Multixeponential T2 Relaxation Analysis of Multislice MR Images in a Stroke Model

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Introduction

The T_2 relaxation within brain tissues may not be a monoexponential function, particularly in brain regions such as white matter or in diseased or injured brain (1-4). Considering that there are changes in tissue hydration state, cellular compartmentation, chemical composition and the susceptibility of the brain to hypoxia-ischemia (HI), it is possible that the T_2 decay after cerebral HI might be affected and provide additional insight into injury processes within the tissue. The standard MRI method for these measurements is the application of non-selective 90º and 180º selective pulses. Because only one pulse is slice selective this approach reduces some of the imperfections in the slice profile that may influence the data analysis. However because this method does not allow for multislice imaging, applications of multicomponent T_2 analysis are currently limited to research studies. In the present study, the effect of stroke on the biexponential nature of the T_2 relaxation was investigated using two different multislice selective pulses - Gauss and sinc.

Material and Methods

Wistar rats were anesthetized with isoflurane during exposure and isolation of the right distal middle cerebral artery (MCA). The MCA as well as both common carotid arteries were then occluded for 60 minutes after which flow was reestablished and the animal recovered. Forty eight hrs later animals were reanesthetized and the head was positioned in a 3 cm diameter quadrature volume coil. MR images were collected using a 9.4T magnet (Magnex, UK) equipped with an Avance console (Bruker, Germany) while the rats were anaesthetized with isoflurane. A set of T_2-weighted spin echo images (128 echoes, TR=1200ms, 3ms between echoes, FOV=3cm^2, 128×128 matrix, Gauss or sinc selective pulses) were collected from 3 slices 1.5 mm thick through anterior cerebrum. 14 rats were imaged using Gauss selective pulses and 5 of these were also imaged with sinc selective pulses. Software developed within the Inst. for Biodiagnostics (Marevisi) was used to select regions of parietal cortex in the hemispheres contralateral and ipsilateral to the MCA occlusion. The data was fit to mono or biexponential functions using a least squares method. χ^2 value was also used to assess the quality of mono or bi-exponential fitting. The accepted fits were considered satisfactory for χ^2 =0.998±0.001. The first two points of the data were discarded from the analysis.

Results

For Gauss selective pulses a multiexponential analysis of the T_2 decay curves obtained from the multi-echo images from normal brain (e.g. parietal cortex) demonstrated that the T2 decays were described well by a single exponential component with a T_2 value of 48ms [Table 1] Within ischemic parietal cortex ipsilateral to the MCA occlusion, analysis of the T_2 images demonstrated that there were two T_2 components, one shorter and one longer than that in normal cortex. When a sinc pulse [Table 1] was used we observed only one T_2 component within the ischemic cortex (T_2=66.2±0.2ms), which corresponded to the weighted averages of the two components observed when a Gauss selective pulse was used. Similar to Gauss, only one T_2 component was detected in the normal brain for sinc pulse experiments. When examining other regions, a biexponential character of the T_2 decay signal was observed if the region included CSF (i.e. T_2 = 31-40ms; T_2 = 200-250ms). The contribution of the short component increased with the increasing area around the CSF, ie. when CSF and gray matter (e.g. habenula) were also included. This change in the contribution of each component was observed when both Gauss and sinc pulses were used.

Gauss pulse

Location	T_2(A)	C(A) [%]	T2(B)	C(B)[%]
Cortex (left, no stroke)	48±0.1	100	-----	-----
Cortex (right, stroke)	72±1	92.7±0.6	11±1	8.3±0.6

sinc pulse .

T_2(A)	C(A) [%]	T_2(B)	C(B)[%]
43.4±0.1	100	-----	-----
66.2±0.2	100	-----	-----

Table 1. T_2 values calculated for different regions of the brain using Gauss selective pulse and sinc. C(A) and C(B) are the percentage contributions of A and B to the overall T_2 component, respectively.

Conclusions

The results demonstrate that a multiexponential analysis of T_2 relaxation within brain may provide useful information concerning different constituents within a region of interest such as CSF and gray matter as reflected by long and short relaxation components. However, with multislice sequences, it is not clear which sequence is optimal. When using the Gauss pulse sequence, T_2 analysis of ischemic tissue resulted in the detection of two components, a fast component and a somewhat longer relaxation component, potentially reflecting ischemic and edematous changes in the cortex. However, this biexponential character of the T_2 signal could also originate from imperfections of the Gauss slice selection when compared to the more selective sinc pulse, where the T2 signal was best fit by a single longer component. Additional experiments are needed to determine the best methods of T_2 multiecho acquisition and analysis for identifying specific cellular changes following stroke.

References

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