Glioblastoma Multiforme: Utilization of Advanced MRI Techniques for Preoperative Planning

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A 45 YEAR-OLD RIGHT-HANDED FEMALE presented with five episodes of right upper extremity numbness beginning in the fingers and hands and progressing to involve the face, with facial twitching, over a period of five days. Each episode lasted no longer than two minutes and then resolved. She was completely aware throughout each event and was able to verbalize and comprehend language perfectly. On physical exam, language comprehension and expression were normal, with normal muscle bulk, power and tone bilaterally.

MRI examination demonstrated a well-circumscribed 18 x 16 x 18 mm enhancing lesion in the left posterior frontal lobe (Figure 1a) with moderate surrounding FLAIR and T2-weighted hyperintensity (Figure 1b). Perfusion weighted imaging demonstrates substantially elevated relative cerebral blood volume within the lesion, greater than six times that of the normal contralateral white matter (Figure 2). Functional MRI demonstrated that motor activation corresponding to finger tapping and tongue motion was located adjacent to the superomedial (Figure 3a) and anterolateral (Figure 3b) aspects of the lesion, respectively. Diffusion tensor imaging was also performed, with maps of fractional anisotropy demonstrating mass effect on and partial effacement of the left superior longitudinal fasciculus (Figure 4).

The patient underwent open surgical resection of the lesion. The histological diagnosis was glioblastoma multiforme, concordant with the imaging findings.

The patient was started on antiepileptic medication (Keppra) to control her presenting symptoms. She underwent radiation with concomitant temozolomide and steroid therapy.

Discussion

Recent innovations in MRI have revolutionized the pre-operative imaging workup of brain neoplasms. In addition to the structural information provided by conventional MR imaging, **perfusion weighted imaging** (**PWI**), **functional MRI** (**fMRI**), and **diffusion tensor imaging** (**DTI**) convey information about tumor grade, and the spatial relationship of tumor to eloquent cortex and major white matter tracts, respectively.

PWI utilizes transient microscopic magnetic field perturbations induced by a bolus injection of exogenous paramagnetic contrast material to measure cerebral perfusion using modified tracer kinetic principles.[3,5] Rapid MRI acquisition permits estimation of contrast concentration-time curves, and computation of hemodynamic parameters including **relative cerebral blood volume** (**rCBV**) which has been shown to correlate significantly with histologic tumor grade.[3,5] The lesion in our study had an extremely high rCBV, which is concordant with the histopathological diagnosis of glioblastoma multiforme.

fMRI is based on the known coupling between brain function and cerebral perfusion: neural activity results in localized increased blood flow and a consequent reduction in deoxyhemoglobin, increasing the MR signal to a small but significant degree.[1] By imaging the patient's brain during the active and resting phases of different tasks (e.g., visual stimulation, finger tapping, or various language processing tasks) and applying the appropriate statistical analyses, functional maps can be created.[1] With respect to neurosurgical planning, specific function of brain parenchyma surrounding the neoplasm can be elucidated, and resection of eloquent cortex responsible for language or motor control can be minimized or avoided.[4] In our study, cortex adjacent to the tumor was seen to be responsible for hand as well as tongue movement, which may offer an explanation as to why the patient initially presented with facial twitching.

DTI uses spatially oriented magnetic field gradients to interrogate proton movement in brain tissue. Without any structural barriers, water diffusion is anisotropic.[2,6] Organized white matter fibers with directionality provide preferential paths for proton Brownian motion along fiber tracts, with restricted movement orthogonal to the tracts, leading to anisotropic diffusion and discernable tract anatomy on colorized maps of fractional anisotropy within each imaging voxel.[2,6] Such information can be useful to the neurosurgeon who can plan an approach to the tumor that minimizes compromise of major white matter tracts.[2,7] Additionally, this technology can play a diagnostic role in differentiating gliomas (infiltration and disruption of white matter tracts) from metastatic disease (displacement of white matter tracts).[2]

MRI has traditionally been the study of choice for evaluating tumor morphology for neurosurgical planning. Advanced MRI techniques are now being used to assess functional properties of the tumor, as well as relationship of the tumor to eloquent cortex and major white matter tracts, resulting in reduced post-operative morbidity.

