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Cost and Utility in the Diagnostic Evaluation of Stroke

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ABSTRACT

The diagnostic evaluation in a patient presenting with acute stroke has several purposes depending on the clinical circumstances. These include identifying stroke mimics, differentiating ischemic stroke from intracerebral hemorrhage in the acute setting, clarifying stroke localization, and determining the stroke mechanism to guide secondary prevention. The neurologist needs to be aware of the cost implications of different approaches to the diagnostic evaluation.

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Case

An 85-year-old woman living alone had a history of atrial fibrillation, hypertension, and hyperlipidemia. She was receiving aspirin but not an anticoagulant. She presented to the emergency department after her family found her with impaired speech and right arm and leg weakness. She was last seen normal 2 days earlier. Examination showed a mild expressive aphasia, a right upper motor neuron pattern facial weakness, and a right hemiparesis affecting her arm more than her leg. CT of the head revealed a wedge-shaped hypodensity in the territory of an anterior branch of the left middle cerebral artery.

Hypothetical Evaluation 1

MRI of the brain with and without contrast and magnetic resonance angiography (MRA) of the head and neck with contrast demonstrated a wedge-shaped area of restricted diffusion in the left middle cerebral artery territory and less than 50% bilateral stenosis of the extracranial internal carotid arteries immediately distal to the bifurcations. A transthoracic echocardiogram revealed a possible left atrial appendage thrombus, a normal ejection fraction, and mild left atrial enlargement. A transesophageal echocardiogram was performed to evaluate the possible thrombus and was normal.

Hypothetical Evaluation 2

Duplex Doppler ultrasound showed less than 50% extracranial internal carotid artery stenosis bilaterally.

DISCUSSION

Clinical Background

Brain CT or MRI is necessary in all patients with an acute focal neurologic deficit to help exclude stroke mimics. Neuroimaging is also required to differentiate ischemic stroke and intracerebral hemorrhage because clinical evaluation alone is inadequate.[1] Either study can effectively identify brain hemorrhage.[2,3] MRI, when obtained within the first 12 hours after stroke onset, is clearly and substantially more sensitive than CT for the detection of acute ischemic injury.[4] It is likely the case that MRI's sensitivity advantage diminishes as time from stroke elapses because of increases in the sensitivity of CT.[5]

Clinical practice guidelines for the management of patients with acute stroke provide recommendations for neuroimaging that focus on selecting candidates for thrombolysis.[6] MRIs, however, are generally obtained beyond 12 hours from onset,[7] as MRI is not immediately available in most emergency departments, and approximately 25% of stroke patients present outside of the established time frame for thrombolytic treatment.[8] Guidelines for acute stroke evaluation and management do not specifically address the optimal strategy for evaluating the brain parenchyma in stroke patients presenting more than 12 hours after symptom onset. Guidelines from the American Heart Association recommend either MRI or CT but do not explicitly address what to do for patients who are not considered candidates for acute therapy.[9,10]

American Academy of Neurology guidelines support the superior diagnostic sensitivity of MRI within 12 hours but also do not address the optimal approach beyond 12 hours.[11] The European Stroke Organization states that either CT or MRI is an acceptable initial neuroimaging technique regardless of the time of presentation.[12] Guidelines do not strongly argue for a specific approach to carotid imaging. Although routine noninvasive imaging of the cervical arteries is universally recommended, guidelines either do not specify a preferred modality[9,12] or offer an expert opinion–based preference for duplex ultrasonography as the initial imaging modality.[13]

Guidelines do not offer specific recommendations on whether echocardiography should be performed when atrial fibrillation is known to be present; however, a decision analysis has argued against echocardiography in the context of known atrial fibrillation.[14] Guidelines do suggest that treatment with oral anticoagulation is appropriate given the patient's atrial fibrillation.[2,3,12,15]

