Combined Magnetic Resonance Tractography and Functional Magnetic Resonance Imaging in Neurosurgical Planning

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PURPOSE: Functional MRI (fMRI) combines anatomic with functional information and has therefore been widely used for preoperative planning of patients with mass lesions affecting functionally important brain regions. However, the courses of functionally important fiber tracts are not visualized. We therefore propose to combine fMRI with diffusion-tensor imaging (DTI) that allows visualization of large fiber tracts and to implement this data in a neuronavigation system.

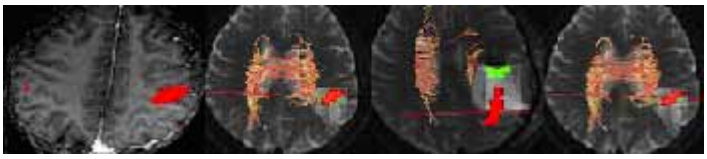
METHODS: 22 patients (16 male and 6 female; mean 35.7 years) with tumor (16 astrocytomas, 4 oligodendrocytes, and 2 meningiomas) involving the motor system, all patients are right-hand. All patients had been underwent surgery with resection of the lesions in our hospital. The lesions locatization were frontal in 13 patients, and parietal in 6 patients, frontal and parietal in 1 patient, and extra-axial tumor in 2 patients.

A superconductive 1.5T scanner (Twin HD GEMS Milwaukee) was employed and head coil was used. DTI and fMRI were performed in all patients. Axial DTI images were scanned with single shot SE-EPI sequence by using the 8 channel phase-array head coil. TR/TE=8000/70ms. The b value=1000s/mm, the number of diffusion sensitive gradient direction was 15, NEX=1, and matrix=128x128. We used block paradigms contrasting motor activation with rest. Function MR imaging was obtained using a single shot EPI sequence (TR/TE=2000/40ms, FOV=220x220, matrix=64x64, phase=110, slice thickness=6mm). The motor task involved repetitive hand-clench and finger-tapping. In a total scanning time of 3 minutes 50 seconds five alternating epochs of rest and activation each lasting 20 seconds. The fMRI data were analyzed by using the brainwave software on GE HD system, the DTI were reconstructed by using functool software on GE ADW work station. DTI was successfully performed at a field strength of 1.5 T (GE Twin HD), employing a spin-echo sequence with gradient sensitivity in fifteen noncollinear directions to visualize the course of the pyramidal tracts, and was combined with echo-planar T2* fMRI during a hand motor task in 22 patients with central gyrus or precentral gyrus lesions. Combined with the DTI and BOLD data by using volume-one software. Intraoperatively, these data were used to aid in neuronavigation.

RESULTS: Fusion of both data sets allowed visualization of the displacement of both the primary hand-clench and finger-tapping motion areas and its large descending fiber tracts. These data were helpful operation. There were no function deficit in 7 patients; there were slight function deficit in 6 patients, recovery in two months ago; there were bilateral hemiplegia in 3 patients, recovery in 8 months ago; there were bilateral hemiplegia in 3 patients, part of function deficit recovery in half of year.

DISCUSION: Resection the intracranial lesion requires a detailed understanding of the structural as well as functional anatomy of the tumor and adjacent WM fibers. The goal of these preoperative studies is to delineate the normal unaffected brain tissue from infiltrated by tumor, whereby optimal tumor resection is perform with minimal damage to vital brain function. The fMRI and DTI data can be used for determining the operative trajectories, that is, for surgical planning; intraoperatively, fMRI and DTI were helpful for preserving the WM fiber and function region at surgery, and the patients had an uneventful recovery with no postoperative motor deficits(1-2).

CONCLUSION: The combination of fMRI with DTI allows for assessment of functionally important cortical areas and additional visualization of large fiber tracts. Information about the orientation of fiber tracts in normal appearing white matter in patients with tumors within the cortical motor system cannot be obtained by other functional or conventional imaging methods and is vital for reducing operative morbidity as the information about functional cortex. This technique might, therefore, have the prospect of guiding neurosurgical interventions, especially when linked to a neuronavigation system.



A B C D

picture A: reconstruct with brainwave, hand-tapping motion area(red area) preoperation.

Picture B: reconstruct with DTI(red-yellow), and hand-tapping motion area(red area), and tumor (green) preoperation.

Picture C: reconstruct with DTI(red-yellow), and hand-tapping motion area(red area), and tumor (green) post-operation in one week.

Picture D: reconstruct with DTI(red-yellow), and hand-tapping motion area(red area), and tumor (green) post-operation in 8 months ago.

References:

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