Non-invasive measurement of blood arrival, drainage and transit times using functional MRI signal

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Background

Objective
We sought to explore the broad clinical significance of the technique.

Patients and Methods / Material and Methods
First, we tested the sensitivity of this "lag mapping", which tracks the phase of sLFO that propagates through the vascular structure, on cerebral infarction and normal pressure hydrocephalus. These patient groups were chosen to evaluate the arrival and drainage times of the blood, respectively. Eighty-one healthy subjects were recruited for comparison. Secondly, we tested the capability of this technique in measuring flow velocity in a healthy control group, using respiratory challenges to create phasic CBF change. Temporal variation of blood transition time was calculated from fluctuation of the phase shifts.

Results
After confirming that the method detects severe hypoperfusion in stroke patients, we observed acute change of drainage time in the periventricular region of hydrocephalus patients by spinal tap test (right figure), suggesting normalization of the deep venous system. Moreover, in the 81 normal control subjects (ages 20 – 83 years), we found a significant effect of normal aging on the drainage time of the region, which indicates an etiological role of aging process in the development of normal pressure hydrocephalus, a condition prevalent in the elderly.

In young healthy controls, a brief breath-holding of 10 s evoked significant global signal change, preserving the lag structure (left figure). By measuring the small fluctuation of the lag phase shift, we found a decrease of BOLD transit time, which indicates flow speed increase, during breath holding. This effect was only observed in the arterial side of the cerebral vasculature, consistent with earlier reports using transcranial Doppler.

Conclusion
BOLD-based blood flow tracking is sensitive to cerebral perfusion and clinical application is encouraged, taking advantage of its non-invasive and repeatable nature.
