Dynamic T_1-Quantification in Small Rodents: A Retrospective Approach with Variable Temporal Resolution

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Target audience: Researchers with interest in dynamic T_1-quantification in small rodents where triggering is needed due to respiratory or cardiac motion.

Introduction: A retrospectively triggered approach to T_1-quantification for dynamic studies is proposed and demonstrated using a Manganese-Enhanced MRI (MEMRI) experiment. A Cartesian Look-Locker Inversion Recovery FLASH (IRSF) method is adapted to use random sampling. Model based interpolation in k-Space is used for reconstruction. The retrospective approach is advantageous as several parameters usually chosen prospectively can be adjusted in post processing. These parameters include the temporal resolution and the trigger position. Choosing the trigger position in post processing allows reconstruction on arbitrary temporal points in the cardiac cycle while also enabling correction of trigger drift over long measurements. An optimal balance between temporal resolution and SNR can be found in post processing.

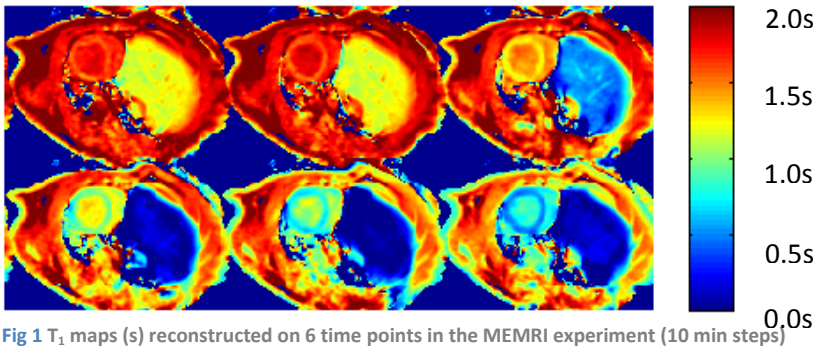

Fig 1 T_1 maps (s) reconstructed on 6 time points in the MEMRI experiment (10 min steps)

Method: Experiments were carried out on a 7 T small animal imaging system using a 72 mm quadrature birdcage and a 4-channel surface array (Rapid BioMed, Rimpar). Healthy Wistar-Rats (Charles River Laboratories) were anesthetized with Isoflurane (1.5-2%). Manganese was administered at 3.3nmol/min/g for 30 min after acquisition of the baseline for 10 minutes. A 20 min washout period is also recorded. Breath and cardiac data is recorded using a pressure based sensor. A retrospective random sampling IRSF sequence as proposed in [1] was used with only global inversions. Specific sequence parameters were: 4.5 cm by 3 cm FOV, isotropic resolution (469 µm)², imaging slice thickness 2 mm, bandwidth 40 kHz, TR 3.4 ms, 2500 readout pulses per inversion, waiting period of 8 s between inversions. Prospective triggering is used only for inversion pulses, readout pulses are assigned to their heart cycle retrospectively by evaluating the recorded pressure sensor data.

Reconstruction is performed using the model based reconstruction demonstrated in [1] with optimizations for faster acquisition. Over the long acquisition time of 65 min a drift in the trigger points is possible. This is corrected automatically by creating and analyzing a series of retrospective CINES from the measurement dataset (see fig. 3).

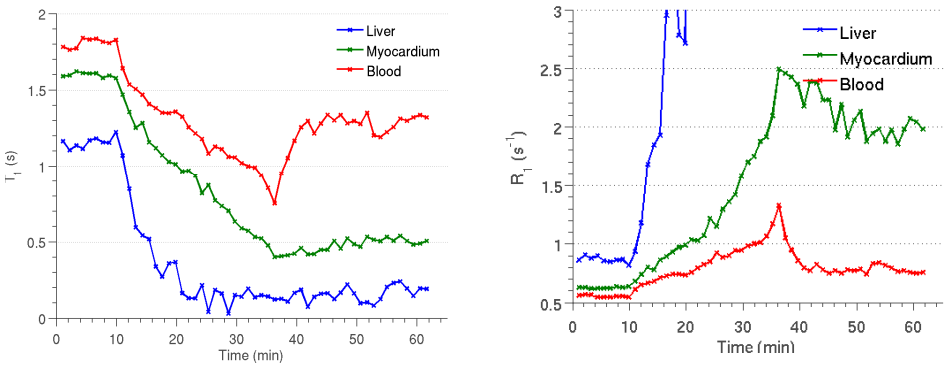

Fig 2 T_1 (left) and R_1 (right) measurement evaluated with 66s temporal resolution.

Results and Discussion: Exemplary T_1-maps at different temporal positions (0, 10, 20, 30, 40, 50, 60 min) are shown in fig. 1. Each map was reconstructed of data acquired over 4 inversions resulting in a temporal resolution of 66 s. In fig. 2 the T1/R1-Dynamic is shown for ROIs in the liver, myocardium and left ventricle. The infusion period and washout period can be clearly visualized. The fast rise in liver R_1 is well resolved due to the high temporal resolution of 66 s. The method is not optimized for T_1-times below 300 ms introducing a higher degree of noise (see fig. 2 liver data from minute 20 to end). The measurement could be further accelerated using a saturation recovery instead of inversion recovery at cost of the equilibrium magnetization data[2].

Conclusion: A retrospectively triggered protocol for dynamic T_1-experiments in small rodents has been demonstrated. Retrospective triggering allows correcting for drift in triggering. The temporal resolution can be chosen to suit the SNR/resolution according to the specific problem at hand.

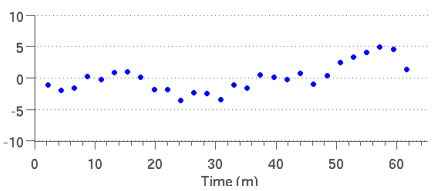

Fig 3 Drift in the trigger points over 60min in % of a full cardiac cycle

References:

[1] Gutjahr FT, et al. Proc. ISMRM 2011, #2033

[2] Li W., et al., Magn Reson Med (2010); 64: 1296-1303

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