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MR Imaging of the Brain: What Constitutes the Minimum Acceptable Capability?

At the most recent ASNR meeting in April, a paper was presented on the use of contrast-enhanced MR imaging in HIV-positive patients who presented with headaches. The author discussed the findings on T2-weighted spin-echo (SE) and T1-weighted images before and after contrast agent administration. In the course of the discussion that followed the presentation, questions were raised concerning the findings on fluid-attenuated inversion recovery (FLAIR) images in their patient study group. Surprisingly, the author disclosed that in his hospital, which incidentally was part of a large university-based training program, the MR system did not have the capability of performing FLAIR imaging. Because FLAIR would have been a particularly useful sequence to depict brain abnormalities in this investigation and because FLAIR has gained widespread acceptance as an important technique, we raise the question: in addition to the standard T1- and T2-weighted SE and T2*-weighted gradient-echo images, what is the minimum acceptable capability for MR imaging of the brain?

The American College of Radiology (ACR) has a program for MR accreditation; however, the ACR's requirements apply only to T1- and T2-weighted SE imaging (which were the main techniques available when the program was being developed 10 years ago). This only partially addresses the current minimum capability to perform clinically effective MR imaging of the brain. Specifically, we believe that every MR system at a minimum should be able to perform FLAIR, fat suppression (FS), magnetic resonance angiography (MRA), and diffusion-weighted (DW) imaging.

FLAIR is a heavily T2-weighted sequence with suppressed signal intensity from CSF, and it also results in an extended gray scale. It is particularly sensitive for detecting periventricular, cortical, and other supratentorial abnormalities where the bright signal intensity from CSF on conventional T2-weighted images can lead to partial volume averaging. FLAIR is particularly important when routine long-TR/long-TE T2-weighted SE images are equivocal or normal. Recent work indicates that FLAIR may be even more sensitive than CT for detection of subarachnoid hemorrhage, and contrast-enhanced FLAIR has recently been shown to be the most sensitive imaging technique to help detect some subtle cortical processes. Despite sporadic, confounding problems with FLAIR, such as incomplete CSF suppression (due to CSF inflow) and the subsequent decreased sensitivity to infratentorial abnormalities, FLAIR is widely recognized as exquisitely sensitive to the majority of brain abnormalities. It can be rapidly acquired as a fast SE hybrid (eg, fast-FLAIR), and we believe it should be available on all MR systems doing routine brain imaging.

FS, most commonly enabled via RF (ie, spectroscopic FS), is virtually indispensable for orbit and skull base imaging. One could make the strong argument that an MR center that does not have the ability to offer FS sequences should not perform these particular studies. This problem is particularly noticeable on low-field-strength MR systems in which the spectral separation between water and fat is not great enough to achieve adequate spectroscopic FS. While short-TI inversion recovery images (which suppress fat on the basis of its short T1) can be performed at low field strength, such sequences cannot be used with contrast material since they may cause enhancing lesions to disappear (because of their shortened T1). Fortunately the latest generation of low-field-strength systems boasts another type of FS sequence called a ''three point Dixon.'' This technique separates fat and water by acquiring them in-phase or out-of-phase as a function of TE at the time of spatial and temporal rephasing. Therefore, patients with suspected orbital or skull base lesions who are being evaluated on low-field-strength systems should only be studied on systems that have FS based on the chemical shift between fat and water.

MRA, although not always necessary for patients referred for brain MR imaging, can be easily integrated into a single MR imaging session. It is an indispensable tool for patient assessment regardless of whether conventional time-of-flight or contrast-enhanced MRA (CE-MRA) is used. The ability to assess the carotid and vertebral arteries in the neck for vascular disease and the intracranial circulation for a variety of vascular abnormalities mandates that it be readily available on all MR systems performing brain imaging.

DW imaging has rapidly become a major tool in modern MR brain imaging. In patients presenting with the abrupt onset of neurologic symptoms, DW imaging enables the likelihood of determining the presence of an acute infarct. While DW findings can also be ''positive'' in acute demyelination, abscesses, and tumors with high nuclear:cytoplasmic ratios, its use for diagnosing acute stroke remains its primary application. Since whole-brain, three-axis DW imaging can now be performed in less than a minute by using echo planar imaging (EPI), many centers now perform DW imaging routinely as part of every brain MR study. This is largely because stroke may be in a clinically silent area, may be unsuspected, or may involve multiple vas-

cular territories. For this reason, we believe that DW imaging should be considered one of the requisite sequences in neuroimaging. DW imaging is most rapidly performed by using EPI, and such ultrafast sequences require stronger, faster gradients than are commonly used today or than were available a decade ago. Fortunately, line scan or projection-reconstruction DW imaging can also be performed with conventional gradients, although at a greater cost in acquisition time.

No modern, clinically relevant MR center should be without the elementary (FLAIR, FS, MRA, DW imaging) sequences. We are certain that many readers of the *AJNR* would feel that this ''basic requirement'' list is too short and should include other techniques such as proton spectroscopy and perfusion imaging. While these techniques have certainly made their way into the literature and clinical practice, the unequivocal clinical need for these sequences is less established than those on the ''basic'' list (at least today in the year 2001). Others might argue that modern MR evaluation of the brain requires EPI capability. High-performance gradients required to perform EPI allow the neuroradiologist to quickly acquire DW images through the entire brain, allow high-resolution CE-MRA images to be acquired during the initial passage of contrast material through the arteries, and allow T2-weighted images to be acquired in 100 ms per section, thus eliminating motion artifact. Images routinely acquired, such as the $b=0$ image of the EPI-DW imaging sequence, are particularly useful for imaging patients who cannot be sedated (eg, head trauma patients and children with respiratory infections).

If the ACR does not plan on requiring these basic sequences (FLAIR, FS, MRA, and DW imaging) as part of its standards, then we suggest that the ASNR consider advocating these sequences on all MR systems where brain imaging is routinely performed.

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