Proton Magnetic Resonance Spectroscopic Changes of the Primary Motor Cortex and Supplementary Motor Area in Hemiparetic Patients with Corticospinal Tract Injury due to Deep Intracerebral Hematoma

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Purpose: To investigate the metabolic changes in the motor and motor association cortices following axonal injury in the internal capsule that was caused by deep intracerebral hematoma.

Materials and Methods: Using proton magnetic resonance spectroscopy (1H MRS), the authors studied the primary motor cortices (M-1) and supplementary motor areas (SMA) of 9 hemiparetic patients with documentable hemiparesis of varying severity, and we studied 10 normal volunteers as controls. To measure the M-1 and SMA biochemical changes, 4 separate single volumes of interest (VOIs) were located bilaterally in the affected and unaffected hemisphere (AH and UH).

Results: 1H MRS provided a neuronal and axonal viability index by measuring levels of N-acetylaspartate (NAA) and creatine/phosphocreatine (Cr). The M-1/SMA NAA/Cr ratios of the AH and UH in patients, and the AH and normal volunteers were compared. The NAA/Cr ratios of the M-1 and SMA in AH, and the SMA in UH were significantly lower than those of normal volunteers.

Conclusion: These 1H MRS findings indicate that axonal injury in the descending motor pathway at the level of internal capsule could induce metabolic changes in the higher centers of the motor pathway.

Key words: hematoma, hemiparesis, MR spectroscopy

INTRODUCTION

Early studies of 1H MRS in stroke have mostly investigated ischemic stroke, and they have shown an increased lactate and decreased NAA within the stroke lesion.[1)] However, attempts to determine whether the magnitude of neuronal damage, as measured by NAA loss, correlates with the disability and impairment in ischemic stroke patients have brought forth inconsistent results.[2)] There has been no previous 1H MRS study that has investigated the metabolic changes in the higher motor cortex following intracerebral hematoma in hemiparetic humans. The aim of this study was to evaluate the local metabolic changes for the primary motor cortex (M-1) and supplementary motor area (SMA) in the affected hemisphere (AH) and unaffected hemisphere (UH), according to their axonal injuries at the level of the internal capsule.

MATERIALS AND METHODS

The M-1/SMA of the AH and the UH were studied using 1H MRS on 9 patients (4 men/ 5 women; range 30-70 yr, right-handed) with documentable hemiparesis of varying severity. In all cases, the hemiparesis was caused by deep intracerebral hematoma in the putamen and the thalamus because these locations are directly adjacent to the internal capsule, and an intracerebral hematoma in these areas mostly brings about hemiparesis as a neurologic sequele. The 1H MRS study

was performed on alert patients with definite hemiparesis of the extremities contralateral to the AH. To control the possible 1H MRS spectral change, we excluded those patients that had undergone any surgical intervention or if they had a major systemic illness, such as uremia. The mean duration of the study was approximately 1 yr, with a range of 7 days to 1 yr after development of intracere- bral hematoma.

In vivo 1H MRS studies were performed on a 1.5 T MRI/MRS system (GE Signa Advantage, Ver. 4.8) using STEAM sequence. A 6.4 mL volume in the cortex was selected using the T2-weighted MR images. For examining the M-1 cortex with the single voxel technique, a cubic volumes of interest (VOI) of 18×18×20 mm was placed in the medial precentral gyrus (Broadman area 4) anterior to the central sulcus in both hemispheres (AH and UH), and for the SMA, the same-sized VOI was placed in the medial side of the superior frontal gyrus (Broadman area 6) just anterior to the M-1 cortex VOI. The spectral parameters used were: 20 msec TE, 2,000 msec TR, 128 averages, 2,500 Hz spectral width, and 2,048 data points.

RESULTS

The NAA/Cr ratios of M-1 in the AH and UH were 1.08±0.12, 1.50±0.17, respectively. There were significant differences between the AH and UH in the NAA/Cr ratios of M-1 ($p<0.05$). The NAA/Cr ratios of M-1 measured in the AH and controls were 1.08±0.12, 1.37±0.12, respectively. There was also significant differences between the AH and controls in the NAA/Cr ratios of M-1 ($p=0.01$). However, the NAA/Cr ratios of M-1 measured in the UH showed no differences when compared with the ratios of normal volunteers ($p=0.115$).

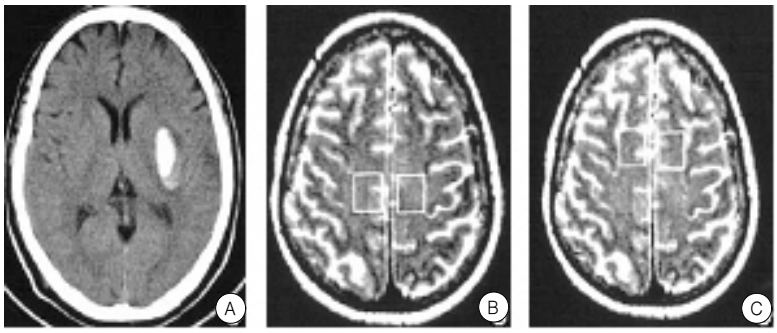

Fig. 1. Voxel site for MRS acquisition in the primary motor cortex (M-1) and supplementary motor area (SMA). (A) CT scan of a hemiparetic patient (Case 1). (B) M-1 voxel. Axial T2W showing a typical site of MRS acquisition of the M-1 cortex (rectangles). (C) SMA voxel. Axial T2W showing a typical site of MRS acquisition of the SMA cortex (rectangles).

CONCLUSION

We sought to determine whether 1H MRS is able to detect the metabolic changes of the M-1 and SMA that follow pyramidal tract injury after intracerebral hemorrhage. We found that the M-1 in the AH has lower NAA/Cr values than in the M-1 in the UH and in normal volunteers. In addition, the SMA also showed bilateral lower NAA/Cr values in both the AH and UH than in normal volunteers. Though we cannot precisely document the exact meaning of these lower NAA/Cr ratios, a presumed retrograde degeneration or functional deactivation may play a role in these NAA losses in M-1 and SMA due to motor tract injury. Further experiments should include longitudinal studies of patients with motor deficit after intracerebral hematomas, and whether there is a reversible component to this NAA loss.

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