pletion of initial therapy, showing stable post-treatment changes or no significant focal accumulation of tracer on CT, will raise the likelihood of local control to nearly 100%. The corollary of this suggested scenario is that progressive imaging changes or focal tracer accumulation will indicate recurrence in about 75% or more of the cases in which those findings occur. With such high positive and negative predictive values, biopsy, with its attendant risks, should be performed only when confronted with a very high likelihood of recurrent tumor. This group will have been triaged on the basis of a pretreatment risk profile and objective post-treatment surveillance studies.

This is not a plea for imaging all patients treated for head and neck cancer. Such a suggestion would be economically irresponsible. It is a plea for the logical and judicious application of powerful imaging tools to help improve the salvage rate and reduce the morbidity of treatment for recurrent head and neck squamous cell cancer. This will become more important as targeted nonsurgical salvage therapies become more widely available in the near future.

ANTHONY A. MANCUSO
Member, Editorial Board

MR Perfusion Imaging

During the last 10 years, a variety of MR techniques have been developed that can provide images of cerebral perfusion (1). These approaches include those that require the injection of paramagnetic contrast agents (bolus-tracking approaches) as well as those that magnetically tag water in arterial blood as it moves into the brain. The effects of ''tagged'' arterial water on brain MR images can be used to calculate quantitative CBF images that can be expressed in classical physiologic units (ie, cc/l00 g/min). The major drawback to these tagging techniques is that, with the current technology, they are rather insensitive and require relatively long imaging times (≈10 minutes). Given this restriction, it is unlikely that MR arterial spin-tagging approaches will be applied to the clinical evaluation of acute stroke in the near future. Nevertheless, they could play an important role in the clinical evaluation of cerebrovascular diseases that provide a longer diagnostic ''window,'' especially for those that require absolute quantitation.

Following the quantitative CBF response to cerebrovascular challenges is one scenario in which MR spin-tagging flow approaches could be very useful. Samuels et al (2) employed the MR spin-tagging response to acetazolamide challenge to study middle cerebral artery stenosis, and used the results to characterize specific patterns of impaired perfusion. In this issue of the *AJNR*, Kastrup et al (page 1233) suggest the use of MR arterial spin-tagging approaches with another variant of the cerebrovascular challenge—breath-holding. Kastrup and colleagues demonstrate that breath-holding can provide reproducible changes in CBF in control subjects that can be followed accurately, both regionally and globally, using MR spin-tagging techniques. The advantage of the breath-hold approach is that it obviates the need for acetazolamide injection or CO_2 inhalation; the disadvantage is that it cannot be used for patients with impaired respiratory function. Both Samuels et al and Kastrup et al underscore the importance of obtaining ancillary data (eg, T_1 relaxation time images) to enable MR spin-tagging data to be interpreted in terms of absolute CBF values. This ability to quantify CBF absolutely is potentially of great clinical importance.

Functional MR (fMR) imaging approaches using blood oxygen level dependent (BOLD) effects also have been used to follow the response to cerebrovascular challenges. BOLD approaches are more sensitive than MR spin-tagging approaches. Kastrup et al emphasize, however, that BOLD results are harder to interpret because fMR imaging responds to changes in various physiologic parameters (eg, CBF, cerebral blood volume, and cerebral oxygen consumption), wheras MR spin-tagging responds primarily to changes in CBF. Nevertheless, MR arterial spin-tagging approaches also present problems in quantitation of CBF. For example, calculated CBF values will be artifactually low when arterial transit times are abnormally long, which might occur in compromised brain regions that have extensive collateral circulation. This issue could be examined using MR bolus-tracking approaches (1), which can give information on arterial transit times in compromised brain areas. Further validation of the quantitative ability of the arterial spin-tagging technique is needed before the results can be applied to individual patients.

The results of Kastrup et al and Samuels et al demonstrate the usefulness of MR arterial spin-tagging approaches for studies of cerebrovascular reserve. These approaches have a number of advantages over other techniques (eg, PET, SPECT, CT, etc); they are noninvasive, easily repeatable, and have relatively good spatial resolution. In the near future, a number of technical advances, such as phased-array head coils and higher magnetic field strengths, undoubtedly will increase the sensitivity of MR arterial spin-tagging approaches, and could make them viable for routine clinical studies of cerebrovascular disease.

