Jikeikai Med J 2006 ; 53 : 147-9

Case Report

Frontal Lobe Function in a Patient with Amblyopia

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ABSTRACT

A 48-year-old man with amblyopia underwent near-infrared spectroscopy to determine the burden imposed by poor visual acuity. The patient and 10 healthy volunteers performed the Wisconsin Card Sorting Test Keio Version (KWCST), which is a frontal lobe functional assessment battery. This patient had a significantly greater increase in total hemoglobin volume in the frontal part of the brain during KWCST compared with the average total hemoglobin volume of the healthy subjects (unpaired t-test ; $P < 0.01$). We believe that this patient compensated for impaired visual acuity by frontal functions, such as by paying more attention or concentrating more intensely.

(Jikeikai Med J 2006 ; 53 : 147-9)

Key words : near-infrared spectroscopy, frontal lobe function, amblyopia

INTRODUCTION

To our knowledge, frontal lobe function in a patient with amblyopia has not previously been documented. We describe a patient with amblyopia who presented with severe disturbance of visual acuity and a hyperactivation of the frontal part of the brain.

CASE REPORT

A 48-year-old man presented at our hospital with amblyopia because of congenital cataract. The visual acuity of the right eye was 0.04, and that of the left eye was 0.02. We believed that he needed to pay much more attention and to concentrate more to perform certain tasks requiring visual cognition than did persons without such a condition.

We tried to measure frontal lobe function in this patient by using a near-infrared spectroscopy (NIRS) imaging system to determine the burden imposed by poor visual acuity. The recently developed NIRS imaging technique[1,2] allows noninvasive visualization of cortical activities during dynamic movement. The system consists of 2 plates with 4 light sources and 4 detectors and allows simultaneous 2-channel recording. The system can detect cortical changes in oxygenated hemoglobin, deoxygenated hemoglobin, and total hemoglobin. To detect the function of the front part of the cerebrum, we placed the lower edge of the plate 2 cm above the upper edge of the eye socket to ensure that fibers covered the front of the brain.

In addition to the patient with amblyopia, 10 healthy volunteers without visual disturbances participated as control subjects (6 men and 4 women ; average age, 30.6 ± 7.2 years). They performed the Wisconsin Card Sorting Test (WCST) Keio Version (KWCST), which is a frontal lobe functional assessment battery. In one cycle, the subjects open their

Received for publication, May 13, 2006
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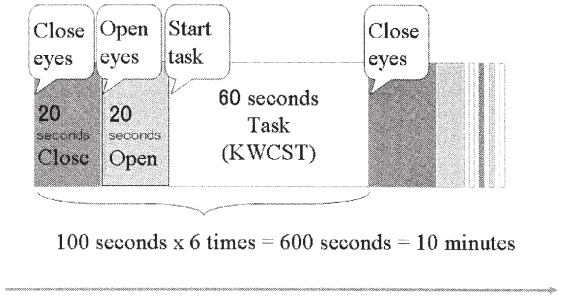

Fig. 1. Experiment protocol in NIRS

eyes for 20 seconds, close their eyes for the next 20 seconds, and then perform each task for 60 seconds. This set is repeated 6 times by a block design (Fig. 1). The KWCST was presented with software (KWCST F-S Version) on a computer display. We allowed the subjects to close their eyes to return brain activity to the pretask baseline and asked them not to move their muscles of facial expression during the task. Before the study, all subjects gave informed consent to participate in the research.

Total hemoglobin volume (THV) showed an extremely large increase in the frontal part of the brain of the patient with amblyopia during performance of the KWCST. The patient's average THV values of 3,000 data in 300 seconds during 5 cycles of KWCST were 0.838 ± 0.128 on the right side of the brain (Fig. 2) and 0.626 ± 0.149 on the left. In contrast, the average THV values of 30,000 data in 300 seconds during 5 cycles of KWCST in the 10 healthy volun-

