Myocardial T_1 mapping at 3T using variable flip angle method: a pilot study

H. POINSIGNON[1,2], M. LOHEZIC[2,3], H-L. CHENG[4,5], P-Y. MARIE[6], J. FELBLINGER[2,7], and M. BEAUMONT[1,6]
[1]CIT 801, INSERM, Nancy, France, [2]IADI, Nancy-Université, Nancy, France, [3]Global Applied Science Laboratory., GE Healthcare, Nancy, France, [4]Physiology & Experimental Medicine, The Hospital for Sick Children, Toronto, Ontario, Canada, [5]Medical Biophysics, University of Toronto, Toronto, Ontario, Canada, [6]CHU de Nancy, Nancy, France, [7]U947, INSERM, Nancy, France

Introduction:

T_1 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 T_1 mapping remains a challenging problem. Techniques for T_1 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 T_1 measurement within a single breath-hold. However, it is a dedicated research sequence and T_1 values are interpolated from apparent T_1 values (T_1*). In this work, we are interested in determining a T_1 method based on standard clinical sequences (e.g. FLASH) at 3T and in estimating the true T_1 value. For this purpose, a variable flip angle (VFA) approach with integrates B_1 correction [3] was adapted to cardiac imaging on healthy volunteers. This study aims at evaluating the feasibility of myocardial T_1 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 T_1 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 (B_1) was performed from two EPI acquisitions (same parameters with FA_1/FA_2=60/120° and 120/240°) [3].

T_1 *measurements :*

A T_1 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 T_1 values. Because of misregistration and geometric distortions between SPGR and EPI sequences, B_1 correction was not applied on a pixel-wise basis. Thus, B_1 error was estimated on each ROI and used to correct myocardial T_1 values.

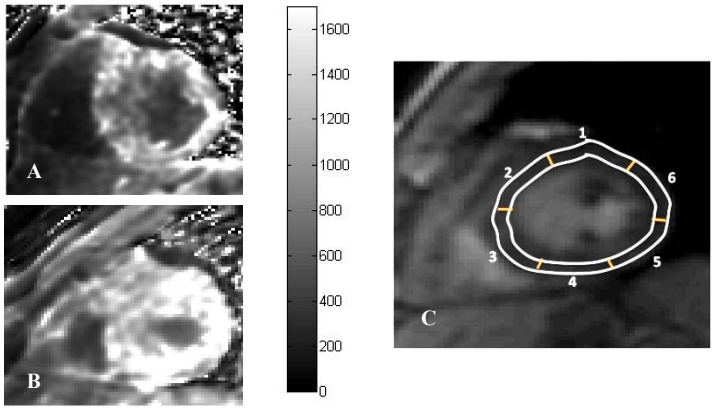
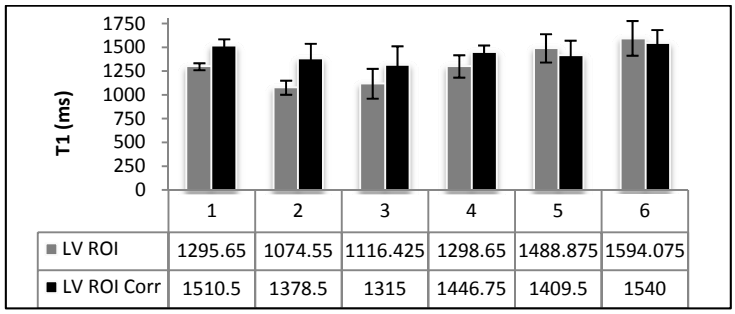


Fig.1: A and B: T_1 maps obtained on two healthy volunteers and C: left ventricle ROI for myocardial T_1 measurements.



	1	2	3	4	5	6
LV ROI	1295.65	1074.55	1116.425	1298.65	1488.875	1594.075
LV ROI Corr	1510.5	1378.5	1315	1446.75	1409.5	1540

Fig.2: Left ventricular T_1 values obtained on the volunteers (mean ± standard error of the mean). Comparison of raw (grey) and B_1-corrected (black) myocardial T_1 values

Results:

Fig.1. shows two T_1 maps before B_1 correction (volunteer 1(A) and 4(B)). Originally, T_1 values were not homogeneous over the whole myocardium. This can also be seen on myocardial values (Fig.2). Raw T_1 values ranged from 1074 to 1594 ms, the T_1 of two septal segments (2 and 3 on fig.1.C) being the lowest. Because of effective B_1 correction, corrected values T_1 were smoothed over the different segments compared to uncorrected ones. Indeed T_1 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 T_1 values ranged from 1315 to 1540 ms.

Discussion and conclusion:

In this study, the feasibility of myocardial T_1 measurements using VFA method has been demonstrated. B_1-corrected T_1 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 T_1 mapping is very sensitive to transmit field B_1 inhomogeneity [3]. Consequently our future works will focus on optimizing acquisition parameters to achieve pixel by pixel B_1 correction and acquiring additional sets of data.

References:

[1] Song et al., ISMRM2010, [2] Messroghli et al., MRM (2004), [3] Cheng et al., MRM (2006); [4] Odille et al., IEEE TBME (2007); [5] Cerqueira et al., Circulation (2002), [6] Stanisz et al., MRM (2005), [7] Oster et al., ICASSP (2008), [8] Fernandez et al., MRM (2010)