Van Heeswijk *et al. Journal of Cardiovascular Magnetic Resonance* 2012, **14**(Suppl 1):O51
http://www.jcmr-online.com/content/14/S1/O51

Journal of Cardiovascular Magnetic Resonance

ORAL PRESENTATION **Open Access**

Quantitative free-breathing 3T T_2-mapping of the heart designed for longitudinal studies

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From 15th Annual SCMR Scientific Sessions
Orlando, FL, USA. 2-5 February 2012

Background

Recently, T_2-weighted MRI for the characterization of edema after myocardial infarction has attracted considerable attention (Friedrich, NatRevCardiol2010). Furthermore, the recently proposed combination of bSSFP imaging and T_2Prep for T_2-mapping at 1.5T has enabled a rapid quantitative cardiac T_2 estimation (Huang et al., MRM2007). However, the accuracy of this method may still be limited due to the complex T_2/T_1 signal weighting. Especially for longitudinal studies designed for monitoring and/or guiding therapy, accurate and reproducible T_2 measurements will be critical. A novel quantitative 3T T_2-mapping protocol was therefore developed and tested in both healthy volunteers and patients.

Methods

An adiabatic T_2prep with 3 incremental TE values, affine coregistration, a navigator and 2D radial gradient echo imaging were combined for free-breathing T_2-mapping at 3T with a spatial resolution of 1.25mm. Bloch equation simulations of this sequence were used to optimize scan parameters and to determine an empirical equation that compensates for T_1 relaxation and which returns the “true” T_2. The T_2-mapping sequence and empirical equation were then validated in a series of 15 phantoms in which the true T_2 was determined with a 9-TE spin-echo sequence. Next, the myocardial short axis T_2 of 8 healthy volunteers was mapped in two different scan sessions while a reference phantom (T_2=43.1 ±0.7ms) was placed next to the thorax. The average myocardial T_2 for both sessions was computed with and without correction with the “true” reference phantom T_2. Finally, this validated protocol was used in 5 patients in the subacute phase after revascularization of acute ST-elevation myocardial infarctions and compared to T_2-weighted TSE imaging.

Results

As a result of both the simulations and phantom scans, optimized sequence parameters included: TE_{T2prep}=60/30/0ms, T_{RR}=3 heartbeats, TR/TE=5.3/2.4ms. The empirical equation to determine T_2 was $S=S0[\exp(-TE_{T2prep}/T_2)+0.06]$, where S and S0 are the measured and steady-state signal (Fig. 1a). Scans of the phantoms with known T_2 confirmed a 12±2%($p<0.001$) improvement in T_2 estimation with the empirical equation as compared to the standard T_2 decay measurements (Fig. 1b). The myocardial T_2 in the volunteers was homogeneous (42±5ms over all volunteers) and on average showed a 5±2% difference between the two scan sessions. When compensated with the T_2 from the reference phantom, this difference decreased to 2±1% ($p=0.02$). In all patients, T_2maps could successfully be obtained and a clear demarcation of zones with elevated T_2 values was consistent with the findings on T_2-weighted MRI and X-ray coronary angiography as shown in the example in Fig. 2.

Conclusions

The methodology presented in this study enables robust and accurate cardiac T_2-mapping at 3T, while the addition of a reference phantom improves reproducibility. Therefore, it may be well-suited for longitudinal studies in patients with ischemic heart disease.

Funding

N/A.

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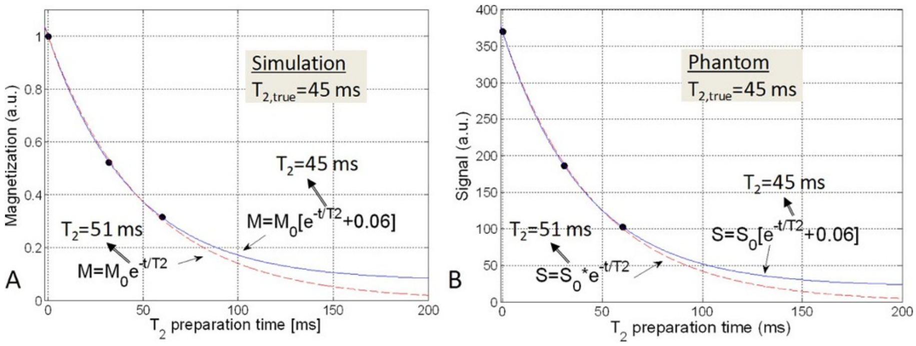

Figure 1 Single pixel T_2-mapping in a simulation and phantom scan. A) Simulated magnetization (black dots) for myocardium with input T_2=45ms at the T_2prep times (60, 30 and 0ms) and fitted curves with the standard (dashed line) and new, empirical (whole line) equation. The new equation leads to more accurate T_2 computations. B) Similar results are obtained in a pixel in a T_2map of a phantom where the T_2 was determined to be 45ms with a 9-TE spin echo scan.

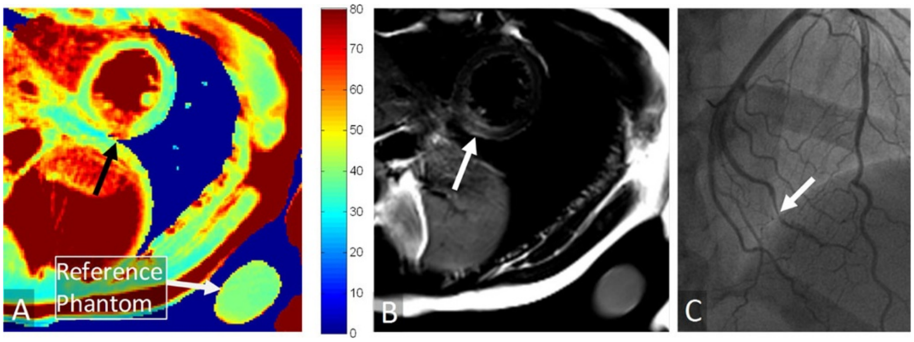

Figure 2 Short-axis T_2map together with conventional T_2-weighted turbo spin-echo and X-ray coronary angiogram in a patient with a myocardial infarct. A) A clearly demarcated zone with elevated T_2 can be seen in the region of the black arrow, which might indicate myocardial edema. The non-infarcted tissue has a homogenous T_2, while the reference phantom adjacent to the thorax appears homogeneous with T_2 values similar to those in healthy tissue. B) The conventional T_2-weighted TSE image confirms the elevated T_2 in the region of the infarct (arrow). C) Consistent with these findings, the x-ray coronary angiogram shows a severe stenosis in an obtuse marginal artery (arrow).

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Published: 1 February 2012

doi:10.1186/1532-429X-14-S1-O51
Cite this article as: Van Heeswijk *et al.*: Quantitative free-breathing 3T T_2-mapping of the heart designed for longitudinal studies. *Journal of Cardiovascular Magnetic Resonance* 2012 **14**(Suppl 1):O51.