Myocardial T₁ mapping at 3T using variable flip angle method: a pilot study

H. POINSIGNON1,2, M. LOHEZIC2,3, H.-L. CHENG4,5, P.-Y. MARIE6, J. FELBLINGER2,7, and M. BEAUMONT1,6
1CIT 801, INSERM, Nancy, France, 2LADI, Nancy-Université, Nancy, France, 3Global Applied Science Laboratory., GE Healthcare, Nancy, France, 4Physiology & Experimental Medicine, The Hospital for Sick Children, Toronto, Ontario, Canada, 5Medical Biophysics, University of Toronto, Toronto, Ontario, Canada, 6CHU de Nancy, Nancy, France, 7U947, INSERM, Nancy, France

Introduction:

T₁ mapping is a useful quantitative MR technique for cardiac tissue characterization (viability, fibrosis), pulse sequence parameter choice and contrast agent concentration measurements. Because of cardiac and respiratory motion, cardiac T₁ mapping remains a challenging problem. Techniques for T₁ mapping of the myocardium are often limited by poor spatial and/or temporal resolution, which restrict their clinical use. The modified look locker sequence [1, 2] is the first technique which allows myocardial T₁ measurement within a single breath-hold. However, it is a dedicated research sequence and T₁ values are interpolated from apparent T₁ values (T₁*). In this work, we are interested in determining a T₁ method based on standard clinical sequences (e.g. FLASH) at 3T and in estimating the true T₁ value. For this purpose, a variable flip angle (VFA) method with integrates B₁ correction [3] was adapted to cardiac imaging on healthy volunteers. This study aims at evaluating the feasibility of myocardial T₁ measurements using 3D spoiled gradient recalled sequence (3D-SPGR) at 3T.

Materials and methods:

MRI experiments:

Four healthy volunteers (three men, one woman, age 25± 5) were underwent a cardiac examination on a 3T MR system (SIGNA HDxt, General Electric, Milwaukee, WI). A rapid 3D T1-mapping method, based on variable flip angles [3], was employed to compute the T₁ map (Matrix 128x128, TR/TE= 3/1.7 ms, FA=3, 9, 17°, Slice Thickness=8mm, Trigger Delay=500 to 900ms, depending on heart rate). The sequences were triggered on respiratory and cardiac cycles to decrease motion artifacts. Signals from a respiratory belt and an ECG sensor were carried by a custom Maglife patient monitoring system (Schiller Medical, France) and used to generate cardiac and respiratory triggers thanks to a dedicated home-made hardware presented in [4]. Eventually, volunteers were asked to hold their breath for 3 to 5s at the end of expiration phase to optimize the sequence time. Excitation field correction (B₁) was performed from two EPI acquisitions (same parameters with FA=60/120° and 120/240°) [3].

T₁ measurements:

A T₁ map was then obtained on a pixel-by-pixel basis using in-house software developed in Matlab®(v.7.2) by measuring the pixel intensities in the series of increasing FA images [3]. The left ventricle myocardium had also been divided into 6 segments according to the AHA recommendations [5] (Fig. 1.C). Mean pixel value of each ROI was used to compute 6 myocardial T₁ values. Because of misregistration and geometric distortions between SPGR and EPI sequences, B₁ correction was not applied on a pixel-wise basis. Thus, B₁ error was estimated on each ROI and used to correct myocardial T₁ values.

Results:

Fig.1. shows two T₁ maps before B₁ correction (volunteer 1(A) and 4(B)). Originally, T₁ values were not homogeneous over the whole myocardium. This can also be seen on myocardial values (Fig.2). Raw T₁ values ranged from 1074 to 1594 ms, the T₁ of two septal segments (2 and 3 on fig.1.C) being the lowest. Because of effective B₁ correction, corrected values T₁ were smoothed over the different segments compared to uncorrected ones. Indeed T₁ values measured on septal regions (2 and 3 on fig.1.C) seemed no longer significantly lower than the ones measured on other segments. Corrected myocardial T₁ values ranged from 1315 to 1540 ms.

Discussion and conclusion:

In this study, the feasibility of myocardial T₁ measurements using VFA method has been demonstrated. B₁-corrected T₁ estimates on the six segments were in good agreement with previously published works at 3T [6]. However, this technique seemed to be sensitive to cardiac motion which is more important on the septal wall. Also, the image quality suffered from heart rate variations. Algorithms to predict RR variations [7] could be used to optimize the trigger delay calculation and increase image quality [8]. It is well known that VFA T₁ mapping is very sensitive to transmit field B₁ inhomogeneity [3]. Consequently our future works will focus on optimizing acquisition parameters to achieve pixel by pixel B₁ correction and acquiring additional sets of data.

References: