Choosing Wisely: A Neurosurgical Perspective on Neuroimaging for Headaches

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Received, March 27, 2014.
Accepted, September 2, 2014.
Published Online, September 24, 2014.

Multiple national initiatives seek to curb spending to address increasing healthcare costs in the United States. The Choosing Wisely initiative is a popular initiative that focuses on reducing healthcare spending by setting guidelines to limit tests and procedures requested by patients and ordered by physicians. To reduce spending on neuroimaging, the Choosing Wisely initiative and other organizations have offered guidelines to limit neuroimaging for headaches. Although the intentions are laudable, these guidelines are inconsistent with the neurosurgeon's experience with patients with brain tumor. If adopted by governing or funding organizations, these guidelines threaten to negatively affect the care and outcomes of patients with brain tumors, who frequently present with minimal symptoms or isolated headaches syndromes. As physicians grapple with the difficult conflict between evidence-based cost-cutting guidelines and individualized patient-tailored medicine, they must carefully balance the costs and benefits of discretionary services such as neuroimaging for headaches. By participating in the development of validated clinical decision rules on neuroimaging for headaches, neurosurgeons can advocate for their patients and improve their patients' outcomes.

KEY WORDS: Choosing wisely, Headaches, Magnetic resonance imaging, Neuroimaging

Neurosurgery 76:1–6, 2015 DOI: 10.1227/NEU.0000000000000560 www.neurosurgery-online.com

Healthcare spending in the United States reached $2.8 trillion, nearly $9000 per person, in 2012.[1] The United States spends more of its gross domestic product on health care than any other country in the world.[2] Hence, healthcare economics reform has dominated the US political scene, and healthcare reforms will continue to shape patient care and physician practices. To direct healthcare reform, national organizations have implemented initiatives to address waste in the medical field. The Choosing Wisely initiative focuses on reducing healthcare spending by setting guidelines to limit tests and procedures requested by patients and ordered by physicians.

Epidemiological analysis has shown that lifetime prevalence of headaches is 93% to 99%.[3] In the primary care setting, headaches are the chief complaint in 1.5% of all visits.[4] Countless medical textbooks and journal articles provide insight into and guidance on the clinical diagnosis of headache disorders, and most primary headaches can be diagnosed through careful history and physical examination.[5] Nonetheless, neuroimaging in the United States between 2007 and 2010 for migraines and headaches approached $1.2 billion.[6] In "Choosing Wisely in Headache Medicine: The American Headache Society's List of Five Things Physicians and Patients Should Question," Loder et al[7] draw attention to improving healthcare efficiency in the diagnosis and treatment of headache disorders. Loder et al discourage neuroimaging in patients with stable headaches that meet criteria for migraine. In parallel, Choosing Wisely guidelines by the American College of Radiology and *Consumer Reports* similarly suggested, "Don't do imaging for uncomplicated headaches."[8,9] Further guidelines suggest that neuroimaging should be ordered only if a stable headache patient displays localizing neurological symptoms or signs.[10]

The proposed neuroimaging guidelines for headaches are inconsistent with the common experience of many neurosurgeons who treat brain tumors. Specifically, patients with brain tumors may present with isolated headaches in the absence of other neurological symptoms and signs. Early diagnosis of brain tumors allows prompt treatment before more severe symptoms, reduced performance status, and worsened

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outcomes. In this article, we discuss the presentation of patients with brain tumors who often present with headaches alone or minimal symptoms. Although we applaud and support efforts to identify excessive and harmful spending in the medical system, we caution against creating over-reaching guidelines that could harm specific patient populations. In an atmosphere in which medical care is under harsh economic pressures, population healthcare initiatives and guidelines are not always best for the neurosurgical patient.

BRAIN TUMOR SYMPTOMOLOGY

Brain tumors may present with focal or nonfocal manifestations or no symptoms at all. Nonfocal symptoms may include headaches, mental status changes, papilledema, or seizures. Mental status changes may include impaired cognitive function, confusion, delirium, or reduced consciousness. Seizures may occur in 15% to 50% of patients with brain tumors.[11] Papilledema is seen in $<$ 20% of patients with brain tumor.[11] Focal findings vary depending on the anatomic location of the lesion and range from speech dysfunction to motor or sensory deficits.

