Detection of Metabolic Status by In Vivo $^1$H proton Magnetic Resonance Spectroscopy in Patients with Brain Tumors

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Nuclear magnetic resonance (NMR) has been used to detect the chemicals earlier before the clinical application of magnetic resonance imaging (MRI). Since late 1980s, magnetic resonance spectroscopy (MRS) became popular with the advancement of MRI. Previous studies on in vitro NMR and in vivo MRS elucidate the effectiveness of its clinical application in different areas. We performed this study, which combines MRI and in vivo MRS, to evaluate the metabolic status of different brain tumors.

We prospectively evaluated the patients with brain tumor by Single-Voxel Proton Brain Spectroscopy Exam (PROBE / SV) in 2000 and 2001. Eight glioblastoma multiformes, 5 astrocytomas, 3 meningiomas, 4 lung carcinomas with brain metastases, and 15 normal brains as the control group were included in this study. The spectra of metabolite peaks of the N-acetylaspartate (NAA), Creatine (Cr) and Choline (Cho) of the brain tumors were evaluated and compared with that of the control group.

As compared with the control group, the quantitative peak ratio of NAA/Cho was significantly decreased in lesions of glioblastoma, astrocytoma, meningioma, and metastasis. The NAA/Cr and Cr/Cho peak ratios were also significantly decreased in glioblastoma and astrocytoma; on the contrary, the Cho/Cr peak ratio was increased. In patients with carcinoma of lung with brain metastasis, the NAA/Cho was significantly higher than the glioblastoma.

When a focal mass lesion was detected on MRI, and the spectroscopy showed marked decrease of NAA/Cho, NAA/Cr and Cr/Cho ratios, either astrocytoma or glioblastoma should be highly considered. If the mass lesion showed higher NAA/Cho peak ratio, and the patient already had a primary malignancy, metastasis was the most likely diagnosis as compared with glioblastoma, astrocytoma and meningioma.

Key words: Brain Tumor; In Vivo Proton Spectroscopy, Magnetic Resonance Imaging; Magnetic Resonance Spectroscopy; Metabolite

Nuclear magnetic resonance (NMR) has been used for the detection of chemicals since 1950 and has been applied extensively for studying the metabolites in isolated tissue and organ since 1970. Many diseases could be accurately diagnosed with the aid of NMR spectrum [1,2,3,4]. In the late 1980s, medical magnetic resonance spectroscopy (MRS), which refers the original information of magnetic resonance imaging (MRI), became more important in medical application. MRS offers spectrum of tissues of interest and allows medical specialists to analyze the nature of the lesion from the metabolites of abnormal or diseased structures. MRS allows the physicians to direct their routine
clinical diagnoses that were previously unobtainable by other radiological or clinical tests [5].

The results of previous studies on NMR spectroscopic behaviors on hepatocellular carcinoma [6,7] fatty liver, liver cirrhosis, as well as cerebrospinal fluid (CSF) [8] indicated that many metabolites are useful in disease diagnosis, and the most exciting potentials are to follow the efficacy of tumor treatment by monitoring the size and metabolites of tumor mass, the hypoxic status and/or improvement after ischemic change or stroke. In recent years, there are great improvements in the diagnostic imaging. Computed tomography (CT) and magnetic resonance imaging (MRI) have solved most of the problems in diagnosis, however, in some cases the differentiation of the disease entities is still difficult. The addition of complementary physiological and biochemical data will further advance the judgment. While neither in vivo morphological imaging with CT or MRI nor physiological imaging with PET is advantageous for diagnosis in special occasions [9], MRS can provide the resolution of cellular process, including energy metabolism and membrane turnover [1]. Such information could have a significant impact on patient management and prognostic evaluation by reducing the diagnostic differentiations [10, 11].

