T1 and T2 Proton Nuclear Magnetic Resonance (N.M.R.) relaxation times in vitro and human intracranial tumours
Results from 98 patients

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Summary

137 samples of intracranial tumours have been studied in proton NMR spectroscopy. T1 and T2 relaxation times are above those of normal grey and white matter. Differential diagnosis between benign and malignant brain tumours does not seem feasible upon proton T1 and T2 alone. Histological correlations allowed us to specify secondary changes accounting for T1 and T2 variations (oedema, microcyst, stroma reaction, necrosis).

Introduction

The different pulse sequences used in Proton Magnetic Resonance Imaging (MRI) (inversion-recovery IR, saturation-recovery SR, spin-echo SE) produce images linked, in a preferential manner, to one or several parameters: spin lattice T1, or spin spin T2 relaxation times, spin density ρ.

It appears therefore necessary to know the physiological or physiopathological significance of the T1, T2, and ρ values for a diagnosis taking into account all the informations supplied by MRI.

MRI tomography of the brain has already supplied numerous results (1-10). The first 'NMR scan' of the human brain was presented by the Wolfson Foundation on May 1979, in 1980 the possibility of multiplanar scans and the first study of intracerebral lesions (3) was published. As early as 1981: the remarkable distinction between the grey-cortical and the white hemispheric matter (4) and the distinction between tumour development and perilesional oedema (5) was established.

Since then, the contribution of M.R.I. Imaging has been considerable – (6-10) but biological interpretation of the images obtained still remains difficult and fragmentary. This accounts for the interest, confirmed by several publications (11, 12), of studies in vitro of human tumour samples aimed at establishing the precise correlations between the histology and the variations of relaxation times: oedema necrosis and inflammation have thus been extensively studied (13, 14, 15, 16, 17).

Our study of intracerebral surgical resections of human tumours is in order:
– to identify the histological criteria accounting for the changes in proton relaxation times.
– to study, on the basis of the values of relaxation times, the criteria of discrimination between the different histological types and the various degrees of malignancy.
– to determine the type of images (T1, T2) and therefore the type of pulse sequences able to provide the most pertinent information concerning intracerebral tumour lesions in M.R.I.

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Table 1. Histological distribution.

<table>
<thead>
<tr>
<th>Material</th>
<th>Gliomas II</th>
<th>Gliomas III</th>
<th>Glioblastomas</th>
<th>Medulloblastomas</th>
<th>Meningiomas</th>
<th>Metastases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers of patients: 98</td>
<td>11</td>
<td>23</td>
<td>11</td>
<td>5</td>
<td>36</td>
<td>12</td>
</tr>
<tr>
<td>Number of samples: 137</td>
<td>15</td>
<td>31</td>
<td>14</td>
<td>10</td>
<td>51</td>
<td>16</td>
</tr>
</tbody>
</table>

Material

137 samples from 98 patients were studied: 50 neuroepithelial tumours, 36 meningiomas, 12 metastases from visceral tumours (see Table 1).

The sub-groups of the different histological types of neuro-epithelial tumours were established according to the criteria of the WHO (1979).

Methods

Measurements were made using a Bruker spectrometer PC 20, at 20 MHz and 22°C in the two hours following the resection, and the sample was kept at 4°C during the waiting period.

The T1 relaxation time had been measured by the 180°–π–90° sequence: in the case of a non-exponential decrement, the calculated T1 value corresponds to a mean T1 value.

The T2 was obtained by the Meiboom–Gill– Carr–Purcell method.

Each sample weighed about 100 mg; each measure was repeated twice. When the volume of the resection made it possible, several samples (from 1 to 3) were studied.

After taking NMR measurements, the samples were kept in a 10% buffered formaldehyde solution for histological processing.

Results

Global results

Relaxation times obtained from samples of normal cerebral parenchyma

To evaluate a reference value for the relaxation times in normal cerebral tissue in our measuring conditions, we studied samples of normal cerebral matter collected during cortectomies.

The average of the T1 of the grey matter samples is 537 ms and that of the T2 is 110 ms: as for the white matter, the T1 is 294 ms and the T2 is 106 ms. (Table 2)

Using this data, we established an arbitrary average from a mixed sample of white and grey matter of which the T1 would be 415 ms and the T2, 108 ms. These times are shown on the tables 3 and 4.

Relaxation times obtained from samples of tumours

Our global results are summarized in Table 3 for the T1 and in Table 4 for the T2.

It is clear that all intracerebral tumours, heedless of their histology have T1 and T2 relaxation times higher than those of the normal parenchyma samples. This accounts for the ability to see lesions using NMR imaging.

The second point which obviously comes to light is the difference between neuroepithelial tumours and intracerebral tumours of other origins: metastases and meningiomas have a tendency to form groups within confined limits and most of them under 800 ms for the T1 and 150 ms for the T2; on the contrary neuroepithelial tumours present large variations of T1 and T2 relaxation times in the same histological group.

In table 5, a correlative study of T1 and T2 relaxa-