Acute Stroke Screening: MR or CT?

The costs and limitations of these effective stroke-screening tools.

BY APRIL A. GRANT, RT(R), AND BRUCE H. GRAY, DO

Acute stroke is the third most common cause of mortality in the US. Eighty-five percent of strokes are ischemic and 15% are hemorrhagic in nature.[1] Once the clinical suspicion of stroke arises, prompt confirmation of the diagnosis and the initiation of treatment is critical to minimize the risk of permanent brain injury. CT and/or MRI with or without contrast (CTA, MRA) have become the mainstay of noninvasive testing. Duplex ultrasound, echocardiography, and traditional catheter-based angiography complement the information provided with CT or MR. Given these options, what test(s) should be performed and in what order? The answer may vary according to practice setting.

"Given these options, what test(s) should be performed and in what order? The answer may vary according to practice setting."

COMPUTED TOMOGRAPHY

CT is excellent for the diagnosis of cerebral hemorrhage and extensive infarction. CT is readily available because most hospitals staff the scanner around the clock. It is often less expensive than MR, has a quick scan time minimizing the need for patient cooperation, has a large gantry opening, and avoids the need for a magnetic field enabling the monitoring of critically ill patients. Early ischemic infarction can be missed on CT because the scan may appear normal for several hours after the onset of ischemia. The sensitivity of CT during the first 6 hours of ischemia was 64% (accuracy, 67%) in the European Cooperative Acute Stroke Study (ECASS) expert reading panel.[2] The local investigators participating in the ECASS trial fared even worse with a 40% sensitivity and accuracy of 45%.[2] Additional information can be gained by performing CTA with a second scan at the time of contrast injection. Perfusion-weighted CTA can be used to delineate areas of hypoperfusion or tissue at risk for infarction. Vascular occlusions can be identified with CTA or MRA with equal sensitivity.[3,4] The need for contrast may limit its use in patients susceptible to renal toxicity.

A multidetector (16-channel) CT scanner is approximately $1.2 million (not including construction or options). The IDX global charge for CT with and without contrast is $1,182. The CPT Medicare fee schedule for code 70740 is $306 (supervision and interpretation), 70740TC is $244 (technical component), and the professional component (70740-26) is $62 dollars.[5]

MAGNETIC RESONANCE IMAGING

Most institutions still prefer CT as the initial test to exclude hemorrhage in the acute stroke patient. The literature suggests that MR is at least as good as CT in identifying hemorrhage when performed at the same time interval, although no reasonable randomized trial has been performed.[6] Immediate availability of the scanner, technicians, and physician readers has gradually increased its utilization for the purpose of excluding hemorrhage. Acquisition of information with MR takes longer than CT, making patient compliance important. MR is contraindicated in patients with a pacemaker, implantable defibrillator, or joint implants that interfere with the magnetic field, making CT still necessary in these patients.

MRI is more sensitive in the detection of posterior fossa stroke than CT and for detecting early ischemic changes.[7] As ischemic brain tissue evolves, the cells initially swell (cytotoxic edema) merely shifting water from the extracellular space. With unresolved ischemia, there is breakdown of the blood–brain barrier, with a significant shift of the water content into the ischemic tissue (vasogenic edema). Complete anoxia for a few minutes can result in

infarction, blood–brain barrier breakdown, and vasogenic edema. This change in water content leads to decreased signal on T1-weighted MR images and increased signal on T2-weighted images. This pattern confirms the diagnosis of ischemic infarction. The newer-generation MR scanners acquire echo planar images in one-tenth of a second per slice. The pulsing sequence can be modified to be very sensitive to the diffusion of water (diffusion-weight imaging [DWI]), highlighting areas of restricted water diffusion (cytotoxic edema) after ischemic insult. This stagnation of water leads to high signal on DWI, allowing the rapid diagnosis of reversible cerebral ischemia. These changes can remain for several weeks after infarction, presumably due to a persistence of cytotoxic cells in the area.

MRA scanning of the brain can be performed by gadolinium injection and acquiring images (T2-weighted) every 40 seconds. The gadolinium is magnetized causing a signal drop compared to adjacent tissue. The signals are plotted over time providing information regarding perfusion (perfusion-weighted images [PWI]). The ability to then determine relative cerebral blood volume and mean transit time provides a map of the cerebral circulation. The perfusion-weighted scan tends to be positive at milder levels of ischemia than DWI. This mismatch demonstrates brain at risk or the ischemic penumbra.[8] The MR assesses the physiologic changes in the brain tissue providing important clinical information to guide therapeutic intervention.