According to the previous investigations, many diseases and clinical presentations of central nervous system are obviously benefited by MRS [12]. Not only the elderly dementia [13,14], congenital anomaly or abnormal development and trauma in the children [15,16,17] can be correctly diagnosed or differentiated, but the clinical condition of patients can also be effectively assessed by MRS [18]. In vivo $^1$H-MRS might provide clinically useful information about tumor metabolism and aid in the differential diagnosis of tumors [19], and assessment of human brain tumor grades [20]. $^1$H-MRS might provide clinically useful information on tumor malignancy and characteristic metabolism. Therefore, we performed this study to evaluate the metabolic status of different brain tumors for assessing the possibility of differentiating of brain tumor and aiding in clinical diagnosis.

**METHODS AND MATERIALS**

**Patient and subjects**

We prospectively evaluated patients with brain tumors by Single-Voxel Proton Brain Spectroscopy Exam (PROBE/SV) in 2000 and 2001. There were 20 brain tumor patients (11 males, 9 females, mean age 51.7 years) included in this study, which were pathologically diagnosed as glioblastoma multiforme (GBM) in 8, astrocytoma in 5, meningioma in 3, and carcinoma of lung with brain metastasis in 4 patients. Fifteen normal controls (2 males and 13 females, mean age 26.3 years) were collected for comparison. In order to obtain a better spectrum, we included only the lesions exceeding 3 cm in diameter to cover the volume of interest (VOI) during MR spectroscopy. The lesions adjacent to the skull or sinuses were excluded from the study to avoid possible shimming problems and scalp fat signals contamination. All patients were examined by PROBE/SV software package before surgery, irradiation, or chemotherapy. No sedation was prescribed except the premedicated chloral hydrate for a 3-year-old girl.

**Imaging and PROBE acquisition**

A 1.5-T whole body MR system (Signa Horizon Lx, General Electric, Milwaukee, WI) equipped with shielded gradient and a quadrature head coil was applied for imaging and spectroscopy. Before spectroscopy, a clinical protocol that included spin-echo T1-weighted imaging, T2-weighted imaging and fluid-attenuated inversion recovery (FLAIR) imaging pulse sequences was performed for conventional MR images. Intravenous gadopentetate dimeglumine (Magnevist; Schering, Berlin, Germany) was administered at a dosage of 0.2 mmol/kg in all patients after the PROBE/SV study. We used either T2-weighted or FLAIR MR imaging to guide the localized VOI for spectroscopic study. The selection of voxel size and position was determined by examining the MR images in all three anatomical dimensions (the sagittal, coronal, and axial planes). In the normal controls, the VOI was randomly selected either at the right or left basal ganglion area (Fig 1). The VOI was selected at the most solid part of tumor in patient group.

A Point-Resolved Spectroscopy (PRESS) was applied with the following protocol: TR/TE (repetition time/echo time), 1500/144,288; voxel, 2 x 2 x 2 cm (the size of average VOI is approximately 8 cm$^3$); phase cycle, 2; spectral bandwidth, 2500 (±1250) Hz; total number of scan, 128. The peak ratios of metabolites were based on the data obtained from PRESS with a TE (echo time) of 144 msec. Only in a few occasion, we used a long TE sequence to differentiate or characterize the mass lesion.

**Data analysis**

Two neuroradiologists (WH Chen, CC Chen) and MRI specialists (JW Chai, KR Lee) evaluated the quality of all of the spectra first, which included the noise, water suppression or contamination by the
nearby tissues. Then, the assignment of individual metabolite peak was carefully checked. The ratios on different peaks were automatically calculated by the software package supplied by the manufacturer. A Student’s t-test was employed to compare the different metabolites peak ratios between brain tumors and normal controls. A p-value of less than 0.05 was considered to be significant.

RESULTS

Generally, the major metabolite peaks assigned from the $^1$H proton spectrum were N-acetyl aspartate (NAA), Creatine (Cr) and Choline (Cho) located at 2.0, 3.0 and 3.2 ppm, respectively (Fig. 1). The peak ratios of NAA/Cho, NAA/Cr, Cr/Cho and Cho/Cr of all of the measurable data were calculated in the Table 1 to Table 5. In the normal controls, the NAA peak is higher than those of Choline and Creatine (NAA/Cho: 1.76 ± 0.3; NAA/Cr: 1.80 ± 0.24). The Choline peak is nearly the same as Creatine (Cr/Cho: 0.98 ± 0.09; Cho/Cr: 1.03 ± 0.12) (table 1).

Four patients were excluded when calculating the quantitative peak ratios due to unavailable data from noise or inadequate location of VOI to cover the tumor location. The metabolite peak ratios of 15 normal brains (Fig. 1), 6 GBM (Fig. 2), 4 astrocytomas (Fig. 3), 3 meningiomas (Fig. 4) and 3 metastases (Fig. 5) were calculated (Table 6). NAA/Cho was significantly reduced in GBM, astrocytoma, meningioma and metastasis when compared with the normal controls. (Fig. 2 and 3) Among those brain tumors, the NAA/Cho was significant different between GBM and metastasis (Fig. 6). NAA/Cr and Cr/Cho were significantly reduced in GBM and astrocytoma, and Cr/Cho was also statistically significantly reduced only in metastasis when compared with the normal control group (Fig. 7). Cho/Cr was increased in all of the 4 tumor groups, but it was statistically significant in GBM and metastasis when compared with normal controls.

Table 1. $^1$H proton metabolite peak ratios of normal controls

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Sex</th>
<th>Age</th>
<th>NAA/Cho</th>
<th>NAA/Cr</th>
<th>Cr/Cho</th>
<th>Cho/Cr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>19</td>
<td>1.34</td>
<td>1.33</td>
<td>1</td>
<td>0.90</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>28</td>
<td>1.78</td>
<td>1.80</td>
<td>1.07</td>
<td>0.96</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>33</td>
<td>2.33</td>
<td>2.17</td>
<td>0.71</td>
<td>1.40</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>36</td>
<td>1.24</td>
<td>1.72</td>
<td>1.04</td>
<td>0.96</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>3</td>
<td>1.49</td>
<td>1.68</td>
<td>0.88</td>
<td>1.13</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>28</td>
<td>1.68</td>
<td>1.63</td>
<td>0.97</td>
<td>1.04</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>21</td>
<td>1.68</td>
<td>1.73</td>
<td>1.03</td>
<td>0.96</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>20</td>
<td>2.31</td>
<td>2.24</td>
<td>1.03</td>
<td>0.98</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>11</td>
<td>2</td>
<td>2.16</td>
<td>1.03</td>
<td>0.98</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>36</td>
<td>1.92</td>
<td>2</td>
<td>0.96</td>
<td>1.04</td>
</tr>
<tr>
<td>11</td>
<td>F</td>
<td>30</td>
<td>1.74</td>
<td>1.71</td>
<td>1.03</td>
<td>0.97</td>
</tr>
<tr>
<td>12</td>
<td>F</td>
<td>35</td>
<td>1.72</td>
<td>1.93</td>
<td>0.89</td>
<td>1.12</td>
</tr>
<tr>
<td>13</td>
<td>F</td>
<td>23</td>
<td>1.77</td>
<td>1.71</td>
<td>1.02</td>
<td>0.98</td>
</tr>
<tr>
<td>14</td>
<td>F</td>
<td>37</td>
<td>1.59</td>
<td>1.55</td>
<td>1.03</td>
<td>0.97</td>
</tr>
<tr>
<td>15</td>
<td>F</td>
<td>30</td>
<td>1.74</td>
<td>1.92</td>
<td>0.92</td>
<td>1.10</td>
</tr>
</tbody>
</table>

Mean ± SD 26.3 ± 11.7 1.76 ± 0.30 1.80 ± 0.24 0.98 ± 0.09 1.03 ± 0.12

Abbreviations: NAA: N-acetyl aspartate, Cr: Creatine, Cho: Choline

Figure 1. Normal control. a. T2 weighted MRI (Matrix 320x224, TR/TE/NEX 4000/90/3) of normal brain. b. The normal spectra at left basal ganglia with major peaks of NAA, Cr, Cho at locations of 2.0, 3.0 and 3.2 chemical shift/ppm respectively.
Figure 2. Glioblastoma. a. T2 weighted MRI (Matrix 320x224, TR/TE/NEX 4000/90/3) showed a tumor mass at left insular cortex and subcortical white matter. b. The spectrum at tumor location showed reduced NAA peak and increased Choline peak. Obvious doublet lactate (Lac) peak is observed at 1.33 ppm chemical shift region.

Figure 3. Astrocytoma. a. T2 weighted MRI (Matrix 320x224, TR/TE/NEX 4000/90/3) showed a tumor mass with central necrosis at left F-P cortical-subcortical region. b. The spectrum obtained from VOI covered peripheral tumor and small portion of central necrotic area showed reduced NAA peak and increased Choline peak. Obvious doublet lactate (Lac) peak is observed at 1.33 ppm chemical shift region.

Figure 4. Meningioma. a. Fluid-attenuated inversion recovery image (Matrix 256x129, TR/TE/TI/NEX 10000/105/2200/2) showed an extra-parenchymal tumor at right F-P region. b. Spectrum with VOI covering the tumor showed nearly total loss of NAA and markedly increased the Choline peak.
In meningiomas, the NAA/Cho and NAA/Cr looked to be reduced when compared with the normal controls, but it was statistically significant only in the former ratio. A big variation on the spectra was observed, which might be attributed to less case collected in this study (Table 4). One of the meningioma case showed a tumor mass located at skull base with spectrum contamination, and it was hard to obtain a good spectra.

The 4 cases of carcinoma of lung with brain metastasis showed reduced NAA/Cho peak ratio with significant alteration of Cr/Cho and Cho/Cr ratios when compared with the normal controls. A significant difference of the NAA/Cho peak ratio was observed between metastasis and GBM (Table 6).

## DISCUSSION

In the diagnosis of brain tumors, an excellent anatomical localization of tumors can be readily obtained by MRI, and MRS may provide additional information in cases in which the differential diagnosis of tumors by neuro-imaging is difficult [21,22]. A high quality and good resolution spectrum is indicated for the correct assignment and reading of the metabolites of human tissue. Not all the MRI/MRS functions
Table 7. The difference of metabolite peak ratios of normal controls and brain tumors (data adopted from reference 27)

<table>
<thead>
<tr>
<th>Histology</th>
<th>No.</th>
<th>NAA/Cho</th>
<th>NAA/Cr</th>
<th>Cr/Cho</th>
<th>Cho/Cr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>3</td>
<td>1.76 ± 0.30</td>
<td>1.80 ± 0.24</td>
<td>0.98 ± 0.09</td>
<td>1.03 ± 0.12</td>
</tr>
<tr>
<td>Glioblastoma</td>
<td>5</td>
<td>0.26 ± 0.08</td>
<td>0.54 ± 0.16</td>
<td>0.49 ± 0.16</td>
<td>2.21 ± 0.56</td>
</tr>
<tr>
<td>Astrocytoma</td>
<td>4</td>
<td>0.47 ± 0.19</td>
<td>1.10 ± 0.38</td>
<td>0.52 ± 0.23</td>
<td>2.24 ± 1.05</td>
</tr>
<tr>
<td>Meningioma</td>
<td>3</td>
<td>0.45 ± 0.58</td>
<td>1.14 ± 0.43</td>
<td>0.47 ± 0.41</td>
<td>3.47 ± 3.07</td>
</tr>
<tr>
<td>Metastasis</td>
<td>3</td>
<td>0.83 ± 0.33</td>
<td>1.65 ± 0.70</td>
<td>0.53 ± 0.12</td>
<td>1.95 ± 0.51</td>
</tr>
</tbody>
</table>

vs. Normal (\(^*P<0.05\)), Glioblastoma vs. carcinoma of lung with brain Metastasis (\(^*P<0.05\))

