Single Breathhold CINE T1 Mapping of the Heart

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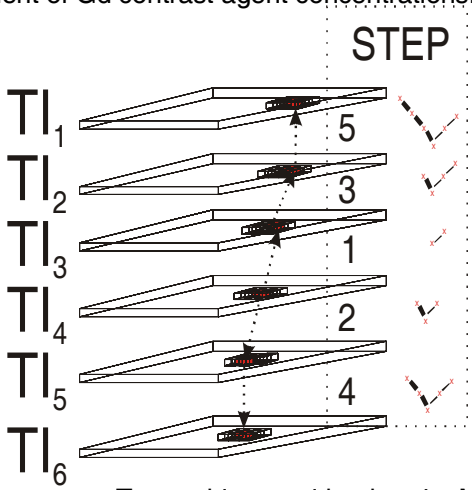
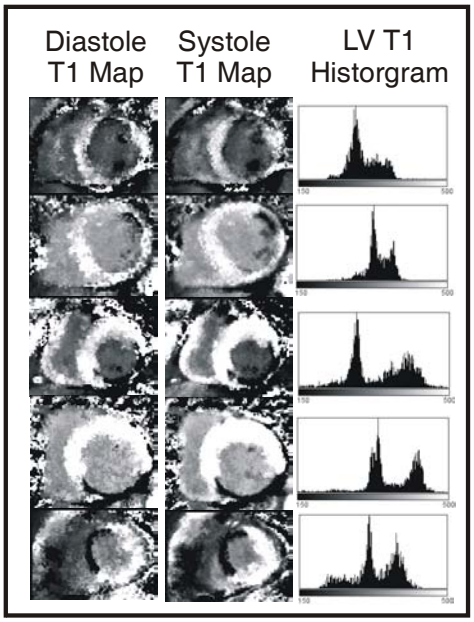
Introduction: MR determination of myocardial viability is typically performed using Gd contrast and a single phase (inversion time) inversion recovery (IR) image which nulls signal from viable myocardium. T1 measurements are challenging due to the number of inversion times needed for curve fitting. A commonly available IR-SSFP-CINE pulse sequence [1, ' TI SCOUT'] provides many inversion times at different cardiac phases. T1 measurements using this sequence have been performed using region of interest analysis at different cardiac phases [2], but T1 mapping has not been performed due to the movement of the heart across TIs and the cardiac cycle. T1 mapping of the heart is interesting because it provides a quantitative rather than a qualitative or relative measurement of Gd contrast agent concentrations.

T1 Mapping Method: For each pixel in the T1 map, a search for the pixels that minimize the IR signal equation using multiple steps that add inversion times to the calculation are performed. At Step 1, we begin with a pixel at TI/cardiac phase 4. The error to the IR equation using a two point fit is calculated for each of the neighboring pixels in TI/cardiac phase 3. The pixel (labeled red) with the least error is selected. Now using the red pixels from TIs/cardiac phases 3 and 4, the error to the IR signal equation using a three point fit is calculated for each of the neighboring pixels in TI/cardiac phase 5. Again, the pixel with the least error is selected. This process is repeated in a centric fashion until all TIs are used. At each step, a translation in each direction of one pixel is allowed. The pixel for the T1 map at cardiac phase 4 is set in the final step. This process is repeated for each pixel in cardiac phase 4 and for each desired cardiac phase T1 map.



Materials and Methods: Imaging was performed using a 1.5T clinical scanner. Ten subjects with chronic MIs participated in this study (MI age=18.0 years±7.5; range=1.2-25.9). Subjects underwent imaging using an IR-SSFP-CINE technique [1]. Sequence parameters were: (TR=2.5 ms, TE=1.25 ms, FA=50 degrees, BW=965 Hz/pixel, voxel size=2.5x1.8x8.0mm^3, 15 k-space lines per cardiac cycle and 19 segments per cardiac cycle yielding 19 images with TIs increasing by 40 ms). A single slice was positioned based on SSFP CINE wall motion imaging to include regions with both dysfunctional and functional myocardium. Images were acquired 20 minutes after injection of 0.2 mmol/kg of the Gd contrast agent. T1 maps were calculated at diastole and peak systole. T1 map region of interest measurements of the viable and infarcted myocardium and LV bloodpool were made and compared using two-way ANOVA.

Results: T1 maps from five patients are shown on the right. The infarcted myocardium has the greatest concentration of Gd and hence the lowest T1 and is depicted as a hypointense region, contrary to conventional delayed hyperenhanced imaging. One can see thickening of the viable myocardium and also the infarcted region at peak systole. Histograms of the T1s of the LV myocardium and bloodpool are also shown. There was a significant difference between the T1 values of all three regions (p<.0001).



n=10	T1(ms) mean ±sd (min-max)
LV bloodpool	304±18 (280-329)
Viable Myocardium	399±27 (360-444)
Infarcted Myocardium	232±25 (185-276)

Conclusions: We have described a method of T1 mapping of the heart. The method is operator independent and provides T1 maps at specified delays of the cardiac cycle. The resulting T1 maps may be used for infarct segmentation or infarct characterization[2]. In the future, the method may allow combined CINE functional and viability imaging.

References: [1]Gupta A et al, Radiology 2004;233:921-6.[2] Goldfarb JW et al, Magn Reson Med. 2005;53:367-71.