Is CT or MRI the Method of Choice for Imaging Patients With Acute Stroke? Why Should Men Divide if Fate Has United?

Turgut Tatlisumak, MD, PhD

In the hyperacute phase of ischemic stroke, CT images are often normal or show subtle changes only. On the contrary, diffusion-weighted MRI (DWI) can reveal the ischemic lesion in its full extent within minutes only in experimental studies[1] and as soon as a patient is available for imaging in clinical studies.[2] As new therapeutic options for ischemic stroke have appeared[3–5] and more of them are under way, having proper (and positive) imaging methods has become an essential issue. Even though most stroke physicians and neuroradiologists have recognized for years the superiority of DWI over CT in patients with acute focal neurological deficits, the work of Fiebach et al[6] published in this issue of *Stroke* is the first to demonstrate this fact unbiasedly in a representative patient population. This work, coming from a dedicated stroke center, is an important addition to the accumulating evidence on the selection of imaging technique in hyperacute stroke.

Patients presenting with a sudden, focal neurological deficit do not always suffer an ischemic stroke. Approximately 5% of these patients will harbor other diseases (tumors, postictal paresis, multiple sclerosis, hemiplegic migraine, transient ischemic attacks, malingering, or even hypoglycemia or liver disease) where MRI is usually far more informative than CT. Another 10% of these patients will have intracerebral hemorrhage that can easily be detected either by CT or by T2*-weighted MRI.[7,8] High sensitivity and the high predictive value of MRI to ischemia help to avoid unnecessary and potentially dangerous therapeutic interventions and ensure that effective therapies will not be withheld for those who are suitable for these therapies.

At least 15% of all ischemic strokes occur in the vertebrobasilar region (posterior circulation). MRI is certainly superior to CT in imaging vertebrobasilar territory. The authors[6] had unfortunately excluded those patients from their study. There is little experience and even fewer evidence-based data on the optimal treatment of these patients given that almost all efficacy trials have concentrated on hemispheric infarctions.

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Both MRI and CT technologies have made great progress recently. Imaging times have shortened, resolution and signal-to-noise ratios have improved, and new imaging modalities have been developed. Magnetic resonance angiography (MRA) and CT angiography can demonstrate the occluded artery (or no occlusion if spontaneous or drug-induced reperfusion has already occurred) with good resolution and require only a few minutes. Both perfusion-weighted MRI (PWI) and CT perfusion studies, depicting the hypoperfused region, require a few minutes and offer multislice imaging, virtually encompassing the whole brain. A "perfusion-diffusion mismatch" on MR images is hypothesized to represent the "tissue at risk,"[9] where therapeutic interventions should be directed. This "tissue at risk" does not completely evolve into infarction without therapeutic interventions, and this measure is still crude but practically useful in decision-making. A similar approach does not yet exist for CT imaging.

The "stroke MRI package" includes scout images, DWI, PWI, MRA, T2-weighted imaging and postcontrast T1-weighted imaging. T2*-weighted imaging is produced within the gradient-echo PWI or separately. This whole package can be performed within 20 minutes. A similar "stroke CT package" is worth developing and may include scout images, conventional CT images, CT angiography, and CT perfusion. This will require approximately 10 minutes to obtain. Patient transfer time to CT scanner can be minimized by installation within the premises of the emergency unit, which is not possible with MRI scanners because of strict site demands. Placement of the patient into the MRI scanner is more timely. Fiebach and his colleagues[6] enjoy the privilege of having their emergency room, neurological ward, and imaging facilities located very close to each other, which is shared by few stroke physicians. Because the patient will remain completely within the magnet bore during an MRI study, patient monitoring is more complicated. Most scanners are usually not immediately available; there is another imaging study proceeding. With CT, the previous patient can be imaged and the scanner becomes available for the stroke patient in approximately 5 minutes, but with MRI it might take up to a half hour. All these factors cause delays during the time window of opportunity when MRI is the preferred method for imaging.

CT scanners and CT imaging cost approximately half that of MR imaging and have lesser site demands. It remains to be seen if the improvements in patient care provided by the advantages of MR imaging can, in turn, pay off the increased

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From the Department of Neurology, Helsinki University Central Hospital, Helsinki, Finland.

Correspondence to Turgut Tatlisumak, MD, PhD, Department of Neurology, Helsinki University Central Hospital, Haartmaninkatu 4, 00290 Helsinki, Finland. E-mail turgut.tatlisumak@hus.fi

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imaging costs by means of improved patient outcome and shortened need for institutional care. CT images will demonstrate the ischemic lesion(s) in full extent at later time points (eg, the next day). Patients who are not candidates for early therapeutic interventions and those with no clinical indication of unusual stroke mechanisms can be imaged with CT with lower costs and better availability.

A few percent of all patients cannot be imaged with MRI because of claustrophobia. Furthermore, some patients have pacemakers, aneurysm clips, or other ferromagnetic material in their bodies and cannot be safely imaged with MRI. Patients with aphasia, depression of consciousness, or confusion cannot give a reliable history on potential contraindications to MR imaging, and family members might not be available within the short time window for acute therapeutic interventions. Interpretation of early ischemic changes on CT images requires extensive training and is still not highly reproducible. Such highly trained experts are not available around-the-clock or on weekends. Interpretation of early ischemic changes on DWI, however, is easy, and there is almost no intra- or interobserver variability. On the other hand, access to MRI scanners is limited both during daytime (overbooked) and during nights and weekends (usually closed). There are, however, some signs that this limitation will be overcome in the near future.

One major reason for our repeated failures in clinical trials aimed at testing efficacy of novel anti-ischemic agents is the lack of good imaging techniques. MRI should increasingly be employed to clinical drug trials for several reasons: it ascertains the selection of the correct patients with good homogeneity, it allows for baseline lesion volume determination (thus overcoming a potential pretreatment bias in efficacy studies) and comparison of lesion volume changes within and between patient groups (reduction of lesion volume can be used as a proof of efficacy, but it is not yet sufficient to replace clinical outcome measures), and it can substantially reduce the number of patients required to address efficacy (or lack of efficacy). This approach has been found to be successful in several experimental studies[10,11] and has already been implanted to clinical trials.[12,13]

In conclusion, MRI is increasingly replacing CT in the imaging of hyperacute stroke patients, and this trend is welcome. Both methods have some advantages and disadvantages; however, MRI is superior when therapeutic interventions are considered and should definitely be preferred in clinical trials. Whereas more than 100 centers worldwide, most located in North America and in Western Europe, are currently capable of and experienced in performing DWI and PWI in hyperacute stroke patients—and the number of these centers is increasing rapidly—in the rest of the world CT is generally the only imaging modality available. It is most likely that CT and MRI will coexist for decades, and the imaging method for patients with acute neurological deficits will be decided according to local conditions and patient characteristics. Patients will benefit from developmental research of both imaging techniques.

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