\(^1\) Only 5 cases available for NAA/Cho and NAA/Cr study
\(^2\) Only 3 cases available for NAA/Cr, Cr/Cho and Cho/Cr study
\(^3\) Only 2 cases available for NAA/Cr, Cr/Cho and Cho/Cr study

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<table>
<thead>
<tr>
<th>Histology</th>
<th>No.</th>
<th>NAA/Cho</th>
<th>NAA/Cr</th>
<th>Cr/Cho</th>
<th>Cho/Cr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>15</td>
<td>1.76 ± 0.30</td>
<td>1.80 ± 0.24</td>
<td>0.98 ± 0.09</td>
<td>1.03 ± 0.12</td>
</tr>
<tr>
<td>Glioblastoma</td>
<td>6</td>
<td>0.26 ± 0.08</td>
<td>0.54 ± 0.16</td>
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<td>Astrocytoma</td>
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</tr>
</tbody>
</table>

vs. Normal (\(^*P<0.05\)), Glioblastoma vs. carcinoma of lung with brain Metastasis (\(^*P<0.05\))

\(^1\) Only 5 cases available for NAA/Cho and NAA/Cr study
\(^2\) Only 3 cases available for NAA/Cr, Cr/Cho and Cho/Cr study
\(^3\) Only 2 cases available for NAA/Cr, Cr/Cho and Cho/Cr study

Figure 5. Carcinoma of lung with brain metastasis. a. T2 weighted MRI (Matrix 320x224, TR/TE/NEX 4000/90/3) showed a small nodular lesion in left temporal-occipital cortex with perifocal edema. b. The spectrum obtained from VOI covering whole tumor and small portion of edema also showed decreased NAA and increased Choline peak.

Figure 6. Scattergram of NAA/Cho on the vertical axis and Cr/Cho on the horizontal axis. Normal controls are found in the upper right hand corner, malignant brain tumors are in the lower left hand corner, especially glioblastoma (GBM).

Figure 7. Scattergram of NAA/Cr on the vertical axis and Cr/Cho on the horizontal axis. Normal controls are found in the upper left hand corner, malignant brain tumors are in the lower right hand corner, especially glioblastoma (GBM).
are perfect and ready to use in commercial market, and most MRI/MRS scanners are not able to eliminate the water signal at 4.75 ppm. In order to eliminate unwanted water signal, the pre-saturation power needs to be increased such that it wipes out all the absorption near water from 4 to 6 ppm. This wipeout process also produces huge baseline distortion for almost the entire spectral range. Thus the integration under each resonance signal presents huge uncertainty. Another difficulty is that heterogeneous voxel presents a very difficult area to record the spectrum. This usually includes area that contains bone, cartilage, water, tumor mass, and/or air/fluid interface. This is why MRS is less popular over the past years although it reveals much valuable metabolic information. In this study, we had the same problems; even the noises are not avoidable within the VOI, which is the reason why 4 cases were excluded for the peak ratios study. Another drawback is non-technical. In order to record MRS, patients need fully cooperation. Minor movement is not permitted and longer scan time is required. Knowing all these obstacles, MRS presents a great challenge to most radiologists. Underlying this challenge, there are still much more to explore for a better understanding of disease status.