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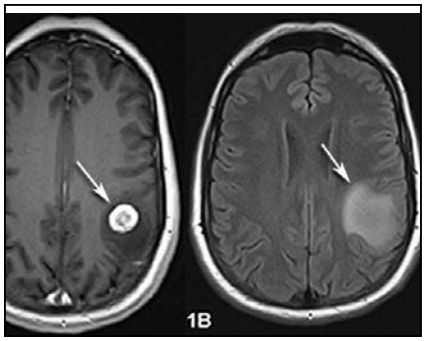


Figures 1a and 1b.

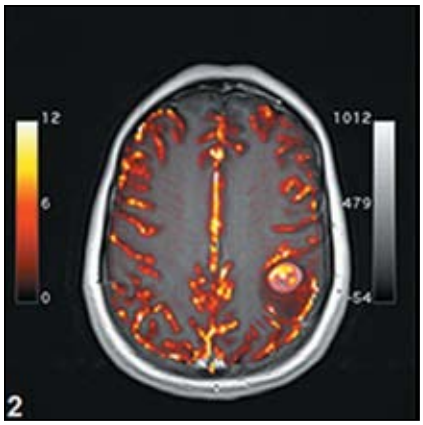
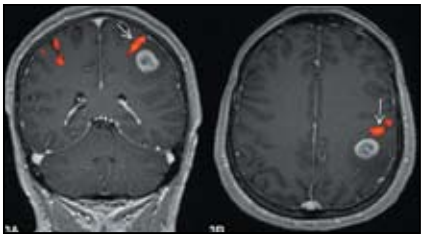


Figure 2.



Figures 3a and 3b.

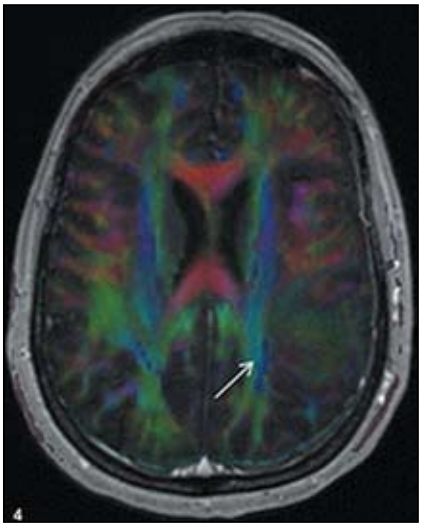


Figure 4.

motor functions: validation with intraoperative electrocortical mapping. *Radiology*. August 2008; 248: 579-589.

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Focal Nodular Hyperplasia on MRI Using a Hepatocyte-Specific Contrast Agent at 1.5 Tesla vs. 3.0 Tesla Field Strength

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A twenty-nine year-old female with an implantable contraceptive presented with right upper quadrant and right pleuritic chest pain. A right upper quadrant ultrasound showed no evidence for cholelithiasis or acute cholecystitis but showed a nine cm hypoechoic central liver mass (Figure 1). A CT pulmonary angiogram was then performed to evaluate her chest pain and demonstrated a pulmonary embolism. Images through the upper abdomen also confirmed the nine cm hypervascular central liver mass straddling the right dome and medial left lobes of the liver (Figure 2). Differential considerations at this point for a hypervascular liver mass included a cavernous hemangioma, focal nodular hyperplasia, hepatic adenoma, or, less likely given the patient's age, a malignancy such as a hypervascular metastasis or hepatocellular carcinoma. A liver MRI using a hepatocyte-specific contrast agent, gadoxetate disodium (Eovist; Bayer Healthcare Pharmaceuticals), was then performed for definitive characterization. This scan performed at a 1.5 Tesla (1.5 T) magnetic field strength showed a background of diffuse hepatic steatosis and redemonstrated a T1 isointense and mildly T2 hyperintense

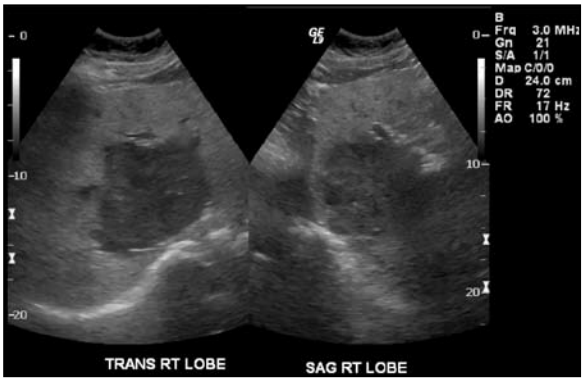

Figure 1. Transverse and sagittal ultrasound images through the right lobe of the liver demonstrates a solid hypoechoic central liver mass.