Functional Neuro MRI

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The brain is uniquely suited for functional MR imaging with the potential for extensive clinical application and benefit for patients. Although neurologic applications for functional MRI, particularly blood oxygen level depending (BOLD) imaging, have been in experimental use since the early '90s, its widespread clinical application is a relatively recent phenomena. Recent advances in functional imaging have allowed for fMRI to be applied to a broad range of clinical disease processes. The combination of conventional BOLD imaging with pharmacological and physiologic techniques such as drug challenges, diffusion tensor imaging and connectivity imaging hold great promise for understanding neuronal processes and development of clinically meaningful diagnostic tests.

Functional MRI works best on and was developed primarily using highly motivated cooperative subjects such as graduate students; however, realization of the full clinical potential of fMRI necessitates the development of techniques to accommodate the needs of real patients as well as strategies for reimbursement. Several relatively recent advances in MRI have greatly increased the success rate and reliability of studying patients. The increased availability of three tesla (3T) imaging systems with their increased signal-to-noise has made fMRI a much more forgiving test to perform. Development of prospective motion correction techniques has allowed for good quantitation and correction of patient motion without resorting to retrospective analysis and its inherent problems with spin history effects and loss of signal related to true activation. Prospective motion correction techniques may derive their greatest benefit when used in combination with real-time at fMRI analysis. The combination makes it possible to assess clinical data sets while the patient is still in the scanner and correct problems leading to patient motion. Although 3T imaging, prospective motion correction, and real-time analysis have greatly increased the reliability of fMRI in the clinical setting several questions remain to be answered with regard to reproducibility. Reproducibility both overtime and across imaging platforms is closely tied to the issue of reimbursement for fMRI. fMRI must be reimbursable before it will reach its complete potential as a clinical tool. It is incumbent on the imaging community to prove the reliability, robustness and clinical utility of fMRI in order to convince the appropriate regulatory entities that it should receive reimbursement commensurate with the time-consuming nature of the examination.

Clinical applications of fMRI have largely relied on block style BOLD fMRI techniques to answer relatively simple questions regarding motor and language mapping in patients. These techniques have been applied most broadly in preoperative evaluations in setting of brain tumors and epilepsy. More recent techniques such as event related paradigms and combinations of event and block style paradigms have allowed for better study of more sophisticated cognitive processes. These paradigms not only produce more complete assessments of cognitive processes presurgically, but they also open up the potential for noninvasive clinical evaluation of cognition for neurodegenerative processes such as multiple sclerosis, Parkinson's disease, and Alzheimer's disease. fMRI has also been recently applied to study the efficacy of therapy for disease processes using drug challenges during fMRI and with fMRI performed during deep brain stimulation.

Probably the most interesting application of functional MRI in the clinical setting is in combination with other physiologic imaging techniques. The combination of fMRI with DTI provides the most comprehensive presurgical mapping available, clearly delineating relationship of tumors or other pathology to both eloquent cortex and critical white matter pathways. The addition of functional connectivity measurements to DTI and fMRI measures has a potential to provide a powerful clinical tool for the assessment of neural networks. Early application of these combined techniques to multiple sclerosis suggests that a new pathway/network driven approach to the assessment of neurologic diseases is now possible.

Functional MRI has great potential both for mapping brain function and as part of a more comprehensive assessment of neural pathways and networks. Technical advancements have increased the robust nature of fMRI allowing it to reach its full potential as a clinical assessment for a wide spectrum of neurological disorders.