PhD10

BIOQIC

Quantitative MRI for assessment of myocardial fat infiltration at ultra-high field strength

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Application Area: Cardiovascular **Modality:** MRI **Related:** PhD 2, 6, 11, 14, 15

Background

The healthy heart obtains approximately 70% of its energy from oxidation of long-chain fatty acids (FA). Under normal conditions, FAs are sequestered as triglycerides (TGs) and stored in adipocytes as lipid droplets, with a small amount also stored in non-adipose tissues, such as the myocardium. There is increasing evidence suggesting altered myocardial substrate utilization and subsequent excessive TG accumulation (steatosis) in myocardial disease (1). The concept of fatty myocardium has received attention because of its role in cardiomyopathy (2, 3).

Hypothesis

Ultra-high-field MRI allows quantification of fat infiltration in correlation with functional changes in cardiomyopathy.

Methods

During this project, a novel high-resolution 3D CSI sequence will be developed that enables acquisition of water and fat images of at least two cardiac phases as well as TG quantification within the myocardium. Advanced, multi-slice B_0 and B_1^+ field mapping methods will be modified to deal with respiratory and cardiac motion-induced field changes. Parallel transmission (pTX) methods will be included to counteract heterogeneous flip angle distributions at 7 Tesla. Furthermore, advanced reconstruction algorithms will be developed for multi-frequency fat spectrum modelling.

Work Packages

WP1: Sequence development at 3T
WP2: Phantom construction
WP3: Sequence development at 7T
WP4: In vivo reference values at 7T

year 1 → *year 2* → *year 3*

WP1: A 3D cardiac-triggered CSI sequence allowing for water-fat imaging in at least two cardiac phases (4) will be developed. Sequence validation will be performed in a phantoms and in healthy subjects at 3 Tesla.

WP2: A phantom containing multiple oil-filled vials of different sizes will be developed in parallel. The phantom will allow for fat quantification of tiny structures that mimic tiny fat infiltration in tissue.

WP3: Existing B_0 and B_1-mapping techniques (Fig1a) will be modified to enable volumetric (multi-slice) mapping for different respiratory states (6). Robust B+ shimming and 3D parallel transmission techniques (5,6) will be integrated into the developed sequence to maximize contrast homogeneity at 7T (Fig1b). Temporal variations of B_0 (due to breathing and cardiac motion, Fig 1c) will be incorporated into the excitation algorithm as well as the water-fat separation algorithm. The phantom (WP1) will be utilized to study spatial resolution limits..

WP4: In-vivo reference values will be obtained in heathy subjects as well as in a small patient cohort and compared to those obtained at clinical field strength.

Clinical Translation

This PhD project will be carried out in close collaboration with clinical partners to ensure that the developed techniques can be directly used in patients in a small feasibility study.

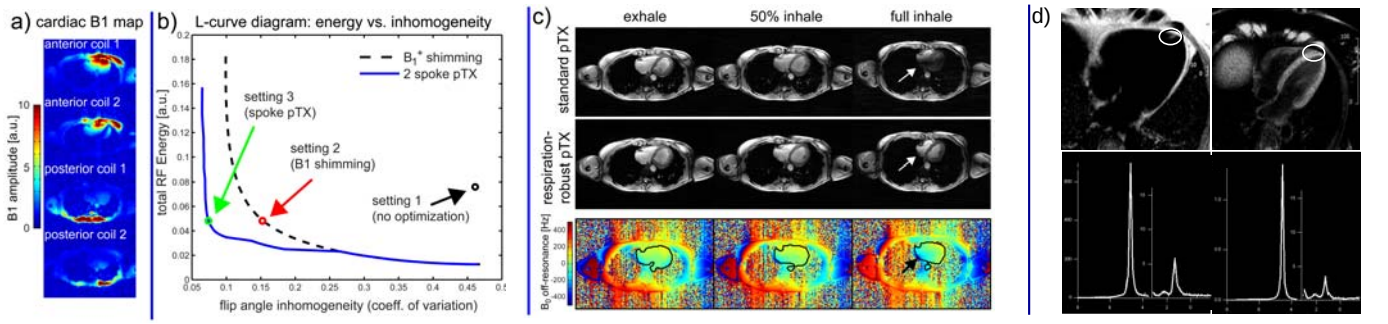

Figure 1: Cardiac MRI at 7 Tesla using parallel transmission techniques. a) Cardiac B1+ amplitude maps of a 16-channel RX/TX coil (only 4 channels shown). b) L-curve optimization plot, illustrating the tradeoff between RF energy and flip angle homogeneity. The "knee" of the curve is typically the point of interest. Full pTX pulses (setting 3) outperform B1+ shimming pulses (setting 2) while the RF energy is kept constant. The non-optimized setting results in signal dropout within the posterior heart region. c) Impact of respiration on the RF pulse design and B_0 off-resonance maps (6). While standard pTX optimization can suffer from respiration (top row) , a different approach can be used, providing RF pulses that are robust to motion (middle row). Cardiac MRI and MRS at 1.5 Tesla (d) showing fat infiltration in a patient suffering from Muscular dystrophy type II.

Literature

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