Endogenous assessment of chronic myocardial infarction with T1ρ-mapping in patients

Joep van Oorschot[1], Hamza El Aidi[1], Fredy Visser[2], Pieter Doevendans[1], Peter Luijten[1], Tim Leiner[1], and Jaco Zwanenburg[1]
[1]*University Medical Center Utrecht, Utrecht, Utrecht, Netherlands,* [2]*Philips Healthcare, Best, Noord-Brabant, Netherlands*

Purpose

To test the feasibility of native cardiac $T_{1\rho}$-mapping in patients with chronic myocardial infarction (MI), and to investigate the accuracy of scar detection by correlation with the established standard of reference for scar detection, Late Gadolinium Enhancement (LGE).

Background

Detection of cardiac fibrosis based on endogenous MR characteristics could overcome drawbacks associated with the use of contrast agents (CA), such as the need for a substantial delay between injection and image acquisition and adverse renal effects[1]. In addition, a quantitative measurement independent of CA concentration, renal function and timing, could be beneficial for use in follow-up studies. In *ex vivo* MI tissue, it has been shown that the $T_{1\rho}$ relaxation time is sensitive to changes in macromolecular content, and that a significantly higher $T_{1\rho}$ is found in the MI region[2]. Studies in animal models of chronic MI showed the first *in vivo* evidence for the ability to detect myocardial fibrosis with $T_{1\rho}$-mapping[3,4]. This study is the first proof of principle of cardiac $T_{1\rho}$-mapping for detection of chronic MI in patients.

Methods

Patients: 21 patients (19 M, 2 F, age 55 ± 9 years) underwent cardiac MRI 2 to 12 months after clinically confirmed myocardial infarction. The study was performed on a Philips Achieva 1.5 T MR scanner (Philips Healthcare), using a 5-channel cardiac receive coil. Written informed consent was obtained from all patients. Five healthy young control subjects (5 male, age 25 ± 3 years) were imaged to confirm measurement of the remote tissue.*In vivo MR:* $T_{1\rho}$-mapping was performed using a $T_{1\rho}$-prepared steady-state free precession (SSFP) sequence. 4 images with different spin-lock (SL) preparation times with amplitude of 750 Hz were acquired (SL = 1, 13, 27, 45 ms). Other parameters: bandwidth/pixel = 530 Hz, TE/TR = 1.94/3.9 ms, resolution = 1.5 x 1.65 mm, slice thickness = 6 mm, FOV = 288x288 mm^2, flip angle = 50 degrees, 2 TFE shots, NSA = 2, SENSE = 1.5. Images were acquired in late diastole during expiration breath holds, with an R-R interval of 3 beats. LGE MRI was performed 15 minutes after contrast injection (0.2 ml/kg contrast agent (Gadovist). (TI = 300-340 ms, TE/TR = 3.5/7.1 ms, resolution = 1.5 x 1.65 mm, slice thickness = 6 mm, FOV = 288x288 mm^2, flip angle = 25 degrees, 5 shots).

Analysis: $T_{1\rho}$-maps were calculated by pixelwise fitting of a mono-exponential decay function in Matlab (Mathworks). LGE images and $T_{1\rho}$ maps were scored using the 17 segments AHA-model[5].

Results

In chronic MI patients $T_{1\rho}$ relaxation time was significantly higher in the infarct region (79 ± 11 ms), compared to healthy remote myocardium (55 ± 6 ms), $p<0.0001$. In healthy controls mean $T_{1\rho}$ relaxation times were also significantly lower compared to the infarct region in patients (50 ± 3 ms), $p < 0.0005$). In patients, myocardial regions with elevated $T_{1\rho}$ relaxation time corresponded closely with areas of delayed enhancement (Figure 1). A sensitivity of 0.77 and a specificity of 0.73 was found for $T_{1\rho}$-mapping compared to LGE imaging (table 1).

Nr segments:	LGE positive	LGE negative	
$T_{1\rho}$ positive	72	63	0.53 (positive predictive value)
$T_{1\rho}$ negative	21	171	0.89 (negative predictive value)
	0.77 (sensitivity)	0.73 (specificity)	

Table 1: Score LGE versus $T_{1\rho}$ in patients with chronic MI (n=21), using the 17 segments AHA-model.

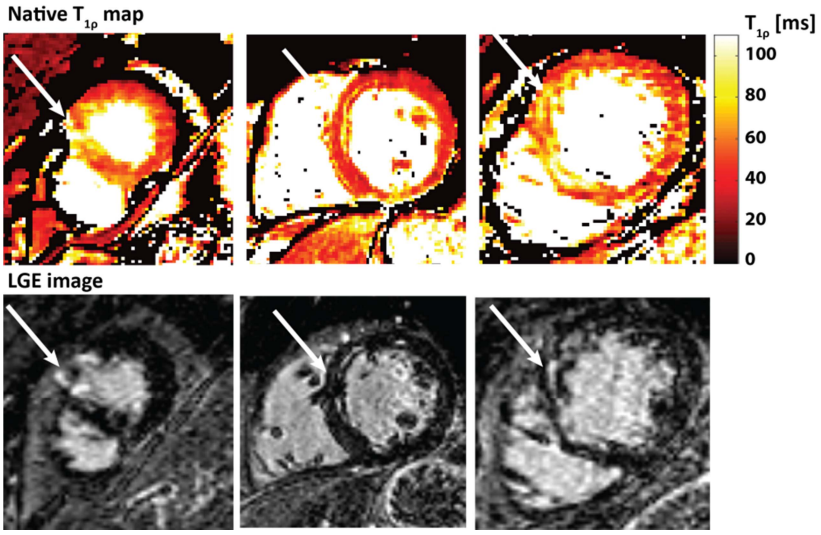

Figure 1: Short axis $T_{1\rho}$-maps with corresponding LGE images in 3 different patients. Arrows indicate the infarcted area.

Discussion

We have demonstrated that $T_{1\rho}$-mapping enables detection of scar tissue in patients with myocardial infarction without the use of a contrast agent. To our knowledge, this is the first report of *in vivo* detection of chronic myocardial infarction in patients with $T_{1\rho}$-mapping. $T_{1\rho}$ is assumed to be sensitive to changes in macromolecular content. It is unknown however if the increase in $T_{1\rho}$ directly reflects an increase of collagen in scar tissue. Further research should be performed on the underlying principle of myocardial fibrosis formation on the myocardial $T_{1\rho}$ relaxation time constants. Although the sensitivity of $T_{1\rho}$ mapping is lower than LGE imaging, there is room for improvements on the $T_{1\rho}$ mapping sequence that could provide a higher sensitivity and specificity, such as black blood imaging and performing the series of SL times in a single breath hold.

Conclusion

We have shown the feasibility of native $T_{1\rho}$-mapping for detection of infarct area in patients with a chronic myocardial infarction. We believe that $T_{1\rho}$ mapping could provide additional information on myocardial tissue characteristics, and be used in the clinic along with quantitative T_1, T_2 and ECV mapping methods.

References: [1]Oorschot et al. *JMRI* (2014) [2]Oorschot et al. *Proc. Int. Soc. Magn. Reson. Med.* 3069 (2012) [3]Witschey et al. *JCMR.* (2012) [4]Musthafa *et al. JCMR* (2012)