Evaluation of myocardial viability in recent, sub-acute and chronic myocardial Infarction using 3.0T CMR quantitative T1, T2 mapping and multi-b DWI combined with LGE

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Target Audience: Cardiologist; Radiologist and researchers who interested in using cardiac magnetic resonance (CMR) T1, T2 mapping and multi-b diffusion weighted imaging (DWI) to evaluate myocardial viability.

Purpose: To evaluate myocardial viability using T1, T2 mappings, and multi-b DWI, and explore the characteristics of pre-contrast T1, ECV, T2 and ADC values for patients with recent, sub-acute and chronic myocardial infarction.

Background: T1, T2 mapping and multi-b DWI are novel CMR technologies with different advantages on myocardium viability evaluation. T1 mapping is sensitive on the detection of myocardial fibrosis, but the in-vivo myocardial T1 measurement is prone to be inaccurate and irreproducible due to many confounding factors. Therefore, a new biomarker, ECV, was elicited and could be computed through a formula, ECV = [lambda × (1 - hematocrit)], where ECV is the myocardial extravascular extracellular volume fraction, and lambda = [$\Delta R1_{myocardium}$]/[$\Delta R1_{blood\ pool}$] before and after gadolinium contrast[1]. T2 mapping is sensitive to the myocardial edema, which usually depicts the regions of risk, reversible with the execution of reperfusion[2]. From the IVIM theory, the DWI of low-b values can describe the perfusion of angiogenesis for tumor[3]. Thus, it is believable multi-low-b DWI can also be applied to depict the coronary microcirculation, which further determines the myocardial viability. To date, T1, T2 mappings, ECV and coronary perfusion has not been evaluated together for the patients with cardiovascular disease (CVD). In this study, we explore the correlation of the three methods for CVD patients with recent, sub-acute and chronic myocardial infarction.

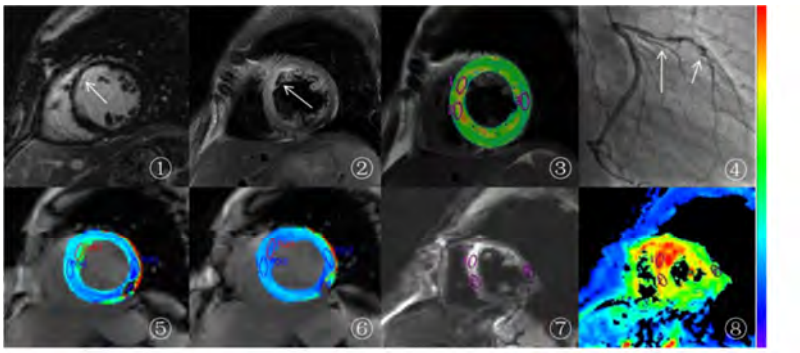

Figure 1. A recent MI patient with approximately 70% transmural anteroseptal myocardial infarction. A strip of high signal at the infarction region could be seen in LGE images, ①, and T2WI images ②. From the quantitative T2 mapping, ③, values of the infarction region, 103.3ms, much higher than the remote region, 59.4ms, which indicated myocardial edema happened. From the coronary angiography, ④, moderate to severe stenosis of the proximal and middle left anterior descending artery that supplies the anteroseptal wall observed. The measurements of pre-, ⑤, and post-contrast, ⑥, T1 mapping permit CRT and ECV computation. The signal intensity at DWI, ⑦, and the ADC value of the infarction zone, ⑧, are both higher than the normal regions.

