Initial Cerebral Metabolism due to Short Visual Stimulation using Human functional Near-infraredgraphy (fNIR): How it's correlate with fMRI?

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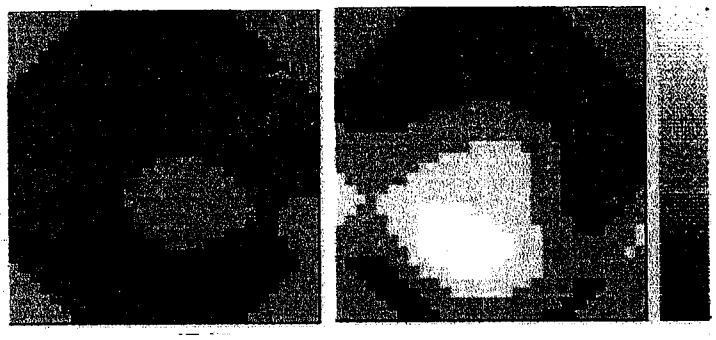
INTRODUCTION: In 1991, near-infrared (NIR) spectroscopic technique which is able to monitor the change of oxy-hemoglobin (Oxy-Hb), deoxy-hemoglobin (Deoxy-Hb), cytochrome aa_3 (1) was developed as non-invasive functional assessment tool in bedside for monitoring regional cerebral blood volume (rCBV) using the scattering near-infrared light (2). In the same time, the method of functional imaging using NIR spectroscopy was proposed (2-4). Recently, we called this regional cerebral functional examination as functional near-infraredgraphy (fNIR). fNIR can be used to provide the direct measurement of real-time Oxy-Hb, and Deoxy-Hb at the bedside. In the first fNIR study, Kato T et al (2-4) prove the increasing Oxy-Hb during visual stimulation. Recently, "initial cerebral metabolism (<3-5s)" which in vivo optical imaging studies (5) have provided evidence of an initial increase in Deoxy-Hb following the onset of activation is seriously discussed because of understanding for T2* change in the fMRI studies (6, 7). In this study, we try to detect the initial cerebral metabolism during short visual stimulation using fNIR in human brain.

METHODS: fNIR experiments were as follows: The rCBV = Oxy-Hb + Deoxy-Hb), HbO_2, and Deoxy-Hb were estimated using a fNIR system with 24-channel (8) (Hitachi Medical Corporation). Light for the fNIR from two laser diodes was directed into the head through a fiberoptic bundle (1 mm in diameter). Near-infrared light with wavelengths of 780 and 840 nm was used. The distance between the photon probes was 3cm. The sampling time for each photon count was 0.5 sec. The changes in the Oxy-Hb and Deoxy-Hb concentration were calculated using the differences in the absorption indexes for the two wavelengths. The center of 24 channels (90 x 90 mm/ square) was located in skull surface on the occiput. Anatomical MRI was performed for the identification of the primary visual area. Informed consent was obtained prior to the experiment. A total of 13 imaging sessions with 9 normal volunteers were performed. The paradigm consisted of two control periods that embedded the short visual stimulation task period. 8Hz flashing light using LED visual stimulator (SMP-4100, NIHON KOHDEN) produced photic stimulation. The stimulus duration of 2sec, 4sec or 6 sec were studied during 7-10 ON/OFF epochs, each a 60-80s OFF period.

Fig. 1 The real-time rCBV maps of the visual activation after the onset of the 2 seconds visual stimulation

A. 5s B. 36.5s



Maps and time courses of functional activation were generated by the Hitachi Medical Corporation made software package (9). The time courses were averaged with 7-10 epochs. The data with the serious motion artifact were removed.

ESULTS & DISCUSSION: The real-time functional mapping of the visual cortex shows **Fig.1** using fNIR. This activation map showed very reliable location related to the primary visual cortex. An initial increase in Deoxy-Hb following the onset of the short visual stimulation was observed in the first time using human none-invasive optical imaging (fNIR). The delayed increase in Oxy-Hb was also observed **Fig.2**. Our results using fNIR were consistent with the early and delayed response from fMRI and animal optical imaging studies. However, an initial decrease in Oxy-Hb following the onset of the short visual stimulation was observed in the first time. This evidence may indicate the increase of the oxygen consumption rate and the contraction of the vascular bed in the initial cerebral metabolism. This decrease of rCBV in the initial hemodynamic responses may be able to contribute to the enhancement of "dip" signal from T2*.

Acknowledgments: The authors wish to thank Emi Kato, Junichi, Furusho, Daisuke Tanaka, Koichi Koike for their research assistance. Supported by NIH grants P41 RR08079.

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Fig. 2 The time courses of "Initial Cerebral Metabolism" related to short visual stimulation in the two subjects
(Vertical line shows the concentration changes (mMol•mm).