Headaches secondary to brain tumors are thought to occur from traction on basal meningeal structures and occur in 48% of patients with brain tumors.[11] Headaches associated with brain tumors may be worse in the morning and slowly progressive.[11] However, despite classic teachings, headaches that are caused by tumors may be similar to tension-type or migraine-type headaches in 77% and 9% of cases, respectively.[11]

SYMPTOMS OF BRAIN TUMORS: WASHINGTON UNIVERSITY EXPERIENCE

After approval by the Washington University Institutional Review Board, we performed a retrospective review of patients who were diagnosed with a brain neoplasm from an open brain biopsy.[12] Preoperative histories and physical examinations were reviewed for presenting symptoms. Superficial open brain biopsies were performed through a small craniotomy to obtain diagnostic pathology. Pathology reports were reviewed, and only neoplasms were included in the study. The cohort's pathology results included 68% glial neoplasms, 12% meningiomas, and 20% other tumor types (Table 1). Seizures were the presenting symptom in 7.4% of patients with a brain tumor. Cognitive and speech dysfunction were the presenting symptoms in 13.7% of patients. Six percent of patients with a brain tumor presented with isolated focal motor, sensory, or visual symptoms. Ten percent of patients presented with nonfocal symptoms, including nonlocalizing subjective sensory or perceptual symptoms, facial swelling, and an endocrinopathy. Forty-eight percent of patients presented with a combination of symptoms. Three percent of patients with brain tumors presented with asymptomatic lesions that were found incidentally on unrelated radiographic examinations. Finally, isolated headaches were the only complaint in 11.6% of patients with brain tumors (Table 2, Figure 1). Not surprisingly, patients with isolated headaches did not experience resolution of their symptoms after brain biopsy; however, cause-specific therapies were initiated. Hence, 24.2% of patients with brain tumors diagnosed by brain biopsy presented with isolated headaches, no symptoms, or nonspecific symptoms.

The proposed neuroimaging recommendations for isolated headaches are contingent on symptom onset and duration, nature, and type of isolated headaches that affect a patient. In our series, 4 of 11 patients with isolated headache presented with new-onset symptomology. These patients would have qualified for imaging by all the proposed guidelines. The other 7 patients had nonacute isolated headaches. In these 7 patients, the duration of the headaches prompted neuroimaging by the referring physician and discovery of their brain tumor. Three of these patients presented with migrainous, unilateral headaches that were without any recent change. If the recommendations by Loder et al and Frishberg et al had been followed, diagnosis would have been delayed or missed for these 3 of 11 patients with isolated headaches (3.2% of all patients with brain tumor; Table 3). The remaining 4 patients presented with stable, nonacute headaches and no clear migraine component. Two were suspected to have tension-headache qualities, 2 were bilateral, and 1 was occipital. No auras, gastrointestinal symptoms, visual disturbances, paresthesias, olfactory symptoms, aphasia, or other atypical symptoms were reported in the 11 patients with isolated headache. If the American College of Radiology/*Consumer Reports* recommendations had been followed, a diagnostic delay or error would have occurred for 7 of 11 patients with isolated headaches (7.4% of all patients). Hence, under the proposed guidelines, neuroimaging may have been delayed or missed in 3% to 7% of patients with brain tumors.

TABLE 1. Brain Tumor Diagnoses

Pathology	n	%
Glial neoplasm	64	68
Meningioma	11	12
Metastasis	3	3
Lymphoma	9	9
Other	8	8

TABLE 2. Presentation of Brain Tumor Patients

Symptom/Sign	Incidence, n/N (%)
Headache only	11/95 (11.6)
Asymptomatic/incidentally found	3/95 (3.2)
Seizures only	7/95 (7.4)
Cognitive dysfunction only	13/95 (13.7)
Focal symptoms only	6/95 (6.3)
Nonspecific symptoms	9/95 (9.5)
Combination of symptoms	46/95 (48.4%)