An interesting sideline to these studies of physiologic perturbations of CBF is the subtlety and

possible pervasiveness of the effects. Although a gross respiratory change such as a 30-second breath-hold would be unlikely to occur during a conventional fMR imaging experiment, more subtle respiratory changes could accompany some activation paradigms, particularly those with ''surprise'' components. This could result in MR signal changes secondary to the unanticipated respiratory (or cardiac) responses. Statistical analysis might classify erroneously respiratory responses as noise, false localization of a cognitive task, or a true but secondary phenomenon. The latter possibility reemphasizes the complexity, as well as the richness, of these new functional imaging techniques.

R. NICK BRYAN
Senior Editor, AJNR

ALAN MCLAUGHLIN
National Institutes of Health
Bethesda, MD

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Imaging Brain Abscesses with Diffusion-Weighted and Other Sequences

With so many pulse sequences now available to image the brain, one has to reflect on what is the most practical way of deriving maximal information in a clinically acceptable period of time. The use of MR imaging keeps expanding, not only providing images of incredible detail but allowing the study of metabolism and physiology. As a result, one could spend hours just studying a single patient.

Diffusion-weighted imaging has been used for evaluation of stroke, tumors, demyelination, and vertebral body compression fractures. It is only logical to attempt to extend its use to patients with brain abscess. If one only uses single-axis diffusion-weighted imaging and one B value, there is no significant time penalty. Nevertheless, many now believe that diffusion-weighted imaging should be obtained in three axes (I_z, I_x, and I_y) and then postprocessed as an expression of its natural logarithm (trace imaging) to reduce the contribution of T2 signal ''shine through.'' In addition, apparent diffusion coefficient (ADC) maps are needed for standardization of the data and for obtaining quantitative information from diffusion-weighted images. ADC maps ideally are produced by using more than two B values. Because these manipulations increase imaging time and generally need off-line post-processing, the question is, when should we use diffusion-weighted imaging? The answer is not simple because diffusion-weighted imaging innovations constantly are discovered.

In this issue of the *AJNR*, Desprechins and colleagues (page 1252) describe the use of diffusion-weighted imaging for characterization of nonspecific ring-enhancing lesions that proved to be abscesses. Although only three patients were studied, their results are impressive. The necrosis within the lesions showed increased signal intensity on diffusion-weighted images and a markedly decreased signal on ADC maps. In similar and recent publications, two different groups of investigators found identical results in a total of six patients (1, 2). Contamination by signal from surrounding edema is not a problem, but abscesses appear slightly larger on diffusion-weighted images than on conventional MR images. This probably represents a summation of the necrotic region and the capsule. Although the capsule of an abscess is generally hypointense on T2-weighted images (assumed to be related to presence of free radicals), the capsule is hyperintense on diffusion-weighted images. The reason for the lack of susceptibility effects from the capsule, leading to signal loss on diffusion-weighted images, is not known. On diffusion-weighted images, the hyperintensity seen in the necrosis probably is related to a restriction of microscopic movement of water molecules as they are contained inside a complex matrix of proteins, inflammatory cells, cellular debris, and bacteria in high-viscosity pus. Additionally, water molecules in abscesses are bound to carboxyl, hydroxyl, and amino groups on surfaces of macromolecules. This also limits their translational movement. This finding was confirmed using ADC maps and thus hyperintense ''shine through'' from T2 relaxation effects does not contribute significantly to the appearance of necrosis on diffusion-weighted images. When ADC maps were generated, a marked reduction in the ADC related to restricted Brownian motion of free water was shown. In contradiction to the utility of diffusion-weighted imaging in the diagnosis of cerebral abscesses, Krabbe at al evaluated one abscess that showed low signal on diffusion-weighted images and increased ADC. Desprechins et al attribute the finding to the technique used, questioning the reported findings. High-grade astrocytomas show low signal on diffusion-weighted images and high ADCs. This is probably because the water molecules in these tumors are allowed a greater degree of freedom in their motion. The so-called necrotic center of a tumor contains a less viscous material composed by less cellular debris and fewer inflammatory cells as well as a more serous fluid (often hemorrhagic). Thus, water molecules are