Retrospective T1 measurements in small rodents using radial trajectory

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Introduction

T1 in the myocardium of small rodents is often quantified using a prospectively triggered inversion recovery snapshot FLASH (IRSF) sequence with cartesian k-space sampling [1].
In this work, we introduce a retrospectively gated IRSF sequence with radial k-space sampling for robust T1 quantification. An important advantage of the radial sampling is that the central k-space points are sampled with high density. Thus, motion artefacts can be compensated easier in comparison to a cartesian trajectory. Furthermore, since the k-space center is acquired with every repetition, the MRI signal is modulated by the cardiac and respiratory motion [2]. Since the measurement of the ECG in high magnetic fields can be corrupted by interferences with strong gradients, an internal measurement of the heart phase would be a useful alternative to the existing methods.

Materials and Methods

All measurements are carried out on a 7T BioSpec (Bruker BioSpin Germany). For mouse imaging, a 72mm quadrature Birdcage was used for excitation pulses with a 30mm 4-channel hole slotted array as receiver. In case of rat imaging, a 4-channel surface coil (RAPID) was utilized as receiver coil.
A IRSF flash sequence was modified for a radial sampling scheme with golden ratio angle increments (• •111°). A gradient delay correction was applied in all encoding directions. To reduce off resonance artefacts, the resonance frequency was determined via press voxel adjustment in the measured slice.

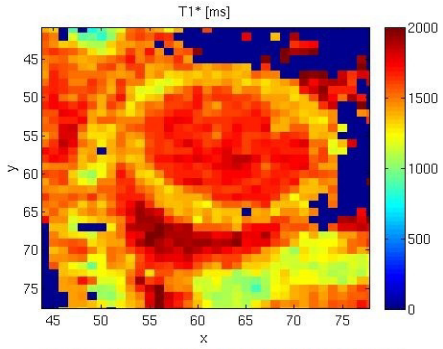

Figure 1 T1 map of the murine myocardium determined with retrospective selection of k-space data

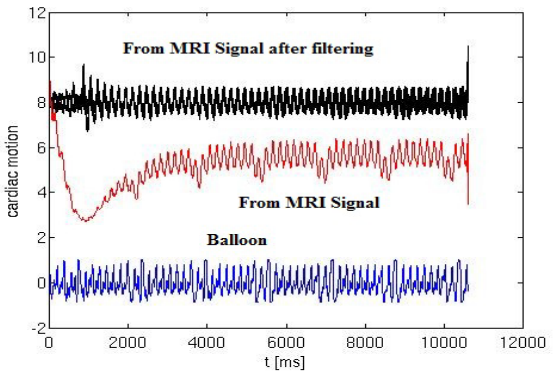

Figure 3: Cardiac motion of the rat heart

For measurements in the murine myocardium, the echo position was set to 15%, which allows a TE of 0.9 ms and a TR of 2.6 ms for a sampling bandwidth of 75 kHz and 76 readout points. The readout FOV was set to 3 cm and the slice thickness 2 mm. For a full scan protocol, 32 global inversions were acquired with 4000 projections, respectively, to cover a scantime of 10.4 seconds per inversion with a waiting period of 15s.

In the rat, 32 global inversions with each 3000 projections were acquired at a echo position of 50% with 96 readout points and a TR of 3.54 ms to obtain a scantime of 10.6 s . The readout FOV was set to 5 cm. To minimize flow artefacts, a flow compensation of first order was implemented in all encoding directions.
Each inversion pulse was triggered in the diastole phase of the heart. The respiratory and cardiac cycle were recorded with a balloon. Simultaneously, the timings of the RF pulses were recorded. With this data, a relative position in the heart phase was assigned for each spoke.
Using the knowledge of the relative heart position, a cine of the heart movement was reconstructed retrospectively in order to find the diastole. To reconstruct images of the temporal response of the signal after inversion, spokes belonging to one third of the heart phase around the diastole were kept for image reconstruction. Along inversion time dimension, several filter methods like KWIC or sliding window-filter are applied to reconstruct time frames. The radial data were reconstructed on a 128x128 matrix using a fast regridding algorithm [3] with Pipe density compensation [4] .

Results

Figure 1 shows a T1 map of the mouse heart, obtained with the proposed retrospective measurement using external balloon triggering. The map shows high edge sharpness and allows the determination of T1 in the myocardium. The values are around 1400 ms in the septum and around 1700 ms in the left ventricle, which is in good agreement with literature. [5]
For the measurement in the rat, the cardiac and respiratory navigator could be extracted from the signal of the k-space center after applying a low pass filter und substracting of T1 relaxation. The results are shown in figure 2 in comparison with the signal of the balloon.

Discussion and Conclusion

In the present study, the retrospective measurement of IRSF in the murine myocardium could be demonstrated to work and offers possibilities for further applications as perfusion measurements. Since T1 measurements in the rat allow lower in plane resolution and, thus, lower encoding gradients, the extraction of cardiac motion from the MRI signal is much less prone to interferences than in the mouse.

References

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