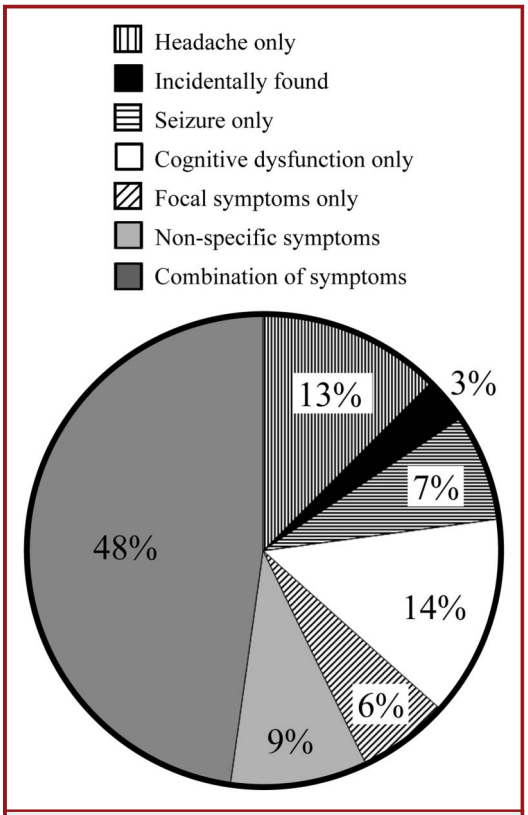

FIGURE 1. *Presentation of patients with brain tumors.*

DISCUSSION

Choosing Wisely guidelines are written from a population medicine perspective in which only a tiny fraction of patients who present with headaches will have brain tumors on neuroimaging. Conversely, in our experience, one-quarter of biopsied brain tumor patients present with an incidentally found lesion, nonspecific symptoms, or headaches alone. The historical review and series in this report serve to illustrate a widespread observation that neurosurgeons frequently treat patients with brain tumor who presented with headaches alone, nonspecific symptoms, or incidentally. Although patients with headaches do not frequently harbor brain tumors, patient with brain tumors frequently present with isolated headaches or minimal symptoms. Therefore, the premise that brain tumors always present with more than headaches is incorrect. Assuming this false premise may lead to medical errors.

TABLE 3. Potential Tumors Missed With Proposed Guidelines

Recommendations	Potential Misses, n/N (%)
Headache Society/Loder et al[7]	3/11 (27.3)
American College of Radiology[8,9]	7/11 (63.6)
American Academy of Neurology/Frishberg et al[10]	3/11 (27.3)

Despite the recently published guidelines,[6-10] Callaghan et al[13] report progressive increases in neuroimaging for headaches in the United States. Physicians wish to avoid failures in making the correct diagnosis for high-stakes situations such as a brain tumor diagnosis. Medical providers have likely continued high use of neuroimaging for headaches because of concerns about potential missed diagnoses and medical errors, which would adversely affect patient outcomes and, in turn, affect malpractice liability.[14] The practice of defensive medicine to reduce medical errors and the subsequent malpractice liability is well described among neurosurgeons, neurologists, and general practitioners. For example, to reduce potential medical errors and malpractice liability, 72% of neurosurgeons report ordering additional neuroimaging solely for defensive purposes.[15] Nonetheless, the role of defensive medicine in increasing healthcare costs is under debate because health policy experts and physicians have contrary views.[16] Policy experts argue that tort reform alone will have little effect on healthcare costs.[17] Meanwhile, physicians contend that defensive medicine significantly contributes to snowballing healthcare costs.[18] In regions with tort reform, the risks and costs associated with malpractice have been reduced.[19] There are also data to support that malpractice reform reduces excessive medical use and defensive medicine.[18] The proposed guidelines intersect with medical error, patient outcome, and liability perceptions and realities faced daily by practicing physicians.

