Varied vasomotor responses among brain territories in unilateral ICA stenosis patients studied using Breath-hold BOLD MRI

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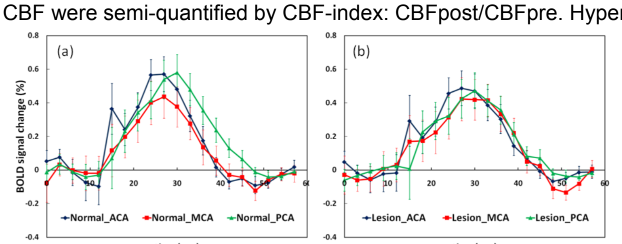
Introduction

Patients with significant internal carotid artery (ICA) stenosis increase the incidence of ischemic stroke by compromising cerebral hemodynamics. They often benefit from carotid interventions, such as carotid angioplasty with stenting (CAS), to prevent subsequent ischemic events. Hyperperfusion syndrome, commonly including unilateral headache, seizures, and intracerebral hemorrhage, usually causes disastrous outcome if occurred after carotid interventions. In recent studies, impaired cerebral vasoreactivity (CVR) is considered as one of the predictors for hyperperfusion syndrome[1]. Hypercapnia stresses such as breath holding have been showed to result in vasodilatation and raise cerebral blood flow (CBF) in human subjects[2] Thus combining breath holding and BOLD MRI may be a useful method to characterize the impaired CVR in patients prone to hyperperfusion after CAS. Most recently, Leoni et. al. [3] found different hemodynamic response among different brain territories in normal subjects during breath holding. The aim of this study was to evaluate the varied hemodynamic responses among different brain territories in unilateral ICA stenosis patients using the same MRI method.

Methods

Seventeen patients with unilateral internal carotid artery (ICA) stenosis participated in this study and were asked to hold their breath for 15 sec after the end expiration of the 45 sec natural breathing. Three cycles of the breath holding task were performed. Evaluations of cerebral perfusion were done by perfusion MRI before and 3-5 days after carotid intervention. A single-shot T2* gradient-echo EPI sequence (TR/TE/FA= 3000ms/50ms/90) was used for BOLD measurements and a fluid-attenuated-inversion recovery (FLAIR) sequence (TR/TE/TI = 9416/90/2200 ms) was used for perfusion quantification at a 1.5T scanner. Twenty axial slices were acquired with a thickness = 5 mm and gap = 1.5 mm gap to cover the whole brain. Other parameters included: matrix size=112x84 and FOV= 192 mm x 192 mm. Echo-planar images were spatial normalized to the MNI template and averaged BOLD signal time curves were drawn from six regions of interest, i.e. ACA, MCA and PCA on both sides, with a template made by an experienced neurologist. The changes of CBF were semi-quantified by CBF-index: CBFpost/CBFpre. Hyperperfusional state was defined when CBF-index>1.



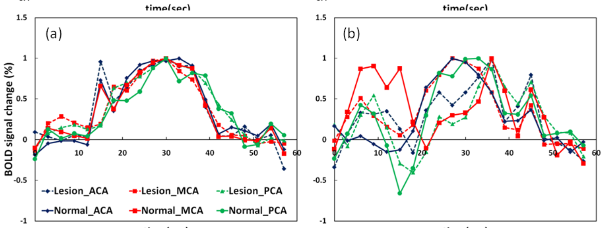


Fig. 2

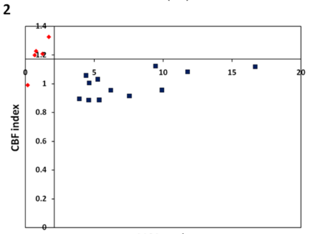


Fig. 3

Results and discussion

Fig.1 (a) and (b) show the BOLD signal time curves averaged over seventeen patients from the normal and stenosis hemisphere, respectively. In the MCA territory, BOLD signal response in lesion side showed delayed onset and smaller amplitude as compared to the normal side. The overall behavior in the normal side agreed with the previous published study[3] in the normal subjects, except for the ACA territory which showed similar response to the PCA in our study. Fig. 2 (a) and (b) illustrate the time curves from two patients with right side unilateral ICA stenosis. The BOLD responses between different ROIs, from the same breath holding task, were consistent in patient A but with large varieties in patient B. Fig. 3 showed the distribution of MCA t-value and CBF-index of each patient. Four patients with MCA t-value<2.1 (p<0.05) also showed CBF index larger than 1.17. The sensitivity is 100% and specificity is 92.3%. Fig. 4(a) showed averaged time curve from patients with MCA t-value >2.1. Fig. 4 (b)-(f) illustrate the time curves from patients showed MCA t-value <2.1, respectively.

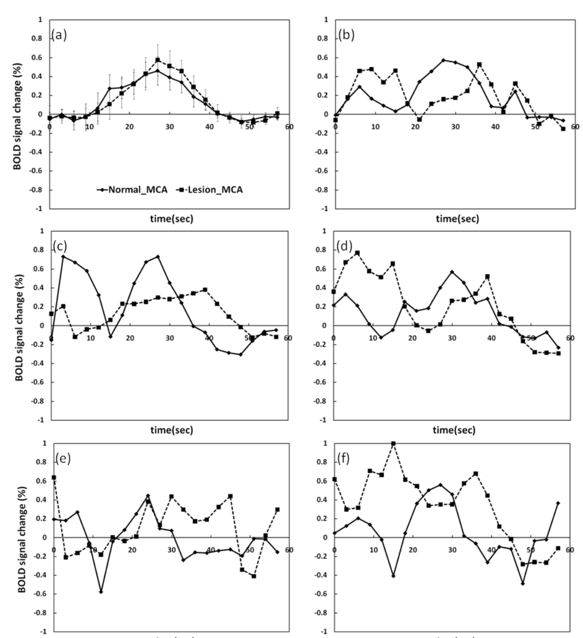


Fig. 4

References

[1] Hosoda, K., et al., Stroke, 2001;32:1567-1573.

[2] Kety SS, et. al.,J Clin Invest 1948; 27:484–492.

[3] R.F. Leoni, et. al., Neuroimage 2008; 41:1192–119