Arterial Spin Labeling Perfusion Imaging for Evaluation of Brain Tumors at 3 Tesla

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Purpose: Assessment of brain tumor perfusion has clinical value because brain tumor vascularity is an indicator of tumor grade, and appears to be related to tumor proliferation and metabolic activity. Contrast-enhanced methods of evaluating vascularity, particularly dynamic gadolinium-enhanced susceptibility imaging, have been employed to gauge tumor perfusion and provide measures of tumor grade, progression and response to therapy (1-5). The gadolinium-enhanced susceptibility imaging technique, however, yields a measurement of relative cerebral volume complicated by the effects of varying vascular permeability and disruption of the blood brain barrier produced by brain tumors, and therefore approximates blood flow, but is not a direct measure of it. In contrast, the arterial spin labeling (ASL) technique permits an actual measurement of blood flow in and around tumors. Additional advantages of the ASL method are that it requires no contrast injection and, with appropriate imaging sequences, it can be free from susceptibility artifacts often found in surgical sites and associated with tumor hemorrhage.

In current clinical practice, gadolinium-enhanced T1-weighted images are an essential component of the imaging assessment of brain tumors. However, tumor infiltration is not delineated by enhancing margins, so relying on the gadolinium-enhanced images to determine extent and progression of tumor has limitations. We hypothesized that ASL would reveal additional abnormality, as compared to gadolinium-enhanced T1-weighted images.

The goal of this work is: 1) to demonstrate the feasibility of routine measurement of brain perfusion at tumor sites with the arterial spin labeling technique, and 2) to develop new diagnostic criteria for radiologists to employ for identifying the extent of brain tumors, and for assessing residual and recurrent tumor in treated patients.

Materials and Methods: In the first month of an ongoing study, fifteen patients with brain tumors were scanned with a 3T GE MR VH/I as part of their clinical evaluation. High-resolution T1- and T2-weighted, gradient-echo, diffusion and perfusion scans and post-gadolinium T1-weighted images were obtained. ASL was performed using background suppressed continuous arterial spin labeling with a stack of variable density spiral readout. Images were acquired at a 48x64x64 on an 18x18x24 cm FOV. 3 ASL averages required just 5 minutes. 3d volumes were reconstructed offline and resliced to match the gadolinium enhanced T1-weighted scans for simultaneous viewing and analysis.

Four glioblastoma multiforme, five intermediate-grade gliomas, two low-grade gliomas, one with likely radiation necrosis and three with uncertain final diagnoses, were studied. Four patients had two examinations. All but one of the low-grade glioma patients and one of the undiagnosed cases, had had prior surgery, chemotherapy and/or radiation therapy, and had been previously imaged at our institution.

Results: ASL produced images of good quality in all patients. While radiation necrosis and surgical resections appeared very hypoperfused, there was no artifact associated with the presence of these treatment related abnormalities. In intermediate and high grade tumors, regions of markedly increased perfusion, relative to gray matter, were frequently apparent. While in many cases the regions of T1 enhancement and hyperperfusion agreed, figure 1, in others enhanced perfusion was observed in nonenhancing tissue and some enhancing tissue was hypoperfused, figure 2.

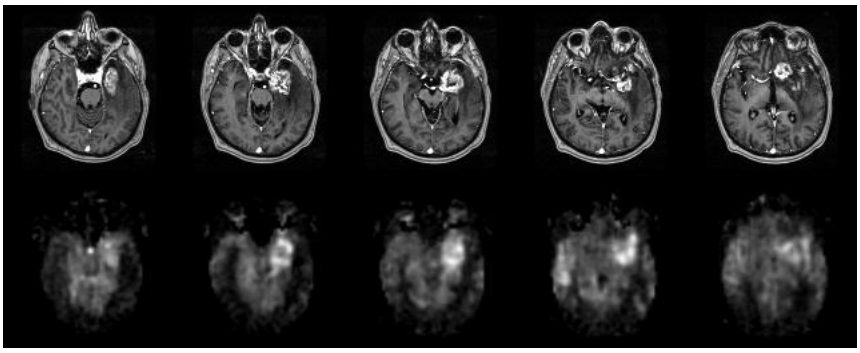

Figure 1:
T1 enhanced, top, and ASL perfusion imaging, bottom in a patient with an intermediate grade tumor. T1 enhanced regions are hyperperfused.

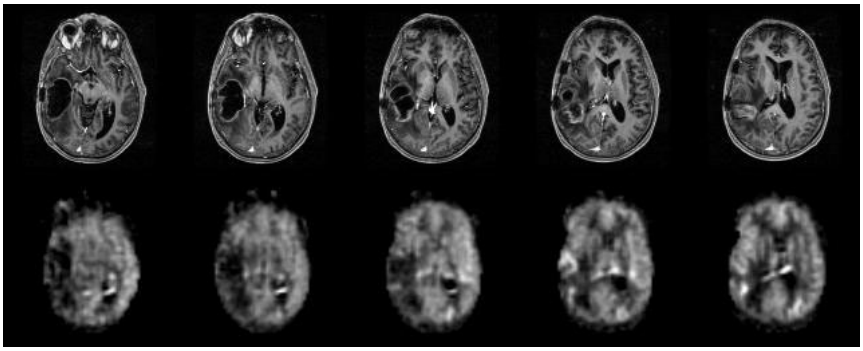

Figure 2:
T1 enhanced, top, and ASL perfusion imaging, bottom in a patient with a high grade tumor following surgical and radiation therapy. Hyperperfusion is observed in T1 nonenhancing regions.

Conclusions: We have demonstrated the feasibility of using the ASL technique in the clinical setting, as a tool the radiologist can use to measure brain perfusion during routine brain tumor MR evaluation. Studies were rapid, well-tolerated, required no contrast, and had no susceptibility artifacts and good resolution. ASL findings indicate that hyperperfusion may be found in association with various grades of tumor, and independent of contrast enhancement. Hypoperfusion may be seen in areas of radiation treatment. These relationships should be explored further to determine whether perfusion is a reliable parameter for making therapeutic management decisions.

(1) Warmuth C, et al. Radiology 2003; 228(2): 523-532. (2) Cha S et al. Radiology 2002; 223:11-29. (3) Law M et al. Radiology 2002; 222:715-721. (4) Henry RG et al. AJNR 2000; 21: 357-366. (5) Cha S, et al. AJNR 2000; 21: 881-890.