Multi-spiral MRI for cardiac T2-star determination

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Introduction: Cardiovascular T2* magnetic resonance imaging (MRI) is a valuable tool in the diagnosis of heart disease. An increase in tissue iron causes a significant drop in the T2* relaxation time, making this method a reliable and non-invasive approach for the diagnosis of diseases associated with a myocardial iron overload [1]. Additionally, recent studies suggest that cardiac T2* MRI could be a promising tool for the characterization of myocardial viability [2]. This issue has become more relevant given the recent incidents associated with MRI contrast agents. To date, there are two commonly used sequence types for cardiovascular T2* determination: ECG-triggered multi-gradient-recalled-echo (multi-GRE) and EPI. Multi-GRE sequences can be easily implemented and are relatively robust. However, they usually require several breath-holds or multiple excitations per cardiac cycle, which shortens the effective repetition time and thus the SNR. Echo-planar-imaging (EPI) sequences do not have these restrictions but suffer from the typical EPI-distortions, especially if the k-space is covered with only a few segments. Spiral sequences are in this regard similar to EPI sequences. Their major advantage in comparison to EPI is that the spiral trajectory inherently refocuses motion- and flow-induced phase errors, a property which can be very beneficial for cardiac applications. However, image reconstruction for data acquired using a spiral trajectory can be complex and time-consuming. In this work a multi-spiral sequence for cardiovascular T2* determination is presented. A multi-spiral sequence is one that acquires each spiral arm multiple times after an excitation in order to generate multiple T2* contrasts, which can then be used to determine T2* values.

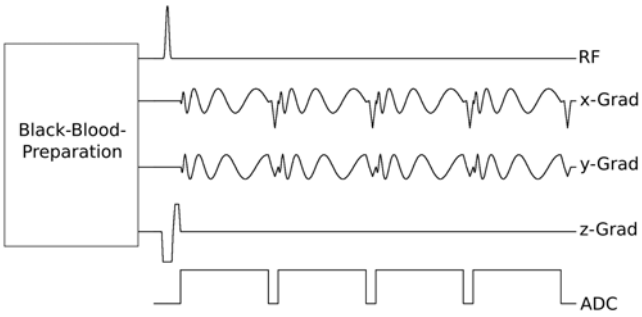

Figure 1: Sequence diagram of the multi-spiral sequence.

Methods: All experiments were performed on a Siemens Avanto 1.5 T imaging system with a 16-channel receiver coil (Rapid Biomedical). A segmented, fully-sampled Archimedean spiral k-space trajectory was calculated online after considering the sequence parameters and the hardware restrictions of the scanner [3]. The sequence is shown in figure 1. A total of 20 cardiac-triggered segments was chosen to allow the acquisition in a single breath-hold. A black-blood preparation was followed by the acquisition of a single spiral arm four times with different delays to enable T2* determination. After every spiral readout, the 0^{th} gradient moment was refocused. The other sequence parameters were as follows: readout duration = 6.25ms; effective echo times = 1.3/8.6/15.9/23.2 ms; FOV = 300mm; in-plane-resolution = (2.3x2.3) mm²; slice thickness = 8mm; excitation flip angle = 90°. The k-space trajectory was measured according to Duyn et al [4]. For data reconstruction, a CGINNG-reconstruction was used with an oversampling factor of 2 [5].

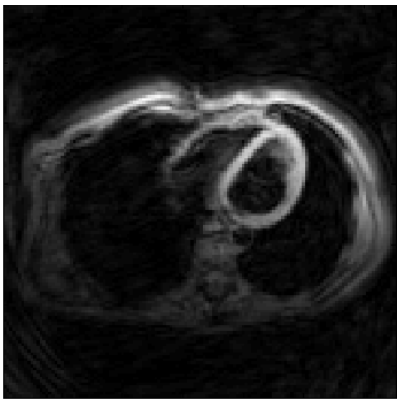

Figure 2: Spiral image of the heart (transversal orientation, TE = 8.6 ms).

Results: Figure 2 shows an image reconstructed using the second contrast of four from the multi-spiral sequence of a healthy volunteer. A region-of-interest was selected from the septum and the signal over this area was averaged for each contrast. An exponential function was fitted to the four datapoints as shown in figure 3, yielding a T2* value of 34.5 ms. This value is consistent with those from previous publications.

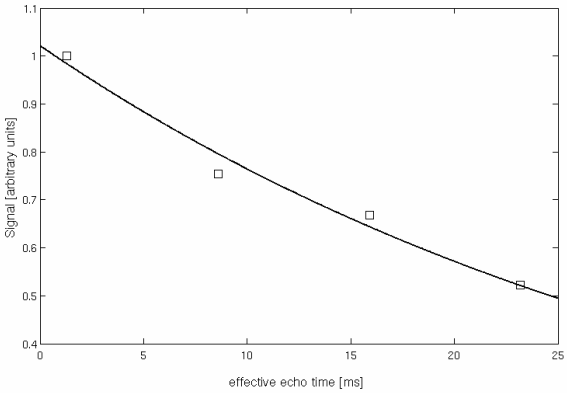

Figure 3: Exponential fit of the signal as a function of the effective echo time in the selected region-of-interest.

Discussion: The first results shown here demonstrate that it is possible to obtain T2* values in the myocardium from multi-spiral acquisitions. However, despite the black-blood preparation there are still some minor flow artifacts in the later acquisitions visible. Although the spiral trajectory itself is inherently flow compensating, the first gradient moment of the spiral trajectory was not refocused after the end of each acquisition. It is important to note that the entire readout for the four contrasts was only approximately 30 ms; a longer total readout time in combination with more contrasts for each arm is expected to yield a more exact T2* value. A multi-spiral sequence which allows for more than four contrasts and with compensation of the first gradient moments is currently work-in-progress.

References

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