The cost of a 1.5T magnet is roughly $2.1 million (not including construction or options). The IDX global charge for MR with and without contrast is $2,564. The CPT Medicare fee schedule for code 70553 is $975 (supervision and interpretation), 70553TC is $859 (technical component), and the professional component[5] (70553-26) is $116.

OTHER MODALITIES

Duplex ultrasound (DUS) has become the most common noninvasive study to evaluate the extracranial circulation. The need to evaluate for significant common or internal carotid artery disease is often necessary for ischemic stroke patients. DUS is portable, easy to perform, reproducible, and has excellent sensitivity and specificity. Infrequently, DUS can miss some very tight ICA stenoses, so confirmation of carotid occlusions seen on DUS occasionally requires angiography.

Echocardiography can be performed with a transthoracic or transesophageal transducer. The purpose is to evaluate the heart as a possible source of embolus. The sensitivity of transesophageal over transthoracic to fully exclude thrombus (although vegetations or tumors can also be seen) makes it the test of choice for this purpose.

Diagnostic angiography with digital subtraction of the carotid, vertebral, and intracranial circulation is being used less for diagnostic purposes. The aforementioned noninvasive studies (CT/MR) are preferred in most cases. This invasive, contrast-requiring study has much greater utility for patients with aneurysms (prior to coiling) and arteriovenous malformations (prior to embolization).

OVERVIEW

Time is brain, and the more rapidly a test is available, the more likely that modality will be chosen. One study showed that to obtain an MRI exam for stroke patients from the emergency room, the wait was nearly twice as long as evaluation by CT.[9] For acute stroke presentation at an academic center with MRI technologists and a stroke team available 24/7, the protocol may be to take the patient directly to MRI barring any contraindications for the procedure. In a large community hospital that has the availability of both modalities, but lacks a stroke team, a combination of scans will most likely be performed. CT will be used first to evaluate for a bleed, followed by MRI to evaluate the location and extent of the ischemia. This is the primary protocol in most hospitals and will likely remain so. For small rural hospitals, acute stroke screening will be performed primarily with CT. Although CT has been shown to be a great deal less specific and sensitive than MRI in the first 6 hours of ischemic stroke, it may be repeated to confirm the diagnosis. Duplex ultrasound, echocardiography, and digital subtraction arteriography will be used selectively as secondary tests in the diagnostic algorithm. ■

April A. Grant, RT(R), is from the Department of Radiology, Greenville Memorial Hospital, Greenville, South Carolina. Ms. Grant may be reached at (864) 455-7915; aogrant@ghs.org.

Bruce H. Gray, DO, is from the Department of Surgery, Greenville Memorial Hospital, Greenville, South Carolina. Dr. Gray may be reached at (864) 455-5122; bhgray@ghs.org.

1. Jensen MC, BranZawadzki MN, Jacobs BC. Ischemia. In: Stark DD, Bradley WG (eds): Magnetic Resonance Imaging, ed 3. 1999; Mosby and Co, St. Louis, MO: pp 255-1276.
2. von Kummer R, Bourquain H, Bastianello S, et al, for the European Cooperative Acute Stroke Study II Group. Early prediction of irreversible brain damage after ischemic stroke at CT. *Radiology.* 2001;219:95-100.
3. Fujita N, Hirabuki N, Fujii K, et al. MR imaging of middle cerebral artery stenosis and occlusion: value of MR-angiography. *AJNR.* 1994;15:335-341.
4. Shrier DA, Tanaka H, Numaguchi Y, et al. CT angiography in the evaluation of acute stroke. *AJNR.* 1997;18:1011-1020.
5. Medicare, South Carolina, personal communication.
6. Atlas SW, Thulborn KR. MR detection of hyperacute parenchymal hemorrhage of the brain. *AJNR.* 1998;19:1471-1477.
7. Tong DC, Yenari MA, Albers GW, et al. Correlation of perfusion- and diffusion-weighted MRI with NIHSS score in acute (<6.5 hours) ischemic stroke. *Neurology.* 1998;50:864-870.
8. Kucharczyk J, Mintorovitch J, Asgari HS, et al. Diffusion/perfusion MR imaging of acute cerebral ischemia. *Magn Reson Med.* 1991;19:311-315.
9. Mullins ME, Lev MH, Schellingerhout D, et al. Influence of availability on detection of early stroke using unenhanced CT and diffusion-weighted MR imaging. *Am J Rad.* 2002;179:223-228.