The following brain metabolites are observed with $^1$H MRS, including lactate, N-acetylaspartate (NAA) and N-acetylaspartylglutamate (NAAG), glutamine (Gln), glutamate (Glu), $\gamma$-aminobutyric acid (GABA), creatine and phosphocreatine (Cr), choline containing compounds (Cho), taurine (Tau), and inositol (Ins). Generally, three major signals of NAA (2.0 ppm), Cr (3.0 ppm), and Cho (3.2 ppm) can be obtained with high reliability at long-echo time, and relative ratios among these peaks are evaluated. Recently, many significant improvements in the quality of $^1$H MR spectra have been developed and marketed by the different manufacturers, which allow quantification of in vivo absolute metabolite concentrations. However, quantification of the absolute concentration does have problems such as the overlapping of resonance lines and line broadening due to eddy current, poor field homogeneity, and incomplete water suppression pulse, particularly at short echo time [23]. Therefore, we applied the ratio of NAA/Cho, NAA/Cr, Cr/Cho and Cho/Cr as a substitute for quantitative measurement of the brain metabolites. There are some investigators used the peak of Cr only, because Cr resonance is considered to be more stable than the peak of NAA or Cho [23,24]. However, it is reduced in the brain of patients with brain tumor or infectious brain masses [24], so that we applied the ratio of Cr and Cho as a reference.

The quantitative metabolites ratios of healthy adult brain detected by $^1$H proton MRS are variable at different locations, some reports to be 30% larger in the white matter [25]. Significant variations may however be seen if the age differs, and the greatest changes are seen during the first year of life. These changes mainly reflect myelination in the brain [25]. In this study, we selected 15 normal controls with the metabolites ratios measured at the basal ganglion region (Fig. 1), which corresponded to the location of most brain tumor cases in this study.

NAA is found in the central nervous system and equated with neuronal (or axonal) damage. A reduction of the NAA peak in MRS is considered to reflect the loss or dysfunction of neurons [24]. Cr is an extremely reliable marker of intact brain “energy metabolism”. A decrease in Cr indicates an energy deficit. The myelinating brain for the biosynthesis of its phospholipids utilizes choline, and the change in Cho marks membrane changes [23]. In the brain tumor, NAA is decreased, Creatine plus phosphocreatine is decreased, and Cho is increased [26]. This increase in Choline is readily recognized in $^1$H spectra, as an increase in the ratio Cho/Cr [23]. In this study, we had the same findings on the GBM, astrocytoma and metastasis (Table 6). A significant difference between the NAA/Cr and Cho/Cr ratios for low grade and high-grade gliomas was reported in the literatures [20], but was not present in this study (Table 6) and other report (Table 7) [27]. Previous report data revealed decreased NAA/Cho, NAA/Cr and Cr/Cho in GBM and astrocytoma, which were also presented in our study (Table 6,7) [27]. All brain tumors contain significantly lower NAA and higher Cho [26]. Figure 6 and 7 illustrates a good separation between malignant brain tumors (glioblastoma, astrocytoma and metastasis) and normal controls. A significant difference was observed between meningioma and glioblastoma with lower Cr/Cho and higher Cho/Cr in one of the previous report (Table 7) [27], which were also seen in one of our meningioma case (Table 4).

According to the literatures, beside lower or absent NAA, lowered Cr and elevated Cho are presented in brain tumors; notable or excess lactate and lipid are also noted [28]. We had observed lactate peak in cases of low grade (astrocytoma) and high grade (GBM) gliomas (Fig. 2,3). The inverted doublet shape at 1.3 ppm is due to the employed pulse sequence with a TE of 144 msec. A previous report revealed no reliable connection between lactate level and tumor grade [20]. Increased lactate may indicate increased anaerobic glycolysis as in ischemic and hypoxic condition due to tumor-specific metabolism.
or inadequate tumor perfusion [23,24].

There is one study described that a definite intratumoral Cr signal strongly suggest the diagnosis of glioma and absence of Cr may indicate the diagnosis of metastasis. In 4 of the 25 metastases with Cr detected, the NAA/Cr is 1.58 ± 0.56, which is higher than that of GBM (0.76 ± 0.40) and glioma (0.74 ± 0.33) [29]. In this study, as well as one of the reference [27], the metastasis also showed higher NAA/Cho when compared with GBM (Table 6,7).

