High temporal resolution functional MRA for investigating the neural activity

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Introduction

fMRI is the gold standard method evaluating the human brain function. It is well known that the signal source of fMRI is the combination of blood flow, blood volume, oxygen consumption change, and so on. However, the exact mechanism of the signal change at fMRI is still controversial [1]. There have been a number of trials to measure the change of the blood flow and blood volume during a certain task using various imaging techniques, such as MRI and optic image [2]. It is hard to acquire the signal change of blood flow or volume change for brain activity in the human subject at the low field MRI. Recently, ultra high field MRI (7T) could provide the opportunity of detecting directly the vascular response by external stimulation, but temporal resolution was too long to investigate a brain function [3]. In this paper, we also present the vascular signal change during motor task at ultra high field MRI (7T), but we conducted this functional MRA (fMRA) study with 3 sec. of high temporal resolution, comparable to fMRI study.

Methods

Our studies consisted of two parts, fMRI at 3T MRI system and fMRA at 7T MRI (Magnetom, Siemens, Germany). For motor task, the subjects were asked to grasp and release a rubber ball repeatedly during on-set time ('left' and 'right' in Fig. 1). Pulse sequences used for the present study were TWIST (Time-resolved WIth Stochastic Trajectories) for fMRA [4], which was used for key-hole examination, and EPI for fMRI. Experimental designs consisted of 5 sessions (with 2 task sessions) same as simple fMRI protocol. fMRI data was acquired with 102 volumes, TR=3 s, TE=30 ms, FOV=180x180 mm, 64x64 matrix, and in-plane resolution of 2.8 mm and first 2 volumes were discarded. Analyses were completed using SPM2 with MATLAB program. fMRA study was performed with TR=5.2 ms, TE=1.15 ms, FOV=146.3x180 mm, and 208x256 matrix, and iso-voxel resolution of 0.7 mm. fMRA experiment has 3 sec. of temporal resolution (T/R) for a volume. The home built hybrid birdcage coil was utilized for the 7T fMRA experiments. To encode small and slow blood signal, limited FOV (z-direction) covering motor cortical regions was utilized. fMRA data analysis consisted of two methods. First, maximum intensity projection (MIP) was also utilized for the clear visualization of vessels supplying blood to motor cortex and time course was measured with signal intensity change in target vessels of interest (Fig. 1). Second, we used SPM2 for fMRA raw data same as fMRI analysis.

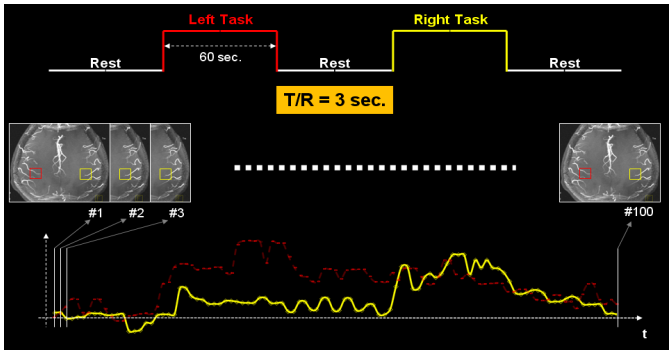

Fig. 1. fMRA paradigm for motor task

Results

Fig. 2 shows the time courses in vessels of interest for motor tasks. Time courses in the vessels supplying blood to motor cortex look well correlated with task protocol (Upper row). Additionally, we measured other vessels supplying to other cortical areas and the changes were not visible (Lower row). Fig. 3 shows SPM results in both fMRA and fMRI. Activation areas look similar in both.

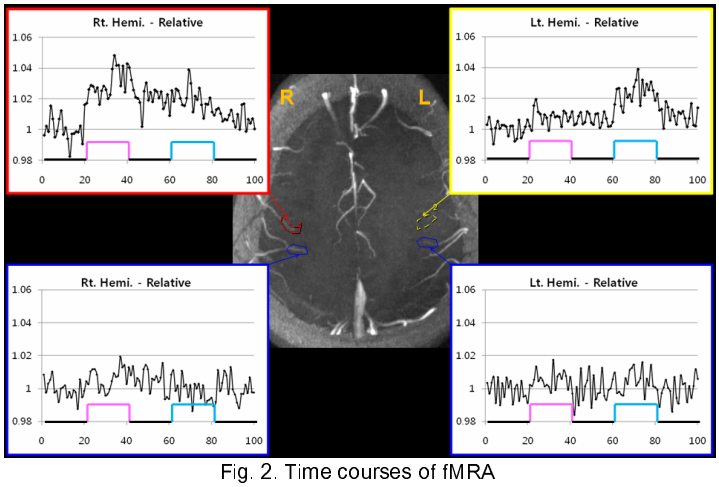

Fig. 2. Time courses of fMRA

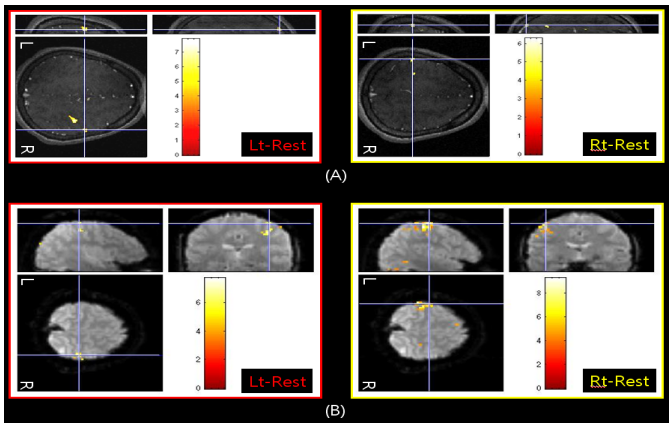

Fig. 3. SPM results from fMRA (A) and fMRI (B)

Conclusions and Discussion

This study was to measure the flow change during a functional task using 7T MRA for investigating the neural activity in the brain. The subtle signal change in MRA can be detected at 7T MRI with high temporal resolution same as fMRI (e.g., 3 sec.). Further studies will be necessary and we hope that they would provide one of clues to reveal the mechanism of BOLD with direct measurement of blood flow. fMRA study with higher spatial resolution still needs for determining the exact site of neural activity and then further proper explanation of its mechanism.

Reference

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