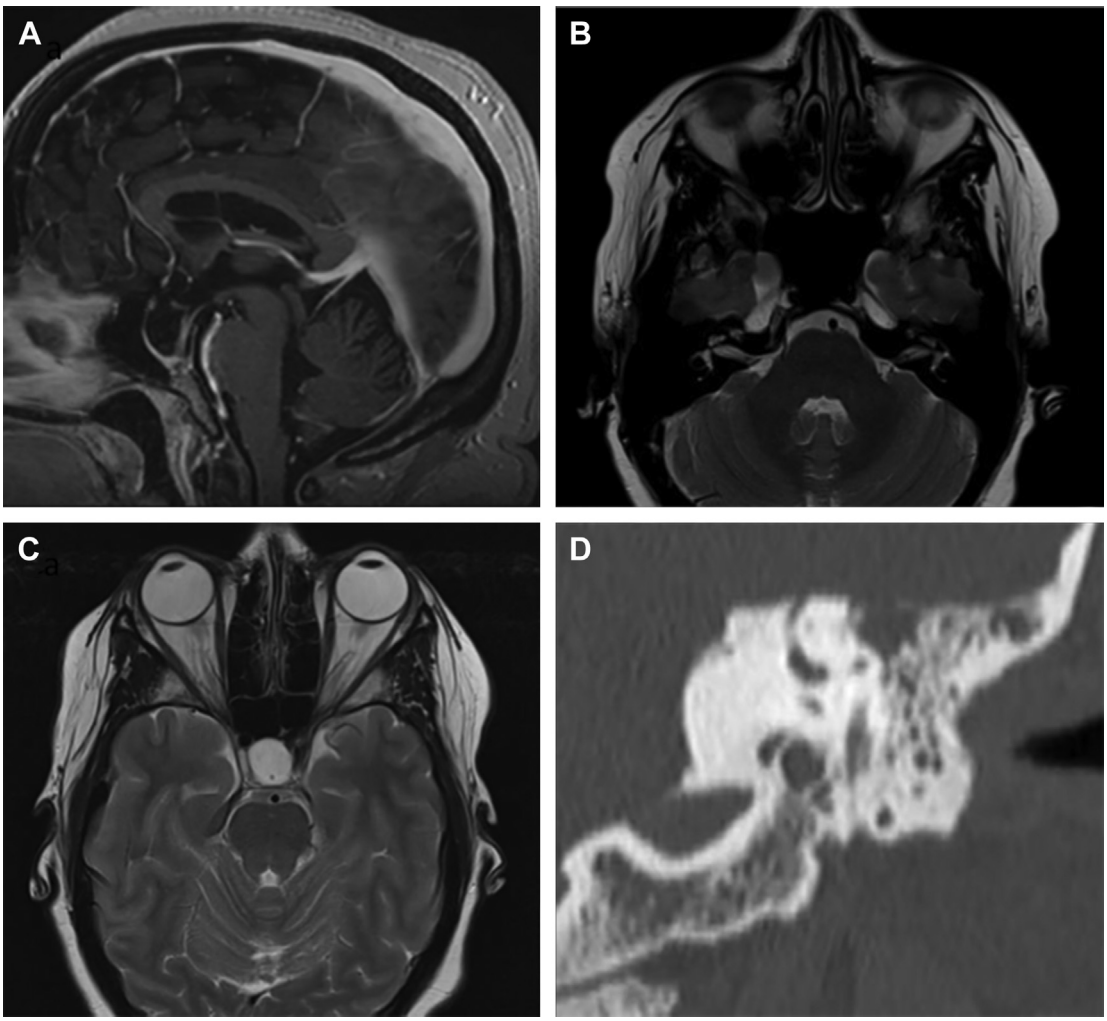

Fig. 1. Imaging findings of idiopathic intracranial hypertension. Sagittal T1-weighted postcontrast image (*A*) in a 26-year-old patient with headache due to idiopathic intracranial hypertension demonstrates an enlarged, partially empty sella. Axial T2 noncontrast images (*B*) in the same patient reveal enlargement of the Meckel cave bilaterally with a right-sided petrous apex meningocele and enlarged subarachnoid perioptic spaces bilaterally (*C*). Coronal bone-algorithm images of the left temporal bone (*D*) demonstrate thinning of the tegmen tympani with a small meningocele and dehiscence of the superior semicircular canal at the arcuate eminence.

A local approach to this is to promote noncontrast imaging in the absence of a clear indication for contrast material. Even when contrast material is indicated, the exclusion of noncontrast imaging is typically ill advised (please see the earlier discussion). One area in which contrast material administration is found to be particularly useful is with the identification of leptomeningeal processes on MR imaging, especially with postcontrast FLAIR images. Specialized contrast-enhanced examinations such as CT angiography (eg, to evaluate for aneurysm) and MR or CT venography (eg, to evaluate for venous sinus thrombosis) may be of clinical interest. In some instances, use of MR angiography (when used in patients with headache, presumably the primary concern is for aneurysm) may be preferable to contrast-enhanced MR imaging and/or CT with its ionizing radiation. As discussed earlier, contraindications, relative or absolute, may also affect this decision-making process.

SUMMARY

Headache is a common indication for neuroimaging. Attention to quality, safety, utilization, and appropriateness including attention to relevant socioeconomics should benefit these patients and the health care system. In addition to a plethora of scholarly articles, many guidelines serve as

assets in the care of these patients. Consideration of imaging in patients presenting with headache is an important aspect of health care and familiarity with these concepts and resources should help.

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