



IMAGING THE ACUTE STROKE

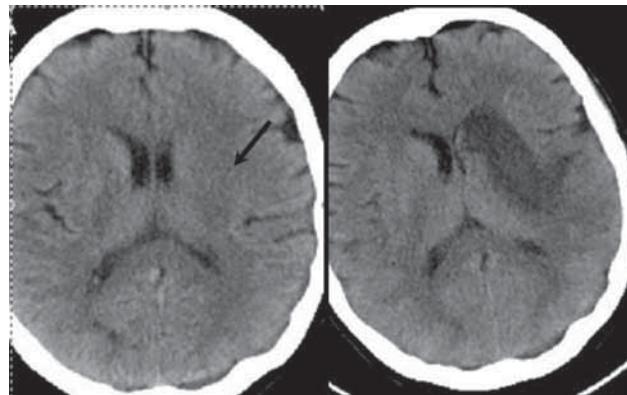
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The role of imaging is increasingly critical in the evaluation of acute stroke. The head CT without contrast remains the most important initial examination, primarily for the detection of intracranial hemorrhage, but also as a screening tool to look for conditions that may mimic stroke clinically, such as neoplasm. CT can also potentially reveal an arterial occlusion immediately (as a hyperdense area), and can provide information about the severity of an ischemic event. In the early hours of an acute stroke, however, the CT scan is often normal, or it can significantly underestimate the severity of the ischemia (Figure 1).

MRI and MR angiography (MRA) are more comprehensive imaging examinations, but they are more time-consuming. Diffusion-weighted MR imaging* can typically

Figure 1: CT images of a 57-year-old patient with an acute stroke. Left: image obtained 2 hours after the onset of symptoms; Right: follow up imaging 24 hours later. On initial non-enhanced CT, the lesion in the left lentiform nucleus (arrow) is obscure; follow up CT demonstrates the full extent of the infarct.

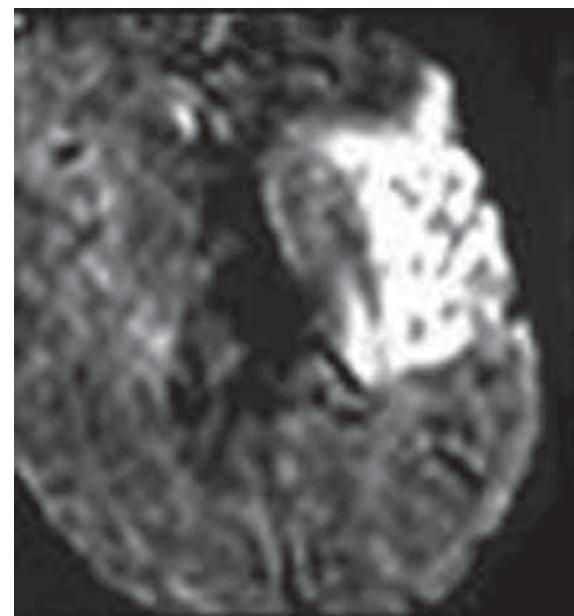


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*Diffusion refers to the movement of free water molecules in tissue. Acute strokes show decreased diffusion due to cytotoxic edema, and appear bright; other pathologic entities rarely do.

detect acute ischemia within minutes of irreversible damage, though it may be less sensitive in the brainstem (Figure 2). Diffusion-weighted imaging to detect acute strokes requires a high field strength magnet, usually 1.5 or 3 Tesla. The unit at LGH (but not the one at Kissel Hill) has the requisite strength to provide this capability 24 hours a day. MRI also has better specificity than CT for the detection of the conditions that mimic stroke, such as neoplasm, contusion, and encephalitis/cerebritis. On the other hand, CT is very useful for follow-up imaging of patients with stroke, both to assess the severity of a completed ischemic event, and to detect hemorrhagic transformation of an ischemic stroke.

Figure 2: Diffusion-weighted MRI demonstrates a large region of restricted diffusion in the territory of the left middle cerebral artery consistent with an acute infarct.



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VASCULAR IMAGING

Direct imaging of both arterial and venous vasculature is possible with either MRI or CT. MR angiography can be performed with or without the intravenous contrast agent gadolinium, and can be performed at the time of the routine brain MRI to directly assess the arteries of the neck and the Circle of Willis. Identification of the precise level of arterial occlusion enables estimation of the amount of ischemic brain parenchyma. MRA also defines the anatomy of the Circle of Willis and the presence or absence of posterior and anterior communicating arteries which can provide collateral blood supply during an acute ischemic event. Imaging of the carotid arteries in the neck can be useful to identify treatable carotid stenoses that may contribute to chronic ischemia or to future acute ischemic episodes. MRA can also be useful in planning endovascular treatments, when appropriate.