One exacerbating factor of this dilemma is the high cost of imaging tests. Outpatient magnetic resonance imaging performed between 2007 and 2010 in the United States cost $7.5 billion.[6] The cost of brain computed tomography and magnetic resonance imaging to each patient approaches $2000.[20] The cost of medical neuroimaging is complicated by a lack of healthcare price transparency.[21] Healthcare reform will require multifaceted approach that addresses the cost of missed diagnoses, medical-legal expenditures, and the relative value of neuroimaging and other diagnostic tests.

Neuroimaging for isolated headaches is typically obtained to rule out a brain tumor. For gliomas and other brain tumors, histology, age, extent of resection, and baseline performances status correlate with outcomes.[22-27] Early diagnosis allows prompt treatment, more surgical options, and better baseline performance status. This translates to improved outcomes. Here, we showed that following the neuroimaging recommendations for isolated headaches would delay or miss diagnosis in 3% to 7% of patients with brain tumor. Therefore, we believe this rate of false negatives in the evaluation of patients would be detrimental to patients seeking care for headaches.

In a dynamic healthcare market, physicians must play a major role in curtailing medical costs. Callaghan et al[28] have astutely discussed that typical Choosing Wisely initiatives do not always discuss the relative values of tests (ie, benefit/cost). In their analysis, Callaghan et al evaluate relative values of neuroimaging

and electroencephalograms for headaches. They suggest that neuroimaging for headaches should generally be avoided because it provides only slightly more benefit than electroencephalograms at a much higher cost. However, this claim is not consistent with the data presented here, historical data, and the neurosurgeon's experience. Indeed, neuroimaging is extremely beneficial for patients who have brain tumors because it is the primary means for diagnosis. In addition, there are added costs and benefits that must be discussed when it comes to ordering neuroimaging for headaches. A reduction in medical errors and, in turn, malpractice liability costs is associated with the ordering of tests. Meanwhile, failure to diagnose a brain tumor because of a lack of imaging may increase costs resulting from delays in treatment. Ordering imaging would allow prompt diagnosis and care, which are associated with improved outcomes.[22-27] There are also less tangible benefits to neuroimaging for headaches that revolve around the fact that a patient has arrived at a physician's office to address a complaint. Addressing this complaint and acquiescing to requests of discretionary services are associated with higher patient satisfaction.[29-31] A patient-centered approach suggests that there is value in ensuring a concerned patient with headaches that he or she does not harbor a brain tumor. Therefore, ordering neuroimaging for headaches would generally address patient uncertainty while improving patient satisfaction. In a patient-centered healthcare system, we must tailor our decisions for each patient to balance the potential costs and benefits of neuroimaging for headaches (Figure 2).

The ostensible friction between patient-tailored medicine and population medicine initiatives underscores the need for further research to develop guidelines on neuroimaging for headaches. Guidelines must be developed carefully and thoughtfully and must adhere to methodological standards pioneered by those who study clinical decision rules.[32-34] The development of a clinical decision tool requires derivation of a model using a wide spectrum of subjects, clearly defined outcomes, predictors, weights, and a large sample size. For this model, failure to diagnose a brain tumor in a patient with headaches is not desirable; therefore, the model must be weighted to generate an extremely low false-negative rate. The second phase of guideline development is model validation, in which the decision rule is blindly applied to a set of new patients. Our preliminary retrospective evaluation determines that the current models fail to diagnose 27% to 64% of patients with brain tumor with isolated headaches. Finally, the model should be implemented in a clinical trial to assess the impact on use, accuracy, physician acceptability, and patient acceptability.[32] On the basis of these standards, the current guidelines have been derived but not completely validated. Hence, the current guidelines constitute Level 4 clinical decision rule criteria,[32,34] which suggest that they require further evaluation before they can be applied clinically. To develop accurate and viable guidelines on neuroimaging for headaches, additional resources must be allocated to evidence-based medicine studies.