Policy Background

Health spending per capita is considerably higher in the United States than anywhere else in the world,[1,16] and the use of new technology is the primary driver of spending growth.[2,3,17] Of most relevance to stroke evaluation, the United States is second only to Japan in the number of MRI and CT scanners per capita compared to the rest of the world.[4,18] Although a high aggregate rate of spending per capita may reflect a rational societal prioritization of health care over other potential expenditures, analyses of regional variations in health care expenditures suggest that as much as 30% of overall health care spending in the United States may be unnecessary.[5,19] Such variation exists in stroke neuroimaging; in 2008, 55% of stroke patients received an MRI in Oregon versus 79% in Arizona. With this variation, a significant degree of inefficiency is likely to

occur—92% of patients who receive MRI also receive CT imaging. As MRI use has increased, no reduction has occurred in the use of CT. Largely as a consequence of MRI dissemination, neuroimaging was the fastest growing cost component of inpatient stroke care from 1999 to 2007, growing by 213% after adjusting for inflation.[6,20]

Costs of Diagnostic Evaluation in Stroke

Costs, as opposed to payments and charges, refer to the actual economic valuation (ie, labor and capital) required to provide a service. Although estimating costs is not trivial, Medicare reimbursement is a commonly used proxy. Medicare reimburses $582 for MRI with and without contrast, $953 for head/neck MRA with contrast, $190 for chest wall echocardiography, $285 for transesophageal echocardiography, and $244 for carotid Doppler studies.[7,21] The aggregate cost of the post–emergency department diagnostic evaluation in Hypothetical Evaluation 1 is $2000 compared to $244 for evaluation in Hypothetical Evaluation 2. Even though the cost of Hypothetical Evaluation 1 is relatively modest, it represents a substantial proportion of the usual hospital reimbursement for a typical stroke admission—about $5000 for the care of a patient with an uncomplicated ischemic stroke. The aggregate societal costs of these differences can be substantial. If all of the patients with ischemic stroke with atrial fibrillation in the United States in a given year (approximately 20% of 795,000[8,22]) receive Hypothetical Evaluation 1 instead of Hypothetical Evaluation 2, the aggregate societal cost would be roughly $300 million per year. Given that additional costly tests can be obtained as part of the stroke evaluation, the aggregate costs of the diagnostic evaluation can be even higher.[23]

Strategies for Minimizing Diagnostic Evaluation Costs

Thoughtful consideration of the pretest probability, clinical context, and probability that a test will change management should help clinicians choose a cost-effective diagnostic strategy for each patient. Considering pretest probability, the primary advantage of MRI over CT in the diagnosis of stroke is its increased sensitivity.[4,9] When the pretest probability of stroke is low, MRI's superior sensitivity means that a negative test will reduce the posttest probability of stroke considerably more than a negative CT. For example, if the pretest probability of stroke is 20% (odds 1:4), the posttest probability of stroke after a negative MRI is about 2% versus about 12% with a negative CT. Conversely, because the specificity of CT is comparable to that of MRI, a positive CT in the context of a high pretest probability is highly valuable. In this case, in which the pretest probability of stroke is relatively high (ie, 80%), the posttest probability of stroke is 99.7% with MRI and similar with CT.[11,24] Therefore, in a clinical context in which a positive CT has increased an already high pretest probability, there is little marginal value for MRI to increase diagnostic certainty. The clinical context should also be carefully considered. While often challenging in a protocol-driven world, minimizing reflexive test ordering may reduce unnecessary costs. For example, obtaining a thrombophilia evaluation in an older patient with no history of venous thromboembolic events is generally not useful.[25]

Finally, consider how test findings might alter management and how probable those findings are compared to the possibility of false-positives. In this case, the patient had known atrial fibrillation, a presumptive stroke mechanism, and a strong indication for oral anticoagulation. What is the probability that an echocardiogram will lead to a management strategy other than oral anticoagulation? A test is of low clinical utility independent of cost when the probability of changing management is low and the possibility of false-positive is nontrivial.[9,12,26] In this case, both echocardiograms were low-value tests. It was unlikely that any finding would alter the decision to recommend oral anticoagulation. The transesophageal echocardiogram was particularly questionable given the possibility of harm associated with the test.

SUMMARY

Patients who have had a stroke routinely undergo a costly diagnostic evaluation. Considerable variation in this evaluation exists across the country with important societal cost implications. By carefully reflecting on the pretest probability, clinical context, and likelihood of altering management before ordering a test, aggregate costs of the diagnostic evaluation can likely be substantially reduced. In doing so, it is important for the neurologist to document the reasons for choosing a particular diagnostic strategy in the patient's medical record.

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