

Metabolic Changes in Human Brain with fMRI and ^1H MRS

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I. INTRODUCTION

Functional magnetic imaging (fMRI) is sensible to detect the signal changes during mental activity within brain tissues and capillary.

Glucose and oxygen are known as the primary substrates of brain energy metabolism and consumed by that organ at the matched rates that maintain stable lactate concentration. Usually the elevation of brain lactate indicates the pathologic evidence. However, the several recent reported the brain lactate elevation during visual stimulation [1].

Physiological activation of brain cortex causes proportionate increases of cerebral blood flow (CBF) and cerebral metabolic rate for glucose (CMR_{glu}), but disproportionately small increases in cerebral metabolic rate for oxygen (CMR_{O₂}). As the result, hyperoxygenation was occurred in capillary and vein. On the other hand, paramagnetic deoxyhemoglobin decreased. For glucose metabolism to rise the excess of O₂ consumption, lactate production is increased[2].

The purpose of this study was to evaluate the blood oxygen level dependent (BOLD) contrast fMRI in the occipital lobe and to compare with metabolic changes based on ^1H MR spectroscopy (MRS) and MR spectroscopic imaging (MRSI) before and after visual stimulation.

II. MATERIALS and METHODS

Healthy human volunteers (eight males and two females with 24-30 years) participated in this study.

All of the BOLD fMRI were acquired on a 1.5T MR system (Vision-Plus, Siemens, Germany, Erlangen) with EPI sequence (TR: 0.96ms, TE: 66ms,

thickness: 3mm, matrix: 128x128, FOV: 210mm) and used with a standard head coil during supervised visual stimulation in occipital lobe. The red flicker with 8Hz was used for visual stimulation. Visual activation was subsequent 2 cycles of 20s rest (20 series) and 20s stimulation (20 series). After imaging acquisition, the MR images were transferred into unix workstation(SUN Spark 20, SUN micro systems, USA) and processed with home made analysis program based on the correlation coefficient method.

¹H MRS data sets were acquired from the same location based on the activation map with STEAM sequence (TR: 2000ms, TE: 20ms, voxel size: 2x2x2, No of acquisition: 128, acquisition time: 4m 23s) in three volunteers. To evaluate lactate peak elevation, PRESS pulse sequence (TR: 2000ms, TE: 135) was used to seven volunteers. Peak of integration area of NAA, Cho, Cr and lactate were measured before and after stimulation. And then, magnetic resonance spectroscopic imaging (MRSI) (TR: 1500ms, TE: 135, No of acquisition: 1, matrix: 16x16, acquisition time: 6m 31s) was acquired to analyze the lactate changes before and after stimulation.

III. RESULTS

The activation maps were successfully produced by BOLD effect due to visual stimulation on occipital lobe in all of volunteers. NAA/Cr ratio varied only from 1.79 ± 0.28 to 1.88 ± 0.20 before and after stimulation in activation area guided by BOLD fMRI images. However, the integration area of lactate was elevated 9.48 ± 4.38 times higher than before stimulation. Lactate elevation was confirmed that shows inversion on PRESS pulse sequence with TE of 135 after visual stimulation (Fig. 1). Lactate metabolite images were acquired during the visual stimulation. This metabolite images consistent with BOLD effect fMRI (Fig. 2).

IV. CONCLUSIONS

Several studies have addressed the metabolic responses to functional activation in human brain using the positron emission tomography. The BOLD contrast fMRI is not enough sensitive to detect the activated area in human brain during visual stimulation. Lactate metabolite map presents the evidence of lactate elevation on the same area of BOLD fMRI. Two results of this study compared together with different physiological effect increased the confidence. But, low spatial resolution of metabolite image and low temporal resolution of spectroscopy due to recoupling will be improved in future.

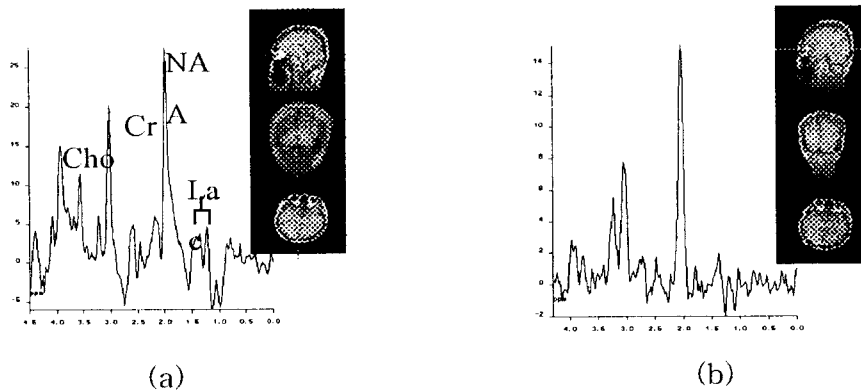


Figure 1. The proton spectrum from single voxel after visual stimulation guided by activation mapping. Lactate peak is elevated after visual stimulation but NAA/Cr ratio is not changed. (a) STEAM sequence (2000/20) (b) PRESS sequence (2000/135). Elevated lactate peak shows inversion on PRESS with TE of 135.

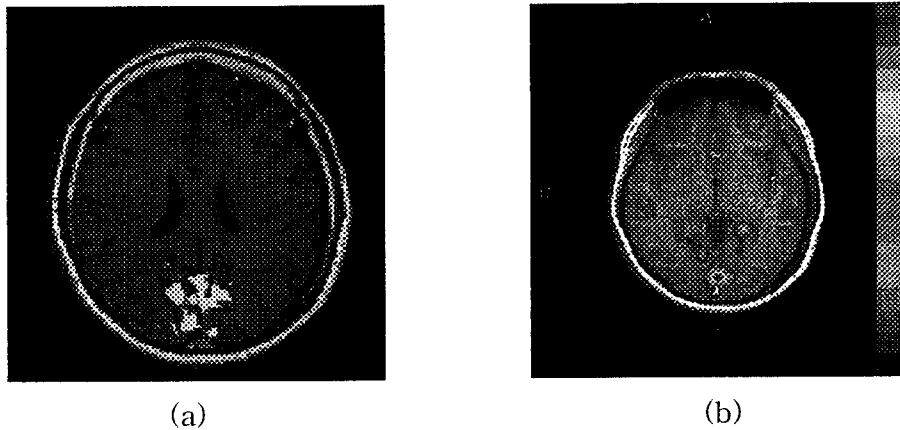


Figure 2. Functional activation images after visual stimulation. (a) BOLD effect oblique axial image (b) Lactate metabolite image. This image presents the evidence of lactate elevation in both occipital lobe and are consistent with BOLD effect image.

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