CONCLUSION

The debate of neuroimaging for headaches highlights the divide between population-driven healthcare methods and individualized

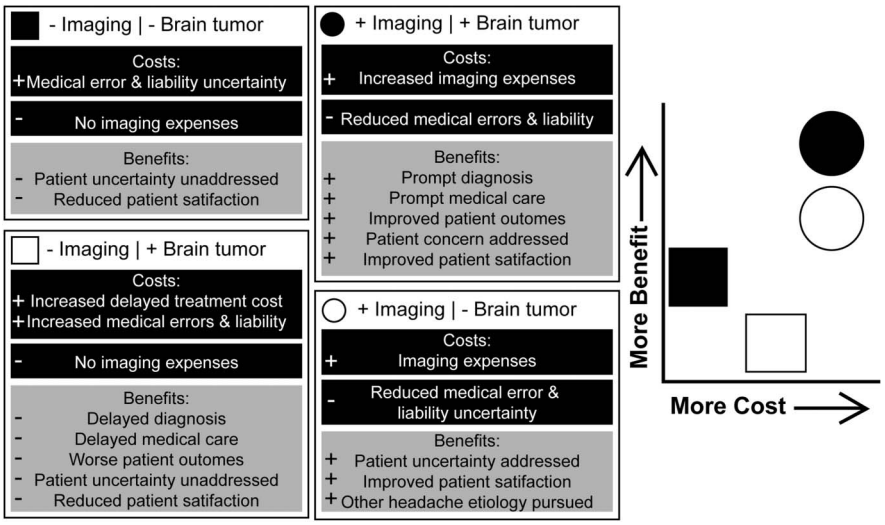

FIGURE 2. *Schematic representation of relative costs and benefits of neuroimaging for a patient with headaches in evaluation of a brain tumor. Increased costs (+), reduced costs (−), increased benefits (+), and reduced benefits (−) are shown for each condition on the left. Generalized patient-tailored cost-benefit schematic is shown on the right. For example, neuroimaging in a patient with headaches who ultimately does not harbor a brain tumor (bottom right) leads to imaging expenses but reduces perceived costs in medical errors and liability. Benefits for this patient includes addressing patient uncertainty, improved patient satisfaction, and rapid pursuit of other headache causes.*

patient-tailored medicine. We support careful and sensible use of neuroimaging in which physicians exercise excellent clinical judgment to reduce waste in the medical system. The expectation is that when a patient seeks medical attention for symptoms or an incidentally found abnormality, he or she will be deliberately and carefully evaluated by a physician. Although we do not recommend routine screening for the general population, we do contend that a substantial number of patients with brain tumors will present with isolated headaches. In addition, a noteworthy number of patients with brain tumors will also present with nonspecific symptoms or no symptoms. Unvalidated guidelines to prevent neuroimaging in patients with headaches may reduce the perceived global economic burden at the expense of medical errors, delayed diagnoses, and inferior outcomes for patients with brain tumor. Ultimately, further research is crucial for the development of validated and tested clinical decision rules on neuroimaging for headaches.

Disclosure

This study was supported by the Department of Neurosurgery at Washington University and grant funding from the National Institutes of Health (T32NS007205-32). The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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Acknowledgments

We thank Sylvia Awadalla, MD, and Christopher Carpenter, MD, for helpful discussions and suggestions.

CME QUESTIONS:

1. What is the most common sign or symptom experienced by patients with brain tumors?
   A. Weakness
   B. Headache
   C. Numbness
   D. Diplopia
2. What headache characteristic is most helpful in differentiating cluster headaches from those associated with brain tumors?
   A. Pulsatile
   B. Lacrimation
   C. Auras
   D. Photophobia
   E. Nausea
3. What clinical presentation warrants an imaging study CT/MRI of the brain according to the Choosing Wisely initiative guidelines?
   A. Intermittent bifrontal headaches
   B. Intractable migraine
   C. Intractable cluster headache
   D. Sudden headache after physical activity
   E. Tension headaches

Enigma Machine

An Enigma machine was any of a family of related electro-mechanical rotor cipher machines used in the twentieth century for enciphering and deciphering secret messages. Like other rotor machines, the Enigma machine is a combination of mechanical and electrical subsystems. The mechanical subsystem consists of a keyboard; a set of rotating disks called rotors arranged adjacently along a spindle; and one of various stepping components to turn one or more rotor with each key press. Enigma was invented by the German engineer Arthur Scherbius at the end of World War I.