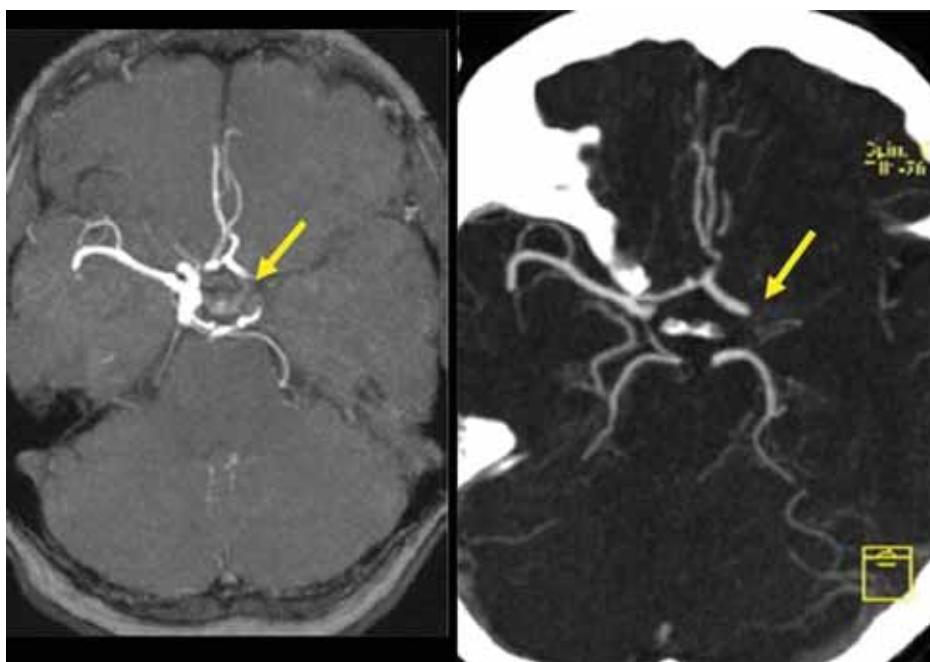
CT angiography (CTA) can provide all the information that MRA provides but at a higher axial resolution and faster speed, and it is useful when MRA is contraindicated (Figure 3). CTA's disadvantages are its dependence on the timing of the bolus of contrast, and its use of

ionizing radiation. Also, because diffusion-weighted MRI is often already being performed, when an angiographic study is desired it is often simplest to perform an MRA at the same time. When venous infarction is suggested by clinical or imaging findings, both CT and MR venography can directly image the intracranial venous structures and detect venous sinus thrombosis non-invasively.

Both CT and MRI can also be used to perform perfusion imaging (Figure 4), which enables detection of relative cerebral blood flow (rCBF), relative cerebral blood volume (rCBV), and relative mean transit time (rMTT), all parameters of blood flow to cerebral parenchyma. When used with diffusion-weighted MRI, a diffusion/perfusion mismatch can be determined. The size of the so-called penumbra of tissue with decreased perfusion, but no restriction of diffusion, can give information about the amount of brain parenchyma that is at risk but has not yet undergone infarction. The size of this penumbra can help guide decisions about thrombolytic therapy.

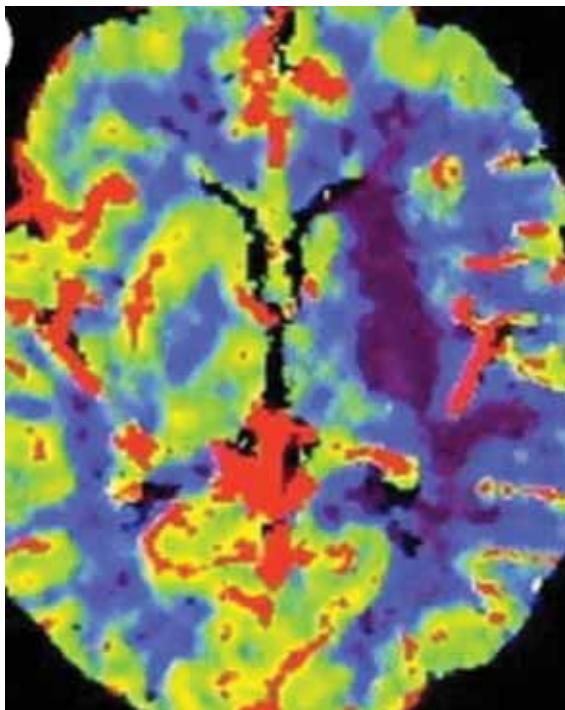
As noted in the article on acute stroke in this issue of *JLGH* by Pacelli, extensive use of intravenous recombinant tissue

Figure 3: MRA (left, yellow arrow) and CTA (right, yellow arrow) demonstrate occlusion of the proximal left middle cerebral artery.



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Figure 4: PCT map shows the extent of left-hemispheric hypoperfusion on rCBF (relative cerebral blood flow).



