Evaluation of Extracellular Volume with limited T1 mapping planes using MOLLI technique

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INTRODUCTION

T1 relaxation time is an intrinsic magnetic property of a tissue. In cardiac MR imaging, each tissue type exhibits a characteristic range of normal T1, and deviation from the normal rang may be indicative of disease *(JCMR 2013;15:13)*. Recent published reports have shown that T1 measurement can reduce the subjectivity, and detect global pathological changes within the heart. T1 value of myocardium pre-contrast administration is associated with edema which may be related to the inflammatory response to myocardial injury; a shortened T1 value post-contrast administration is associated with fibrotic scar or diffuse fibrosis. Since T1 measurement is affected by multiple factors, such as dose and type of contrast, time after contrast administration, renal clearance, extra-cellular volume (ECV) calculation can eliminate part of these dependencies. Modified Look-Locker Inversion (MOLLI) sequence has been reported used for cardiac T1 mapping to evaluate multiple cardiac pathologies *(JMRI 2007;26:1081-1086)*. Recently, the T1 mapping sequence has been added to our routine cardiac MR work up protocol in one of our MR scanners. Under this protocol, T1 mapping images were acquired before and after double dose gadolinium-based contrast administration in only one or two planes to avoiding increasing scan time too much. Pre- and post- contrast T1 values of myocardium and blood were measured, and the contrast ECVs of myocardium were calculated. This retrospective review is to assess the effects of T1 mapping and ECV calculating for multiple cardiac pathologies under this cardiac work up protocol.

MATERIALS AND METHODS

Subjects: Eighty-eight patients (M= 52, F=36, mean age = 54 ± 18) were included in this study. Cardiac MR (CMR) imaging was performed for all case at a 1.5 T MR scanner (Magnetom Avanto, Siemens) with body matrix and spine matrix coils.

T1 mapping: In addition to routine sequences for cardiac work up, breath hold MOLLI acquisitions were applied before and after contrast administration (0.2 mmol / kg of gadobutrol [Gadavist, 1 mmol / mL] Bayer Healthcare Pharmaceuticals Inc, Wayne, NJ 07470) for T1 mapping. In the beginning of the study, only mid-short axis plane was obtained. In the later time mid-4 chamber view was also obtained. The post contrast T1 mapping data were acquired at 13.4±4.2 (range of 10 – 28) minutes after contrast bolus. The parameters of MOLLI sequence were TR/TE = 740/1.06 ms, FOV = 340mm, slice thickness = 8mm, voxel size = 2.2 × 1.8 × 8 mm. Time of the acquisition = 17 heat beats. T1 maps were obtained inline after motion correction.

ECV calculation: Standard ROIs for T1 measurement were placed on ventricular septum and blood pools of left and right ventricle. Additional ROIs were made when needed. ECVs of myocardium were calculated with a formula: ***ECV=1.05*(1-Hct)/100*λ-0.045*** in which, partition coefficient ***λ = (r1myo post –r1myo pre) / (r1 blood post – r1 blood pre)*** *(JCMR 2011;13:16)*. For each subject, a hematocrit (Hct) value obtained most closed to the time of the CMR study was used for ECV calculation.T1 values of blood / myocardium and myocardial ECV values were compared based on the diagnosis of cardiac MR imaging.

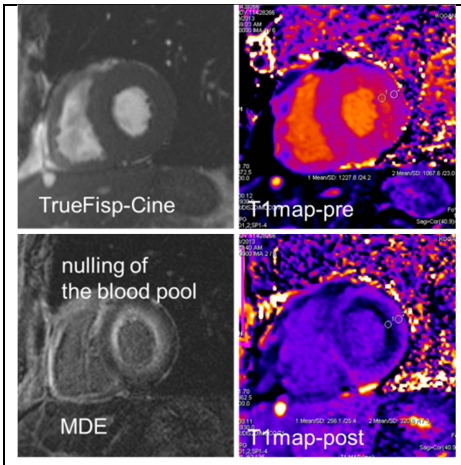

Figure 1. ECV values in a case of amyloidosis: V. septum = 58.18%; Sub-endocardial = 72.48%; Sub-epicardial = 49.82%

RESULTS AND DISCUSSION

Table 1. T1 and ECV values

	number of patients	T1 Blood (pre-Gd)	T1 Myo (pre-Gd)	T1 Blood (post-Gd)	T1 Myo (post-Gd)	ECV %
Unremarkable-All	**31**	1530 ± 60.7	993.7 ± 40.7	219.6 ± 32.6	359.2 ± 44.4	24.0 ± 3.5
Cardiomyopathy	**23**	1527 ± 81.5	1015 ± 36.0	213.4 ± 23.2	342.4 ± 53.4	26.3 ± 5.9
Infiltrative cardiomyopathy	**5**	1513 ± 100.2	1029 ± 111.3	258.6 ± 38.8	327.0 ± 26.9	37.2 ± 14.3
GV/Valvular disorders	**11**	1510 ± 60.2	988.9 ± 33.6	224.0 ± 28.7	346.5 ± 55.4	25.7 ± 5.6
Pericardil & other	**18**	1549 ± 123.2	993.0 ± 47.6	216.2 ± 33.4	351.9 ± 63.2	24.4 ± 4.7
Total	**88**	1529 ± 83.3	1001 ± 46.8	220.1 ± 31.4	349.9 ± 49.2	25.6 ± 6.3

Average T1 and ECV values based on the standard ROIs at ventricular septum are shown in Table 1. Our results suggested that

- Patients with infiltrative cardiomyopathy (amyloidosis=3, sarcoidosis =2) show highest average ECV value (37.2±14.3%) (Figure 1). This indicates that adding MOLLI T1 mapping sequence to a cardiac work up protocol is a simple and effective way to catch T1 and myocardial ECV message, even only limited planes (mid-short axis and mid-4chember view) were applied (to shorten the scan time).
- Patients with unremarkable (relatively normal) CMR results have lowest average ECV value (24.0±3.5%), in which, 22.5±3.0% for male and 25.2±3.4% for female. This difference is probably because male usually have higher Hct than female (42.5% vs. 38.6% in this study). This ECV value can be used as a reference range in practice. Patients with cardiomyopathy (ischemic=13, non-ischemic=10 in this study) or vascular dysfunction have higher average ECV values (26.3±5.9%, and 25.7±5.6% respectively).