Myocardial T1 mapping using a faster Modified Look-Locker Inversion-recovery (fast-MOLLI) method on 3T MRI : Quantification of myocardial fibrosis in dilated cardiomyopathy (DCM)

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Introduction : Late gadolinium enhancement (LGE) is the widely used method to evaluate the myocardial fibrosis in various heart diseases. In the conventional LGE using the null-point method, image contrast relies on the difference in signal intensity between fibrotic and "normal" myocardium. However, such difference may not be detected if the fibrosis is diffuse. Therefore, we consider that the conventional LGE has a limitation in diagnosis of diffuse interstitial fibrosis such as dilated cardiomyopathy (DCM). Myocardial T1 mapping allows us to enable direct myocardial signal quantification and has potential for a better characterization of myocardial tissue composition. In this study, we evaluated the pre-contrast and post-contrast myocardial T1 in patients with DCM compared with normal myocardium, using a faster Modified Look-Locker Inversion-recovery (fast-MOLLI) method on 3T MRI.

Methods : 3 patients with normal myocardium (1 single vessel ischemia and 2 conduction abnormality) and 6 patients with DCM underwent gadolinium-enhanced cardiac MRI at 3T clinical machine (MAGNETOM Verio, Siemens AG Healthcare Sector, Erlangen, Germany). Fast-MOLLI was performed at short-axial slice in basal and mid-ventricular level at pre-contrast, post-contrast 3minutes and 21 minutes. Fast-MOLLI was implemented as a two inversion recovery (IR) sequence with the first of 3 and the second of 5 consecutive image acquisitions, decreasing by about one-third the acquisition time compared with original-MOLLI method. T1 map was reconstructed using 8 source images with different inversion time. SSFP (True-FISP) sequence was used for readout (single-slice, single-shot, TE/TR=1.1/2.5msec, flip angle 35°,FOV 320x223mm, matrix 192x256 and slice thickness 8mm). The T1 map was divided into 6 segments, and fan-shaped ROIs were set in each segment (Figure 1). Then, segment-based T1 was measured. LGE in the 9 patients was also performed with IR True-FISP (fixed inversion time=350msec) at 2, 5, 10 and 20 minutes after gadolinium administration. In DCM patients, presence or absence of LGE was decided visually for each segment on 10 minutes delayed image.

Results : Figure 2 showed the mean T1 of normal myocardium, and visually unenhanced and enhanced myocardium in DCM at pre-contrast and post-contrast scan. Pre-contrast mean T1 of normal myocardium in this study (1146±43msec) was similar to that of healthy normal volunteer study (1140±43msec, not presented here). Pre-contrast T1 of visually unenhanced segment in DCM (mean T1 : 1255±50msec) was significantly longer than that of normal myocardium ($p<0.01$). Post-contrast T1 at 3minutes and 21 minutes delayed scan of visually unenhanced segment in DCM (mean T1 : 379±39msec and 623±56msec, respectively) was significantly shorter than that of normal myocardium (mean T1 469±50msec and 738±38msec, respectively) ($p<0.01$). The increment of R1 (=1/T1) after gadolinium administration, indicating concentration of gadolinium in tissue, correlated to pre-contrast T1 ($r=0.68$ at 3min, $r=0.64$ at 21min, $p<0.01$) (Figure 3).

Discussion and Conclusion : To our knowledge, this is the first study to evaluate the fibrosis of DCM using T1 mapping. In patients with DCM, apparently unenhanced myocardium in LGE images showed a longer pre-contrast T1 and a shorter post-contrast T1 than normal myocardium. Our results suggest that pre-contrast T1 mapping using fast-MOLLI without administration of gadolinium could detect the diffuse fibrotic change that is difficult to detect in only the conventional LGE image using null-point method. Myocardial T1 map will be of great help to better understand and diagnose the underlying cardiomyopathic process. Further studies are needed to put T1 mapping to practical use, such as monitoring of therapeutic effect and prognostic information.

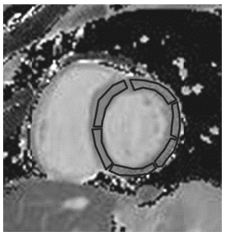

Figure 1. The T1 map was divided into 6 segments at each slice, and T1 was measured for each ROI.

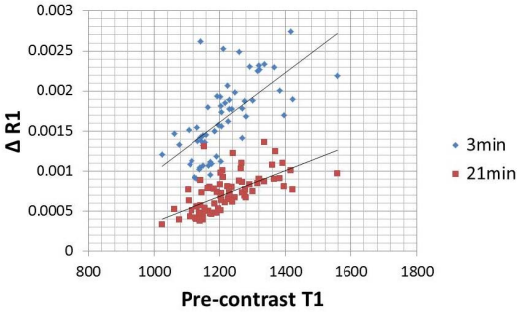

Figure3. Correlation between pre-contrast T1 and ΔR1 (the change of R1(=1/T1) between pre-contrast and post-contrast).

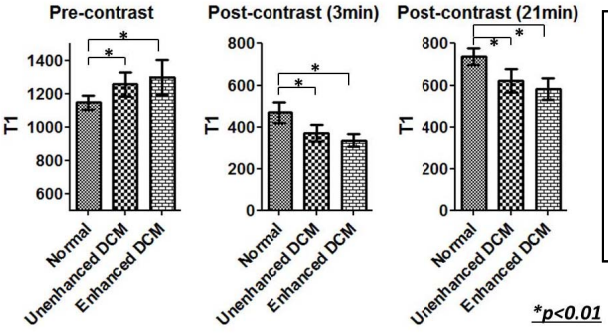

Figure 2. Mean T1 of normal myocardium, unenhanced and enhanced myocardium in DCM at pre-contrast and post-contrast (3minutes, 21minutes).

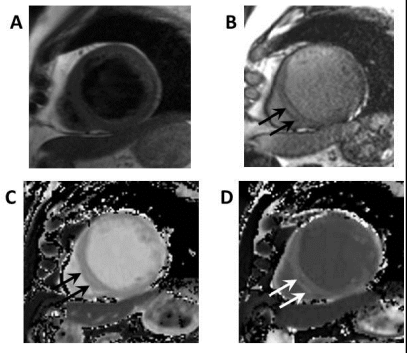

Figure 4. A case of DCM. (A) T1-weighted image, (B) LGE, (C) Pre-contrast T1 map, (D) Post-contrast (21 minutes) T1 map.
LGE demonstrate mid-wall enhancement in inferoseptal segment (arrow). T1 of inferoseptal segment in pre-contrast and post-contrast are 1343 and 616 msec, respectively. In unenhanced myocardium except inferoseptal segment, pre-contrast mean T1 (1310 msec) is higher than normal myocardium, and post-contrast T1 (658 msec) is lower than normal myocardium.