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plasminogen activator (rt-PA) for acute stroke has been impeded by the small number of patients who present within the 3 hour window for IV therapy, and the failure of clot lysis in a substantial percentage of cases. It has been well-documented in other vascular beds that direct administration of lytic agents into the offending clot works more quickly and consistently than non-selective administration into the systemic circulation. A major trial in the mid-1990's (PROACT II) demonstrated that recombinant pro-urokinase (r-proUK) could work that way in the brain as well.¹ In a group of patients treated with direct infusion of r-proUK directly into the clot in the first 6 hours after onset of symptoms, 40% demonstrated an improved functional outcome at 90 days compared with 25% of controls. The longer window of eligibility (6 hours) greatly increased the number of patients eligible for treatment, but there was a bleeding rate of 10% in the study population attributed to the longer treatment window and the simultaneous use of heparin. The FDA did not approve r-proUK in the United States and it was never marketed here.

Figure 5: Internal carotid angiogram of a right middle cerebral artery embolic occlusion (arrow).

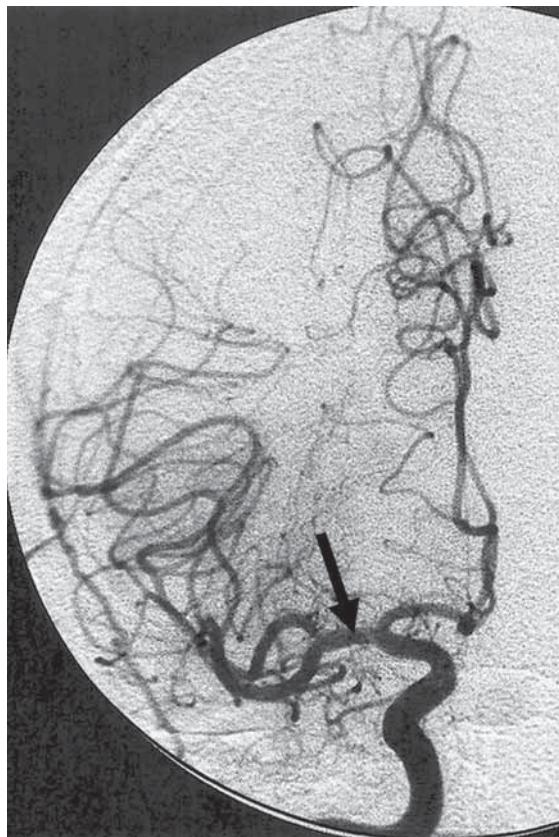


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Most centers that still employ thrombolysis with rt-PA use it intra-arterially, which is an off-label use of the drug, but there is no evidence that rt-PA is less-effective than pro-UK when used in this manner. Intra-arterial therapy requires a very high level of technical expertise, which is not available in many areas. Although there are numerous case reports and even series that document some miraculous saves with this therapy, (Figures 5,6) no other controlled trials have been done, and although a number of us have been trained in this approach at LGH, its use has been limited to a very few selected cases.

As discussed more fully by Pacelli, the FDA has approved Concentric Medical's Merci device (Figure 7), a mechanical device capable of extracting the obstructing clot directly. It is hoped that avoidance of a lytic agent will reduce the risk of procedure-related hemorrhage, but this remains unproven. Other devices, which use ultrasound to break up the clot, are also being tested.² We are currently evaluating the Merci device at LGH and hope to offer this therapy in the future, if its benefit can be proven.

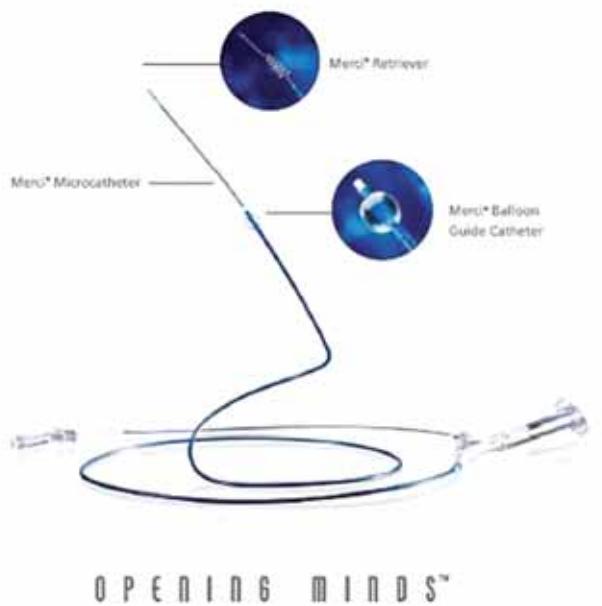
Figure 6: Recanalization of RMCA after intra-arterial thrombolysis (arrow).



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Figure 7: The Merci® device, a mechanical tool that can extract an obstructing clot.

The Merci® Retrieval System



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REFERENCES

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