QUANTITATIVE DIFFUSION WEIGHTED MAGNETIC RESONANCE SPECTROSCOPY OF GLIOMA AND METASTATIC TUMOR IN HUMAN BRAIN IN VIVO

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Introduction:

Diffusion weighted magnetic resonance spectroscopy (DW-MRS) is useful for evaluation of the intracellular environment [1]. Previous studies showed that the most abundant metabolites that are detected by ^{1}H-MRS are primarily located in the intracellular compartment of the brain and therefore DW-MRS offers excellent tools to specifically measure the intracellular response to cerebral injury [2]. The pathological changes in cells of glioma and metastatic tumor, the most common types of tumor in human brain, are related to the diagnosis and treatment of cerebral tumors. In this study, the apparent diffusion coefficients of brain metabolites were measured by DW-MRS on a clinical MR scanner for detecting pathological changes in cases of glioma and metastatic tumor in human brain.

Methods:

Ten glioma patients (6 males and 4 females, mean age 46±15.9 years, range 11-62 years) and six metastatic tumor patients (2 males and 4 females, mean age 70±7.6 years, range 65-84 years) were recruited for this study. Twelve age and sexual-matched health controls (4 males and 8 females, mean age 67±8.4 years, range 60-78 years) were selected for metastatic tumor patients. All the controls were free from neurological or psychiatric disease and their brain MRI scans were normal. All subjects had given their permission to be part of the study which was proved by the Investigational Review Board at our hospital. The DW-MRS sequence based on point resolved spectroscopy (PRESS) sequence technique was implemented for this study. The equipment used for the MR examinations was a 3.0T clinical whole-body system (Signa EXCITE HD; General Electric, Milwaukee, WI) with gradients with a maximum amplitude 40 mT/m and a maximum slew rate 150 mT/m/ms. Parameters for the DW-MRS sequence were as follows: TR 2000 ms, TE 144 ms, voxel size 2×2×2 cm^3 (8 mL), spectral width 5000 HZ, and data points 4096. Data were acquired at only two different b-factor values: 45 and 1050 s/mm^2. The region of interests of DW-MRS were located in 1) the lesion area of glioma patients and its opposite un-affected areas; 2) the lesion area of metastatic tumor patients and 3) the left frontal cortex of health controls (Fig. 1). Post-spectral processing was carried out by SAGE software (GE Medical Systems). Pure water subtraction was used to reduce residual water from each suppressed frame. Phase corrections were performed before the summation of FIDs. Since the integral peak area was more sensitive to the random noise [4], peak height was used to determine the signal intensity of metabolites in this study. The apparent diffusion coefficients (ADCs) value was estimated by the following equation:

$$ADC=-\ln\left[S(b_2)/S(b_1)\right]/(b_2-b_1)$$

Where S (b_1), and S (b_2) are the signal intensities for the two b-values, b_1 and b_2.

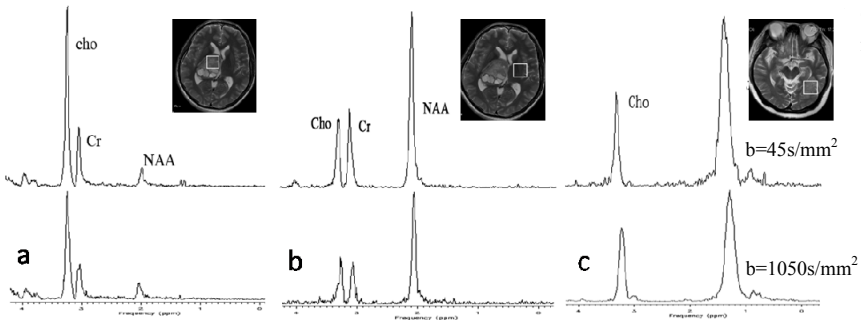

Fig.1 Brain regions of examination and spectrum: a) Volume of interest (2.0×2.0×2.0= 8cm^3) was located in the lesion area of glioma patients and spectrum was taken at low (45 s/mm^2) and high (1050 s/mm^2) b-values. b) Volume of interest (2.0×2.0×2.0= 8cm^3) was located in the opposite unaffected area of glioma patients as control and spectrum c) Volume of interest (2.0×2.0×2.0= 8cm^3) was located in the lesion area of metastatic tumor patients and spectrum.

Table 1. ADCs (mean±SD) of metabolites in the glioma patients, metastatic tumor patients and their health controls.

Subjects	n	ADC (mean±SD, ×10^{-3}mm^2/s)		
		NAA	Cr	Cho
Glioma Patients	10	0.22±0.06	0.22±0.08	0.23±0.07
Glioma Patients unaffected regions	10	0.20±0.08	0.20±0.07	0.18±0.09
Metastatic Tumor Patients	6	0.26±0.08*	0.26±0.04*	0.23±0.08
Health controls of metastatic tumor patients	12	0.17±0.09*	0.16±0.08*	0.16±0.07

Statistically significant differences relative to controls: *P <0.05,

Results:

The ADCs of three major metabolites, including choline-containing compounds (Cho), creatine (Cr), N- acetyl-aspartate (NAA), in patients and healthy controls were shown in Table 1. The ADC values of Cho and Cr obtained from glioma patients increased by 21% and 13% than those obtained from the opposite unaffected regions, respectively. No difference in ADC of NAA was found between the lesion and the unaffected region. For the metastatic tumor, the Cho ADC value in lesion regions were about 1.57 times the values found in the healthy controls. The Cr ADC values in metastatic tumor patients were 63.5% larger than the healthy controls ($p < 0.05$), and the ADC values of NAA were 57.2% larger than the healthy controls, with significant difference ($P<0.05$).

Discussion and Conclusions:

In our study, although there is no significant difference between the glioma patients and its unaffected regions, ADCs increases of Cho and Cr can be detected. These observations are somewhat in conflict with the previous results which suggested that the ADC of Cho in BT4C rat glioma was similar to that determined in health in normal rat brain [5]. We supposed that the reduction of organelles in glioma cells will extend the intracellular space leading to the increase of the ADC of Cho. However, tumor tissues are comprised of different kinds of tumor cells which contain various organelles. The ADC change of the Cho is the weighted of ADCs in different tumor cells, which result a visible but not significant increase. The increase of ADCs of metabolites in metastatic tumor is consistent with the previous results [6]. Because of the significant necrosis area in metastatic tumor, the metabolites leak into the extracellular from the neurons. Consequently, the ADC of metabolites increased. These findings give support to the pathological changes in the intracellular environment for the glioma and metastatic tumor..

References:

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