T1ρ-mapping of the heart in a single breath-hold

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Purpose

Development of an accurate cardiac $T_{1\rho}$-mapping method that can be performed in a single breath-hold.

Background

Quantitative imaging (mapping) of myocardial tissue properties is currently subject of intense research efforts[1]. In addition to the more established T_1- and T_2-mapping methods, $T_{1\rho}$-mapping shows promising results for the endogenous detection of myocardial fibrosis[2]. This technique is mainly applied in cartilage imaging, and is known to be sensitive to changes in macromolecular interaction[3]. It has been shown that it can be used to detect chronic MI without the use of an exogenous contrast agent[4].Typically a $T_{1\rho}$-map is obtained by multiple $T_{1\rho}$-weighted images with different spin-lock (SL) preparation times. However, in cardiac imaging this is challenging, since small changes in breath-hold position will lead to artefacts in the resulting $T_{1\rho}$-map. In this study we propose a cardiac $T_{1\rho}$-mapping method in a single breath-hold.

Methods

Subjects: Five healthy volunteers (age 28 ± 3 years) underwent a cardiac MRI exam on a Philips Ingenia 1.5T MR scanner (Philips Healthcare). Furthermore we imaged two patients with a chronic myocardial infarction (MI) (55 ± 3 years). Written informed consent was obtained from all subjects. $T_{1\rho}$-mapping was performed using a $T_{1\rho}$-prepared steady-state free precession (SSFP) sequence. 5 images with different spin-lock (SL) preparation times (SL = 0, 10, 20, 30, 40 ms) with amplitude of 500 Hz were acquired (Figure 1). Each SL pulse consists of 2 continuous RF pulses with opposite phase to compensate for B1 variations, and a refocusing pulse between the spin-locking halves to compensate for B0 errors[5]. Other parameters were: bandwidth/pixel = 723 Hz, TE/TR = 1.74/3.5 ms, resolution = 2 x 2 mm, slice thickness = 8 mm, FOV = 288x288 mm^2, flip angle = 35 degrees, SENSE = 2. Images were acquired in late diastole during expiration breath hold, with an R-R interval of 3 beats. In the healthy volunteers 3 slices were acquired, basal, mid and apical, and in the MI patients 7 short axis slices were acquired, covering the heart from apex to base. To test repeatability all subjects were scanned twice with the same protocol, and taken out of the scanner in between. In the MI patients, conventional LGE images were acquired with the same spatial resolution as the $T_{1\rho}$-maps 15 minutes after contrast agent injection.

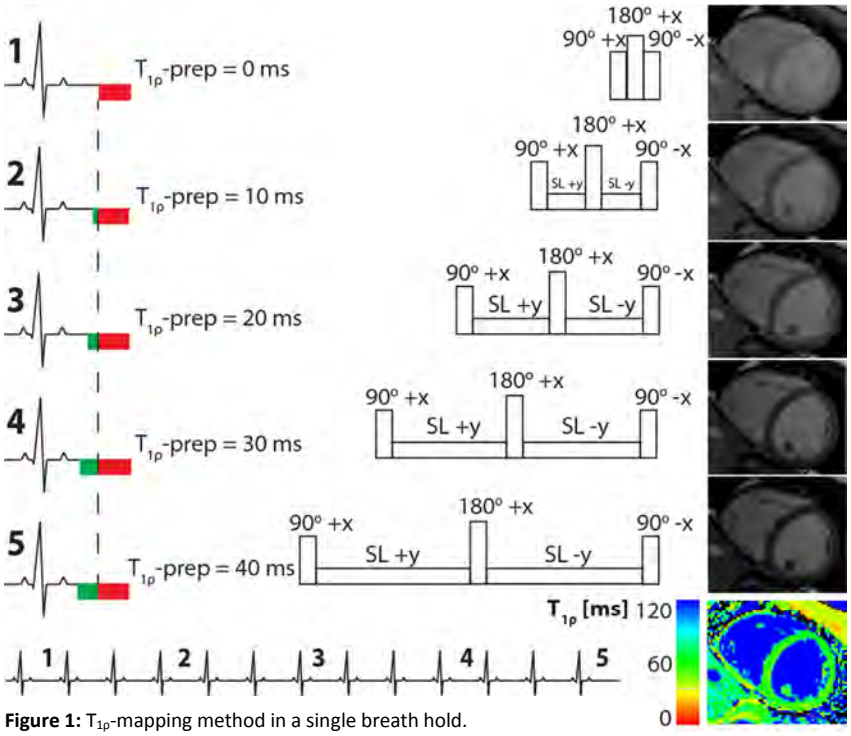

Figure 1: $T_{1\rho}$-mapping method in a single breath hold.

Analysis: $T_{1\rho}$-maps were calculated by pixelwise fitting of a mono-exponential decay function in QMass (Medis). $T_{1\rho}$-values for each slice were obtained by manually drawing of an ROI. The coefficient of repeatability (CR) was calculated by $CR = 1.96\sqrt{\sum(d_2 - d_1)^2/n - 1}$.

Results

High resolution $T_{1\rho}$-maps were successfully acquired in all subjects. The mean $T_{1\rho}$-relaxation time was 52.7 ± 3 ms. Repeatability is shown in the Bland-Altman plot (Figure 2). The coefficient of repeatability in the healthy subjects was 3.74 ms, and in the infarct patients 4.59 ms.

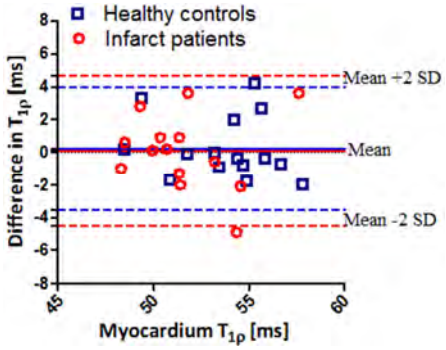

Figure 2: Bland-Altman plot of repeatability of $T_{1\rho}$-mapping method. Bias was 0.24 in controls and 0.07 in MI patients.

Discussion

We have developed a $T_{1\rho}$-mapping method that enables the acquisition of a $T_{1\rho}$-map in a single breath-hold, with high repeatability. This method can potentially be used for endogenous detection of fibrosis in patients with different cardiomyopathies. Currently we are testing the accuracy and precision of this $T_{1\rho}$-mapping method for endogenous infarct detection in a patient population.

Conclusion

A $T_{1\rho}$-mapping method was developed that can be used to acquire a $T_{1\rho}$-map in a single breath-hold with high repeatability.

References: [1]Oorschot et al. JMRI 2014 [2]Musthafa, H.-S. N. *et al. JCMR* 2012 [3]Menezes et al. MRM 2004 [4]Oorschot et al. Proc. Benelux ISMRM 2014 [5]Li et al 2007