Significance of T2 Relaxation Time Correction in Quantification of Glioma Patients by Proton MR Spectroscopy. A Clinical Study

A.Matsumura , T.Isobe, I.Anno*, T.Yoshizawa , Y.Nagatomo, H.Fujimori, Y.Itai*, T.Nose

Departments of Neurosurgery and Radiology*, Institute of Clinical Medicine, University of Tsukuba, 305-8575 , Tsukuba, Ibaraki, Japan

Introduction

In previous clinical proton magnetic resonance spectroscopy (^{1}H-MRS) studies on intracranial tumors, relative evaluations of NAA/Cr, NAA/Cho and Cho/Cr ratios were frequently used which do not reflect changes of each metabolite. Quantification of each metabolites with water as internal standard has been used, however, in relatively long TE sequence, the quantification value will be remarkabely distorted if no T2 relaxation correction is applied due to T2 relaxation time changes in pathological process,

Therefore, we have performed a quantitative ^{1}H-MRS study with measurement of T2 relaxation time of metabolites in order to improve the clinical diagnostic ability by evaluating each metabolites individually and analyzed these metabolic alterations.

Materials and Methods

^{1}H-MRS was performed in 7 healthy volunteers (M:F=3:4, age 20-26 yr.) and 8 patients with intracranial glioma (4 low-grade [Grade I&II] and 4 high-grade glioma [III and IV]). ^{1}H-MRS were performed on a clinical 1.5-T superconducting MR whole body system (GYROSCAN ACSII, Philips Medical Systems) with a circulary polarized head coil using Single voxel PRESS sequence. The voxel was 2x2x2cm^3 (8ml) at parieto-occipital lobe in healthy subjects and 8-27ml at the lesion in patients with gliomas. Number of signal averaged were 128 in metabolites and 16 in tissue water. For calculation of relaxation time , measurement conditions were as follow:

T1 relaxation time; TR of 1500, 2000, 3000, 6000 and 8000ms with TE of 136 ms.

T2 relaxation time; TR of 2000 ms with TE of 68,136 and 272 ms.

T1 and T2 relaxation time of metabolites and water were calculated by fitting to the curve of the spin echo sequence using the folowing equation :

$$M_S = M_\infty \times \{ 1 + \exp (- TR / T1) - 2 \times \exp [- (TR - \tau) / T1] \}$$

$$M_S = M_0 \times \{ \exp (- 2 \tau / T2) \}$$

Spectra aquired with TR of 2000 ms and TE of 136 ms were used in calculations of metabolite concentration. Tissue water concentration of 64.6% (35mmol/kg wet weight) was used as an internal reference.

RESULTS AND DISCUSSIONS

1. RELAXATION TIME

Table 1 reveals relaxation time values of normal subjects and glioma patients. T2 relaxation time of NAA was shortened to 46% in high-grade glioma and 55% in low-grade glioma compared to normal subjects (p<0.001). T2 of Cr was also shortened in high-grade glioma (87%; p<0.05) and low-grade glioma (81%; p<0.01) than volunteers. That of Cho was shortend in high-grade glioma (72%; p<0.01), but no significant difference in low-grade glioma. T2 relaxation time of Cho in high-grade glioma showed also a significant shortening (p<0.01) compared to low-grade glioma. T2 relaxation times of tissue water in both high-grade and low-grade gliomas were twice as long as normal subjects (p<0.001).

There is a report that T2 of metabolites is shortened in edematous brain (1). Other report of Usenius et.al (2) did not revealed significant T2 relaxation time changes. Although details are yet unclear, various factors, such as change in ratio of extracellular and intracellular spaces, effect of cellular osmotic pressure, change in cellular form, cellular energy metabolism, blood flow, temperature, are suggested as contributing factors and further basic study is required to explain this phenomenon. Magnetic susceptability within the VOI may also be a factor.

Table 1

Diagnosis	NAA	Cr	Cho	tissue water
T1 (ms)				
normal volunteer(n=7)	1433.5±102.5	1471.6±106.9	1450.9±129.8	1134.6±57.9
T2 (ms)				
normal volunteer (n=7)	368.8±22.5	205.3±9.6	265.4±17.7	88.6±4.5
low grade glioma (n=4)	201.2±34.7^c	167.1±20.2^b	273.0±19.2	174.2±22.7^c
high grade glioma (n=4)	170.5±11.7^c	180.0±25.7^a	191.2±22.2^b	220.9±39.2^c

Values are means±SD.

Significance between normal volunteer: $^a p < 0.05$ $^b p < 0.01$ $^c p < 0.001$

2. METABOLITE CONCENTRATIONS (Table 2)

Compared to normal subjects, NAA were reduced in high-grade glioma (44%; p<0.001) and low-grade glioma (43%; p<0.001). The decrease in NAA may be caused by relative increase of glia cells which do not contain NAA. The degree of invasiviness may be evaluated by the amount of NAA decrease. Cr were also reduced in high-grade glioma (57%; p<0.001) and low-grade glioma (78%; p<0.001). High-grade glioma revealed a significant decrease (p<0.01) of Cr compared to low-grade glioma. This may reflect the higher proliferation activity and increased energy metabolism according to the malignancy. Cho was increased in high-grade glioma (130%; p<0.05) and low-grade glioma (160%; p<0.05). The increase in choline seems to be not correlated with malignancy. This is also supported by the increase of Cho in benign tumor such as meningioma (data not shown).

Table 2

Diagnosis	NAA	Cr	Cho
normal volunteer (n = 7)	10.78±0.40	7.73±0.40	2.10±0.13
low grade glioma (n = 4)	4.61±1.00^c	6.00±0.28^c	3.39±0.86^a
high grade glioma (n = 4)	4.71±0.85^c	4.40±0.54^c	2.74±0.58^a

Values are means±SD.

Difference compared to Normal volunteer $^a p < 0.05$ $^b p < 0.01$ $^c p < 0.001$

As conclusions, T2 relaxation time of the metabolites itself had some remarkable differences compared to normal subjects and moreover quantification with T2 correction revealed an individual indicator of the metabolites (2). The degree of malignancy and response to various therapy may be evaluated more precisely by using the present method.

REFERENCES

1) Kamada K, Houkin K, HIda K et al., MRM 31, 537-540, 1994

2)Usenius JPR,Kauppinen RA,Vainio PA, et.al., J Comput Assist Tomogr, 18, 705- 713, 1994