High Resolution Functional MR Venography with 7T MRI

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Introduction

Magnetic resonance venography (MRV) has been used to assess the effects of medical treatment for and the resolution of cerebral venous diseases. The contrast mechanism involving MRV used for functional or anatomical applications has been based on the local magnetic field inhomogeneity created by deoxyhemoglobin, which determines MR signal intensity [1,2]. Susceptibility weighted imaging (SWI), one of most prevalent MRV techniques, has been utilized for the visualization of cerebral veins and venous malformations [3,4]. However, it has a low temporal resolution of several minutes, while MRV using SWI could visualize the BOLD effect with high spatial resolution during stimulation [5,6]. In this study, we introduce an imaging method, called functional MRV (fMRV), to investigate the venous dynamics during stimulation using TWIST. We evaluated the proposed technique by investigating dynamic changes of the veins closely associated with the visual cortex to visual stimuli.

Methods

A fast imaging sequence, known as time-resolved angiography with interleaved stochastic trajectories (TWIST) [7], was utilized to detect the dynamic change of veins with a high spatial resolution of 0.5x0.5x0.5 mm^3 and temporal resolution (T/R) of 3 sec in twelve healthy subjects. After obtaining informed consent regarding the study's purpose, MR imaging was performed using a 7T MR scanner (Magnetom, Siemens, Germany) equipped with a quadrature transmit/receive surface radio-frequency (RF) coil. We compared images obtained with TWIST with high-resolution conventional T2*-weighted images using 3D SWI, which were acquired with the same imaging resolution as TWIST sufficient to generate significant susceptibility weighting. Then, fMRI was performed with temporal and spatial resolutions of 3 seconds and 3 mm isovoxels, in order to locate the activation area in the brain during visual stimulation.

Results

We compared fMRV images obtained with TWIST and SWI sequences. High venous vessel contrast was obtained with SWI with high signal to noise ratio (SNR); however, the change in the vessels during visual stimulation was not prominent. In contrast, subtraction image obtained with TWIST provided a more conspicuous change in the venous vessels. Direct visualization of the dynamic venous response to stimulation is displayed in Figure 1. An area was selected which contained the peak activation point determined from the fMRI activation map as shown in 1(a). The signal change with time was plotted in 1(b), in which the percent signal change in the selected area was about 6%. The dynamic change of the vessel in the area of peak activation is also shown in 1 (c) and (d) during stimulation and post-stimulation periods, respectively. Stimulation induced change in the vessel as well as a lag in the dynamic signal change at the onset and end of neural stimulation were clearly visualized.

Discussion

In the present study, we proposed an fMRV technique, which can visualize venous dynamics with high temporal resolution during brain activation by external stimulation. A fast imaging technique, TWIST, was utilized to extract the necessary information for imaging venous blood selectively in the human brain with sub-millimeter resolution. The area of t he neural activation site observed by conventional fMRI was usually limited to a few millimeters and not sensitive enough to observe the increased deoxyhemoglobin concentration within venous vessels. Ultra high field 7T MRI, however, has the potential to facilitate the distinction between capillary and venous contributions. With this capability, it may be viable to predict where activation occurs in functional brain imaging. In the present study, fMRV at 7T with TWIST was able to visualize the dynamic venous response induced by neural activity and provide high temporal dynamic imaging, which has not been seen in the previous studies. Therefore, the dynamic venous response detected using this technique at 7T MRI may provide essential, more precise and complementary information to the well known hemodynamic or BOLD response to neural activity.

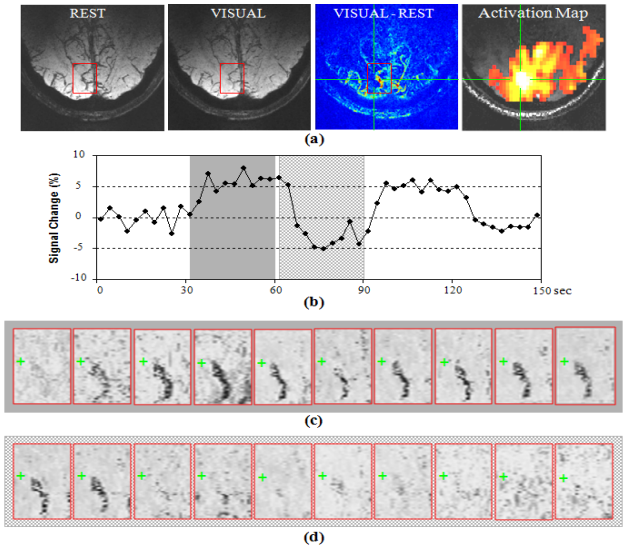

Fig 1. The dynamic venous change during stimulation.

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Reference

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