$T_{2\rho}$ and dipolar contrast

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Introduction : So far, A.G. Redfield's work [1] leaded the NMR community to two main research fields: The first one is the investigation of solid state media characterized by very short T_2–values using Magical Echoes Pulse Sandwiches (MEPS) [2]. While being a very efficient approach to acquire images of *ex vivo* samples, this method is rather slow (around 40min for a 64x64 pixels image). The second approach uses a spin lock pulse to investigate the spin-lattice relaxation times in the rotating frame ($T_{1\rho}$). This second approach is well suited to investigate motion restricted molecules like proteoglycan content [3]. In this work we use a third approach to capitalize the dipolar interaction removal properties of the MEPS to create Dipolar Free (DF) images contrasted by the spin-spin relaxation times in the rotating frame ($T_{2\rho}$). DF images were compared to the reference Spin Echo (SE) sequence.

Material and Method : Experiments were performed at 4.7T on a Bruker Biospec system. A classical spin echo sequence was modified (Fig. 1) to substitute the 180° pulse by a Magic Sandwich Echo (MSE) burst RF pulse [1]. During the burst, dipolar interaction is reduced to *-1/2* times its value without the burst pulse. Classical SE image (subject to dipolar interaction) were then compared to DF image acquired with same T_E and T_R [4,5]. The difference of the DF image to the SE image normalized by the spin echo image gives the ratio of signal enhancement obtained with the DF sequence on a pixel-by-pixel computing basis. In vivo experiments were performed on rat brain. On a kiwi, acquisition of SE and DF images at different echo times (T_E=40, 60, 80ms, T_R=1500ms and a 10μT burst for the DF image) was performed to estimate the dipolar free transverse relaxation values (T_{2DF}). By analogy to the well-known estimation of the relaxation rates $1/T_2^*=1/T_2'+1/T_2$ (c.f. Abragam [6]), the dipolar component of the transverse relaxation (T_{2D}) can be deduced from the dipolar free component (T_{2DF}) and the classical T_2 component using the formula: $1/T_2=1/T_{2DF}+1/T_{2D}$. T_{2DF} represents the remaining relaxation rate if there was no more dipolar interaction in the tissue and T_{2D} represents the relaxation rate accounted to dipolar interaction.

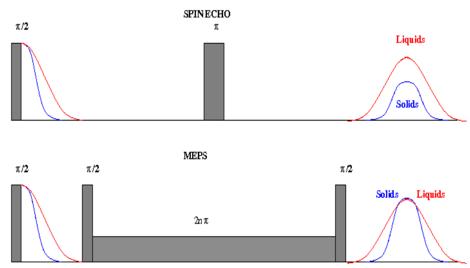

Figure 1 : Chronogram of a SE and MEPS Dipolar Free sequence.

Results : Figure 2 shows respectively from left to right the SE, DF and percentile enhancement images acquired *in vivo* on the brain of a normal control rat. The DF image was acquired with the same parameters as the SE (T_E/T_R=60/1500 ms) and with a MSE burst of 5μT intensity (213Hz) and 40ms duration. At this echo time a signal increase of the order of 100% was observed in the brain parenchyma and the increase was about 300% for the surrounding tissues. Figure 3 shows T_2, T_{2DF} and T_{2D} maps respectively, acquired on a kiwi. Mean T_2 values were calculated on 4 different areas (c.f. A, B, C, D designed on Figure 3) and are reported Table 1. As expected, T_{2DF}-values were found higher than T_2-values and an increase of the transverse relaxation time of a factor exceeding two can be observed in different areas of the images.

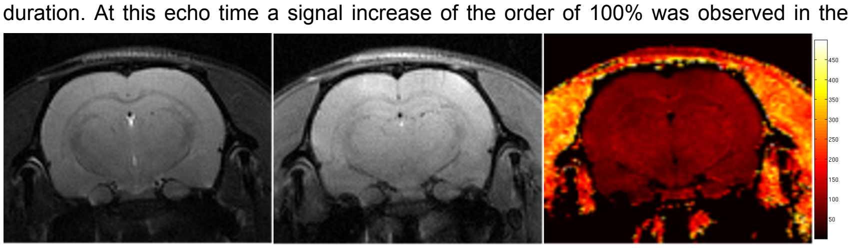

Figure 2: Spin Echo, DF and percentile image ratio obtained in a healthy rat brain (FOV=2.5x2.5cm, 128x128 pixels, NA=4, slice thickness=1.5mm, T_E/T_R=60/1500 ms)

Region	T_2 (ms)	T_{2DF}	T_{2D}
A	60±18	94±37	126±90
B	93±34	205±75	129±100
C	70±26	154±57	122±94
D	28±12	36±21	55±83

Table 1: T_2, T_{2DF} and T_{2D} estimates in different regions of the kiwi

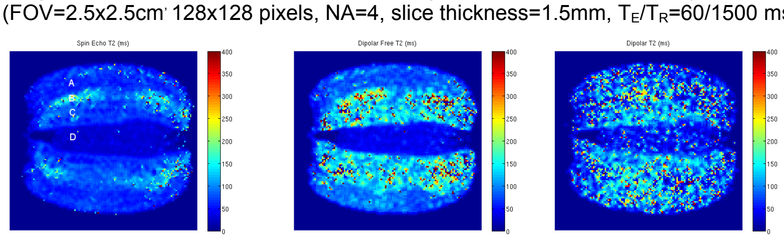

Figure 3: T_2, T_{2DF} and T_{2D} maps measured in a kiwi (FOV 6x6 cm2, 128x128 matrix and slice thickness=1.5mm).

Conclusion : The developed sequence exploits at the same time the contrast abilities of a $T_{2\rho}$ sequence and the signal enhancing properties of solid imaging techniques. Compared to a classical spin echo technique, the sequence described can provide a signal enhancement which can excess 300% depending on molecular mobility and echo time. This new contrast may prove useful in the investigation of quasi-solid properties of tissues. Using this sequence, the T_2-components related and unrelated to dipolar interaction could be successfully distinguished and separated.

References

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