The application of MR spectroscopy to brain tumor is not only indicated for the differential diagnosis of any focal or space occupying lesions, presurgical planning, post radiation necrosis, residual viable tumor or recurrence, but also for guiding surgical biopsies and focal therapy [26, 30]. In some condition, too large of the voxel size combined with too small of the tumor size and location of tumor near the skull base or CSF space will make an unreliable spectrum. This might be solved in the future by the multi-voxel MRS. We should recognize that if MR spectroscopy simply to be added on to the MRI or if a special MR spectroscopy examination is executed. The brain lesion could be more specifically diagnosed.

CONCLUSION

In the brain tumors, NAA metabolite is invariably decreased and Choline is often increased. When a brain tumor showed markedly reducing NAA/Cho ratio with decreasing of NAA/Cr and Cr/Cho ratios, either astrocytoma or glioblastoma should be highly considered. If the mass lesion showed higher NAA/Cho peak ratio, but patient already had a primary malignancy, then metastasis was most likely to be suggested between the glioblastoma, astrocytoma and meningioma. Although the spectrum cannot provide us a good tool to differentiate or characterize among different species of brain tumors, the characteristic change of the metabolites peaks might be advantageous for differentiating brain tumor from other brain diseases.

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REFERENCES


使用活體氫質子磁振頻譜分析術偵測腦內腫瘤
病人的代謝狀況

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核磁共振（NMR）頻譜分析早在臨床使用磁振造影（MRI）以前就被用來偵測各種化學物質。自從1980年代晚期以來，磁振造影頻譜分析術（MRS）已經由MRI發展而趨普遍。先前在標本NMR與活體MRS所做的研究與累積的經驗，證實了在人體不同範圍的臨床使用功效。我們做此項合併MRI與活體MRS研究的目的在評估不同腦內腫瘤的代謝狀況。

我們前瞻性地以Single-Voxel Proton Brain Spectroscopy Exam（PROBE／SV）來評估本院在2000年及2001年間的所有顱內腫瘤病人。一共有8位多形神經膠母細胞瘤、5位星狀細胞瘤、3位腦膜瘤、4位肺癌合併顱內轉移以及15位正常對照者收在此一研究中。我們評估了顱內腫瘤的N-acetylaspartate（NAA）、Creatine（Cr）和Choline（Cho）等代謝物尖峰的頻譜並和正常對照者比較。

與正常受試者比較，NAA/Cho的定量尖峰比在多形神經膠母細胞瘤、星狀細胞瘤、腦膜瘤
與顱內轉移病人皆呈現明顯的降低。而NAA/Cr及Cr/Cho尖峰比亦在神經膠母細胞瘤與星狀細胞瘤明顯降低，但是Cho/Cr尖峰卻是昇高的。在肺癌顱內轉移的病患，其NAA/Cho明顯的較
多形神經膠母細胞瘤為高。

當磁振造影檢查在顱內偵測到局部腫塊病灶時，若頻譜分析術發現NAA/Cho比明顯的降低，以及NAA/Cr及Cr/Cho比亦為降低時，多形神經膠母細胞瘤或是星狀細胞瘤腫瘤必須要高度懷疑。如果此一腫塊呈現較高的NAA/Cho尖峰比，同時病患已知有其他的原發惡性腫瘤時，在多形神經膠母細胞瘤、星狀細胞瘤與腦膜瘤中必須要懷疑到顱內轉移。雖然頻譜不是鑑別顱
內腫瘤的良好工具，但由代謝物尖峰的特別變化，對於與其它顱內疾病的區別，仍然很有幫助。

關鍵詞：顱內腫瘤、活體質子頻譜分析術、磁振造影、磁振頻譜分析、代謝物