BEYOND EDEMA: MYOCARDIAL T2 IN CHRONIC MYOCARDIAL INFARCTION SWINE
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Target Audience: Cardiologist, Cardiac MRI scientist, Clinicians

Introduction:
T2 correlates with pathologic processes within myocardial tissue. Recently, quantitative T2 mapping has been shown more robust than qualitative clinical T2-weighted (T2W) imaging in many diseases though most effort has been directed at acute injury and visualization of edema.2,3 Chronic myocardial infarction (MI), can also demonstrate altered T2, as the fibrotic scar tissue, mainly consisting of collagen, increases the interstitial space per unit volume.3 Yet there are limited reports of measurement of T2 in chronic MI.4,5 In this work, we explore quantitative T2 measurement as a way to characterize chronic MI without extraneous contrast agent.

Methods:
Animal Model: Reperfused MI was induced by 120 min occlusion of the middle left anterior descending coronary artery in N=5 Yorkshire swine (37-45 kg). Imaging was performed 14-16 weeks post-MI. MRI: 3D whole-heart free-breathing T2-mapping,9 consisting of interleaved volumes were acquired with T2Prep TEs = 0, 25, 45 ms (TR/TE 4/1.2 ms, flip angle 18°, 1.25×1.25×5.0 mm3 voxels interpolated to 0.98×0.98×5 mm3). After in vivo MRI acquisitions one of the animal received second contrast injection and was excised. The heart was scanned with T1-weighted (T1W) spoiled gradient echo (SPGR) sequence about 1 hr post infusion for infarct identification (TR/TE 12/2.2 ms, flip angle 18°, voxel size 0.25×0.25×0.5 mm3). Histology: The heart was fixed and fully preserved in 10% formaldehyde. After preservation, the heart were sliced and photographed and histology with Masson’s Trichrome staining was obtained. Post processing: 3D T2 maps were calculated per voxel using linear regression of the log of the signal and poor fits (R^2<0.9) were rejected. Representative apical/middle/basal slices were chosen from each case for quantitative comparison. 90 radial segments of each slice (total 1350 segments of each type of images) were made to extract the mean T2 or signal intensity (SI) from T2 maps and LGE images. Otsu’s method[8] was used to compute a global threshold which maximized the separability of classes in gray levels to differentiate MI from normal myocardium in LGE. Average T2 value from infarct and normal area was analyzed by unpaired 2-tailed Student’s t-test with significance defined as p<0.05.

Results:
Chronic infarct was detected in all animals by LGE. T2 map showed excellent correlation with the myocardial distribution of infarct as evidenced by elevated T2 and the correlation with hyper-enhanced infarct area from LGE (Fig 1). T2 in infarct was significantly higher than that of normal myocardium (62.9±14.1 ms v.s. 46.3±4.7 ms, p = 0.0002) (Fig 2). High spatial resolution T2 mapping enabled heterogeneity detection in and around the infarct area. Figure 3 showed that collagen penetrated into normal myocardium at the border zone of infarct in T2 map (Fig 3A and B), which excellently matched with the ex vivo T1W image and histology. Fine fibrosis structure can be appreciated in the zoomed in images (Fig 3 B and C) and the corresponding histology (Fig 3D).

Discussion:
The exact mechanism of myocardial T2 enhancement in chronic scar is not completely understood. In scarred myocardium, both water and collagen content have an impact on relaxation times. The relative water content and its distribution impact T2 measurements. Water in myocardial scar tissue might be also more mobile than those in healthy myocytes.6,9 In addition, there is a positive relationship between collagen content and T2 measurements in cardiac muscles, in contrary to skeletal muscles and tendons.10,11 This might explain at least in part, the differences between the various tissues. It is not known yet, however, if T2(W) is suitable to differentiate acute and chronic MI.4,5 In this work, we explore quantitative T2 measurement as a way to differentiate chronic MI from normal myocardium in LGE. Average T2 value from infarct and normal area was analyzed by unpaired 2-tailed Student’s t-test with significance defined as p<0.05.

Conclusion:
Myocardial T2 mapping has the potential to noninvasively characterize chronic MI size, location and transmurality without exogenous contrast agents. The observed changes in T2 may generally apply to any collagenous scar tissue, an important idea since collagen, though present in relatively small amounts even in normal tissue, strongly influences cardiac function.12 Hence, native T2 is a promising imaging probe to assist the further understanding on the myocardial tissue characterization.