Quantitative changes in T2* reflect remodeling of both remote and ischemic myocardium in a murine heart failure model

Eissa Aguor1, Cees van de Kolok1, Pieter A.F.M Doevendans1, Gustav Strijkers2, and Fatih Arslan1
1Cardiology, UMC, Utrecht, Utrecht, Netherlands, 2Department of Biomedical Engineering, Eindhoven University of Technology, Eindhoven, Netherlands

Introduction: Heart failure is an increasing burden to western societies due to aging and increased survival of patients suffering from myocardial infarction. Early identification of adverse structural changes in the myocardium may optimize clinical management. Late Gadolinium enhancement (LGE)-MRI is widely used to assess infarct size and myocardial fibrosis. We have recently shown that quantitative T2* mapping can provide additional information on infarct status and changes in the infarcted myocardium in relatively small murine infarctions after ischemia/reperfusion injury1. In this study, we further explored quantitative changes in T2* in both infarcted and remote myocardium in a murine heart failure model induced by severe myocardial infarction.

Materials and Methods: Mouse model Myocardial infarction (MI) was surgically induced in C57Bl/6J mice (n=12) by permanent ligation of the left coronary artery. MRI protocol MRI at 9.4 T was performed at baseline, 1, 7 and 28 days after surgery. The protocol consisted of Cine-MRI, multi-gradient echo T2* mapping and LGE. A slice was positioned at the mid-ventricle lower papillary muscle level in mid-diastolic phase to include an area of remote viable tissue as well as a substantial infarct area. T2*-mapping was performed using a cardiac triggered multi gradient-echo sequence, with the following parameters: TR=1 R-R interval, TE=1.22, 3.45, 5.68, 7.91, 10.14, and 12.37 ms, slice=1 mm, matrix=128×128, FOV=3×3 cm². In the same slice LGE measurements were performed with a cardiac triggered inversion-recovery segmented gradient echo sequence, with the following parameters: TI=160 ms, TR=5.8 ms, TE=2.2 ms, 16 segments, slice=1 mm, matrix=256×256, FOV=3×3 cm². In the same slice LGE measurements were performed with a cardiac triggered inversion-recovery segmented gradient echo sequence, with the following parameters: TI=160 ms, TR=5.8 ms, TE=2.2 ms, 16 segments, slice=1 mm, matrix=256×256, FOV=3×3 cm². Seven to 9 slices with inter slice distance of 1 mm were measured to cover the heart from apex to base. Analysis Pixel-wise quantitative T2* values were calculated in Mathematica 7 (Wolfram). Cine images were used to compute end-diastolic volume (EDV), end-systolic volume (ESV) and diastolic wall thickness (WT). Ejection fraction (EF) was calculated as 100%(EDV-ESV)/EDV. Infarct location was determined on the basis of the LGE measurements and the akinetic area observed on Cine images on day 1.

Results: Fig 1 shows a collection of representative T2* maps in the myocardium and corresponding LGE images at 1, 7 and 28 days after myocardial infarction, as seen in Fig 2, baseline myocardial T2* was 15.0±1.1 ms in the remote myocardium (septal wall) and 14.6±1.0 ms in the free wall. At day 1, LGE displayed a homogeneous enhancement of the infarction. In the same slice LGE measurements were performed with a cardiac triggered inversion-recovery segmented gradient echo sequence, with the following parameters: TR=6.8 ms, TE=1.9 ms, number of movie frames=15, slice=1 mm, matrix=256×256, FOV=3×3 cm². In the same slice LGE measurements were performed with a cardiac triggered inversion-recovery segmented gradient echo sequence, with the following parameters: TR=6.8 ms, TE=1.9 ms, number of movie frames=15, slice=1 mm, matrix=256×256, FOV=3×3 cm². Seven to 9 slices with inter slice distance of 1 mm were measured to cover the heart from apex to base. Analysis Pixel-wise quantitative T2* values were calculated in Mathematica 7 (Wolfram). Cine images were used to compute end-diastolic volume (EDV), end-systolic volume (ESV) and diastolic wall thickness (WT). Ejection fraction (EF) was calculated as 100%(EDV-ESV)/EDV. Infarct location was determined on the basis of the LGE measurements and the akinetic area observed on Cine images on day 1.

Conclusions: Quantitative T2* values changed dynamically in this murine heart failure model. T2* in infarcted areas exhibited a significant decrease starting from day 1, and further decreased with scar maturation. In contrast to our previous observations in relatively Quantitative changes in T2* reflect remodeling of both remote and ischemic myocardium in a murine heart failure model small murine infarctions, T2* in remote tissue also decreased significantly from baseline, most likely as a result of adverse ventricular remodeling of non-infarcted areas after MI. Serial LGE scans revealed merely changes in the infarct area, whereas the remote myocardium did not exhibit any dynamics in LGE assessments. In conclusion, quantitative T2* assessment may provide a valuable readout of both the infarct and remote areas in heart failure after MI.