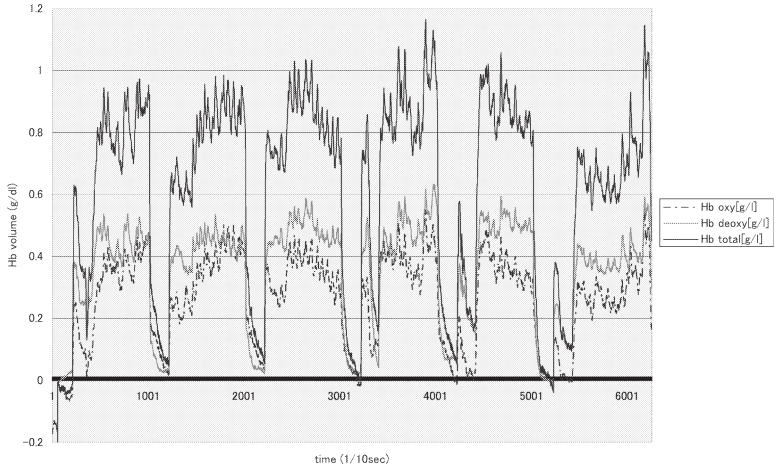

Fig. 2. Hemoglobin change in the right frontal part of the brain in a patient with amblyopia

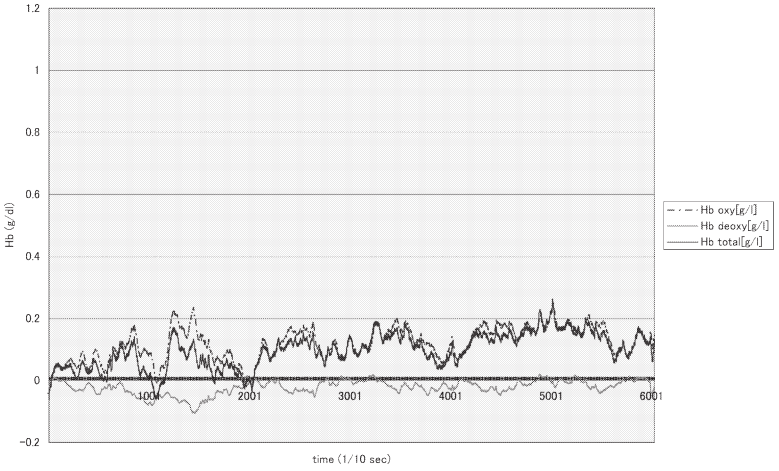

Fig. 3. Hemoglobin change in the right frontal part of the brain in a typical healthy subject

teers were 0.059 ± 0.047 on the right side of the brain and 0.031 ± 0.066 on the left. Fig. 3 shows hemoglobin changes for the right side of the brain in a typical healthy subject. The patient with amblyopia had a significantly greater increase in average THV values of 3,000 data in 300 seconds in the frontal part of the brain during 5 cycles of KWCST compared with the average THV values of 30,000 data in 300 seconds in the 10 healthy subjects (unpaired t-test ; $P < 0.01$).

The scores of KWCST of this patient was 4 in categories achieved (CA), 4 in preservative errors of Nelson (PEN), and 0 in difficulty maintaining set (DMS). These scores were slightly worse than the averages of the 10 healthy controls (CA, 5.0 ± 0.82 ; PEN, 0.4 ± 0.52 ; DMS, 1.2 ± 1.03) because of his poor acuity.

Discussion

Fallgatter et al.[3] have previously demonstrated frontal activation during the WCST assessed by 2-channel NIRS[1]. Hashimoto et al.[4,5] have suggested that NIRS can serve as an objective means of evaluating frontal lobe function during the KWCST in patients with diffuse axonal injury. However, to our knowledge, frontal lobe function in a patient with amblyopia has not previously been documented.

In our patient, the average THV in the frontal brain area during the frontal assessment battery was much greater than that in 10 healthy control subjects. The frontal activation task requiring visual cognition, attention, and executive function resulted in hyperactivation in the frontal part of the brain in the patient with amblyopia. We believe that this patient compensated for impaired visual acuity by frontal functions, such as by paying more attention or concentrating more intensely. On the other hand, we could not completely exclude the influence of activation of the frontal belly of the occipitofrontal muscle. More examinations of frontal lobe function in patients with visual disturbance, including studies with functional magnetic resonance imaging, are expected in the future.

Acknowledgments : We thank all the participants and Chunichi Denshi Co., Ltd., for their cooperation in this study.

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