Table 1 Measurements (mean±SD) of LV zones in groups of MI patients

Zone	Values	Recent MI	Subacute MI	Chronic MI
Infarction	ECV	0.511±0.111	0.289±0.164	0.075±0.154
	T2(ms)	101.59±10.33	79.47±8.51	64.94±12.51
	ADC(mm^2/s)	0.014±0.0026	0.0096±0.0030	0.0079±0.0018
	PreT1(ms)	1110.6±148.8	852.7±596.9	471.1±84.7
Around the infarction	ECV	0.292±0.121	0.063±0.262	-0.437±0.194
	T2(ms)	98.23±24.21	75.44±13.56	65.27±9.46
	ADC(mm^2/s)	0.012±0.0033	0.011±0.0020	0.0092±0.0020
	PreT1(ms)	856.5±156.1	732.9±530.1	505.8±132.1
myocardium remote	ECV	0.158±0.154	0.045±0.208	0.042±0.148
	T2(ms)	72.36±14.37	64.38±8.00	66.41±8.36
	ADC(mm2/s)	0.011±0.0022	0.0110±0.0022	0.011±0.0026
	PreT1(ms)	725.0±62.0	555.8±254.4	543.7±98.7

Methods: 15 MI patients, including 3 recent (< 8 days), 6 sub-acute (9-90 days), and 6 chronic (> 90 days), with consent written were recruited for the study. The CMR exams were performed on a 3T scanner (GE MR750) with an 8-channel chest coil, including conventional CINE, T2WI, first-pass perfusion, late gadolinium enhancement (LGE), T1, T2 mapping, and multi-b DWI (b=0, 20, 60, 100, 150, 200 s/mm^2) sequences. Figure 1 illustrates the whole package of the MR and coronary angiography examinations of a recent MI patient. According to the results of LGE and T2 mapping, the parametric mappings were segmented into the infarcted region, regions around infarction and remote region. The value of four parameters at each region was transversely averaged and statistically analyzed with receiver operator characteristic (ROC) analysis.

Results: As shown in Table 1, the PreT1 and ECV of the infarction zone in resent MIs and sub-acute MIs were higher than the normal myocardium, while no much difference in chronic MIs. T2 in the infarction zone of resent MIs and sub-acute MIs were higher than the normal myocardium, but similar to around the infarction zone. No significant differences of T2 values were observed in chronic MIs. For ADCs, no difference was observed for remote myocardium, but for infarction the ADC of recent MI > ADC of subacute MI > ADC of chronic MI. In general, the values in infarction zone and at recent MI were significantly different with those of sub-acute and chronic MIs, especially for ECV and T2 values. Figure 2 depicts the ROC curve in MIs, the area under the curve of pre-T1, ECV, T2 and ADC is respectively 0.552, 0.720, 0.638 and 0.356. Among these values, one can see the ECV value has the higher sensitivity and specificity.

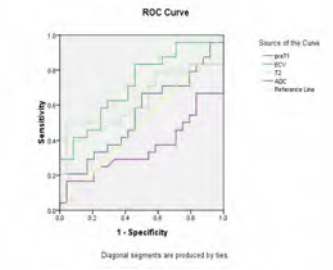

Figure 2 Receiver operator characteristic curves for the detection of myocardial infarction by pre-contrast T1mapping, ECV, T2 mapping and ADC, as reference to the results of LGE.

Discussion & Conclusion: T1, T2 mappings and multi-low-b DWI are sensitive techniques to diagnose MI especially resent MI. The MR findings, e.g. pre-T1, ECV and T2, of the infarction zone are significantly different in resent, sub-acute and chronic of MIs, which are of great value for clinical practice. From this preliminary study, it is not hard to quantitatively identify the infarcted myocardium from the normal. But, the parametric characteristics of the reperfusion reversible myocardium around the infarction zone still need a large number of examinations to figure out, which is our ongoing study. It's been demonstrated ECV has a high correlation with MIs much closer to the findings of LGE comparing with other parameters. Though the variation of ADC values isn't obvious, it reflects some information of perfusion-like microcirculation of coronary system. The high signal of damaged myocardium in multi-low-b DWI can be used in a screening of acute chest pain to get rid of MI, and even the differences in ADC values could be helpful to identify resent MIs from subacte and chronic MIs.

References: 1 Jean-Pierre L, et al., JMRI (2013)；2 Valentina OP, et al., JACC: CARDIOVASCULAR IMAGING，NO. 4, 2013. 3 Messroghli DR, et al. MagReson Med 2007;58:34-40; 4 David V, et al. JACC: CARDIO VASCULAR IMAGING VOL. 4, NO.3, 2011;