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Clinical Application of Functional Magnetic Resonance Imaging

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Since the introduction of magnetic resonance imaging (MRI) by Lauterbur in 1973, through the efforts of many scientists, MRI has grown up to be a major imaging modality together with X-ray CT in radiological field because of its excellent soft tissue differentiation in human body. Currently, new scanning methods and MR system development can provide both morphological and functional information on brain. Of new methods, functional MRI (fMRI) may have a large potency in neuroscience and neurosurgery fields because it can allow the investigation of a wide range of cognitive functions in human brain by localizing their cortical areas in a noninvasive and intact way. Functional MRI has been already a routine tool methodologically in clinical environment on 1.5T MR system, but its possibility for the clinical application should be further evaluated related to the reproducibility and precision of the localization of the cortical areas.

The basic principle of fMRI performed in most clinical environments is based on the BOLD (blood oxygenation-level dependent) effect and MR sequences sensitive to magnetic susceptibility have been used for fMRI study. The task performance for cognitive functions induced local increase in blood flow at the specific cortical sites related to them, which resulted in the increase in signal intensity by excess of oxyhemoglobin in blood as a source of mapping. Experimentally, the activation map images are obtained by taking a series of images of the brain in quick succession during the cognitive tasks and the rest periods and statistically analyzing the images for differences among them. Many hardware and software tools for the presentation of task paradigm and data-processing software are necessary to obtain the successful fMRI images and a variety of scientific fields such as psychology, neurology, biomedical engineering, biophysics have been involved with fMRI study. Many psychological problems have been investigated using fMRI and its good results have been reported. In clinical environments, clinicians have been interested in the precise cortical localization of the motor and sensory system of hand and foot, and in the hemispheric dominance of language and memory systems. Patients with intracranial masses and epilepsy may undergo a neurosurgical operation to remove the pathological regions. In these cases, surgeons will be able to perform the operation more safely with fMRI than without fMRI because they may avoid the danger of removing the very important cognitive sites related to the motor, sensory, language and memory systems during the operation. Our hospital has performed the study on fMRI for the patients with epilepsy and intracranial masses during 4 years. Especially, we evaluated the usefulness of fMRI to know if it can replace an invasive WADA test in determining the language hemispheric dominance and showed the promising results. Also, the motor and sensory systems of hand and foot have been investigated and the fMRI results on them were shown to be similar to those of invasive electric stimulation experiment. Although the successful reports on the clinical application of fMRI have been published around the world, however, low task performance and small head motion in patient groups may cause the probability of bad or wrong results to be higher in patients than in normal volunteers, which may result in the blockade for broad clinical application of fMRI. The trial of various task paradigms and the adequate selection of the data post-processing algorithm to eliminate the unavoidable artifacts have been steadily studied for fMRI to be accepted as a clinical routine tool. In conclusion, I think fMRI may be a useful and supplementary tool in surgical planning of patients with intracranial masses and epilepsy, though many theoretical or technical problems remain for clinical implementation of fMRI.