Cerebral Hemodynamic Impairment Assessed with Resting State fMRI

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Background and Purpose: Assessment of cerebral perfusion is essential for clinical management of ischemic patients. While most of the imaging techniques ever tested entail exogenous contrast agents, tracers or vasodilators, non-invasive methods exploiting endogenous contrasts are emerging as potential substitute. We previously demonstrated that temporal shift of blood-oxygenation-level-dependent response to neural stimulation can indicate local hemodynamic impairment in chronic ischemic patients. In the current study, in order to allow for global assessment, we further applied resting state functional MRI (rfMRI) for the evaluation of hemodynamic impairment in chronic and acute ischemic patients.

Methods: Patients underwent 10 min rfMRI and dynamic susceptibility contrast (DSC) perfusion-weighted imaging. Temporal shift of low-frequency oscillation (0.01-0.1Hz) was determined by calculating Pearson's correlation coefficients between each voxel's signal time course and time-shifted (±20s) global mean signal in the unaffected hemisphere, and by choosing the shift that gives the best positive fit voxel-wise. Regions of abnormal DSC perfusion were automatically determined by including all voxels within either anterior or posterior circulation territory showing delay in time-to-peak compared to corresponding contralateral voxels. rfMRI based temporal dynamic maps were compared with DSC perfusion data by calculating Dice's similarity coefficients.

Results: Most brain regions with normal perfusion showed no temporal shift to global mean signal. Regions showing delayed time-to-peak (2.1-7.7s relative to contralateral) in perfusion data showed delay in rfMRI (Dice's coefficient 0.31-0.70). Mean transit time was also elongated (0.5-2.5s). The rfMRI-based maps of abnormal perfusion were highly reproducible. When the patient's head motion was small (<2mm), similar maps could be repeatedly obtained from anterior- or posterior-half of the 10 min data.

Conclusions: Resting-state fMRI can indicate areas of abnormal perfusion in ischemic patients. Although the approach has the same limitations to other measurements in that patient's head motion and hemorrhage lead to inaccurate assessment, non-invasiveness, simplicity and high reproducibility of rfMRI temporal analysis will be of clinical value as an alternative to current techniques in patient selection for treatments of chronic and acute ischemia.

References:

1. Impaired hemodynamic response in the ischemic brain assessed with BOLD fMRI. Neuroimage 2012;61:579-90.
2. Time lag dependent multimodal processing of concurrent fMRI and near-infrared spectroscopy (NIRS) data suggests a global circulatory origin for low-frequency oscillation signals in human brain. Neuroimage 2010;53:553-64
3. Identifying the perfusion deficit in acute stroke with resting-state fMRI. Annals of Neurology 2012 e-pub ahead of print

Fig.1 Resting-State fMRI Temporal-Shift Analysis vs. DSC-PW TTP measurement

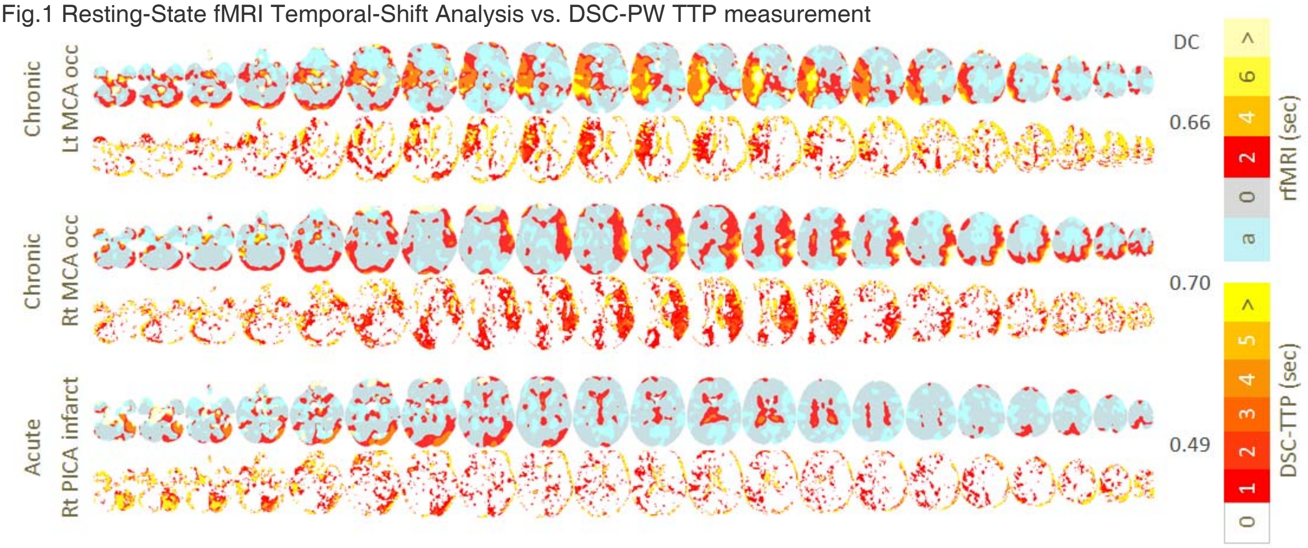

Fig. 2 Correlation Coefficients; Regional vs. Shifted Global Mean

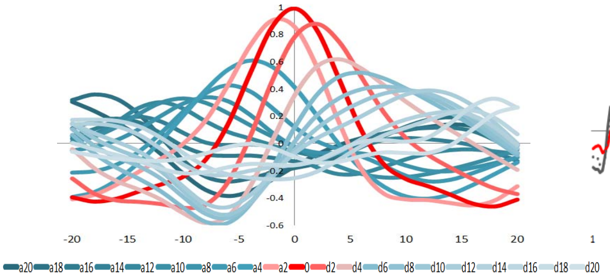

Fig. 3 Signal Time Course; Ischemic vs. Global Mean