Endogenous assessment of diffuse myocardial fibrosis with T1ρ-mapping in patients with dilated cardiomyopathy

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Purpose

To validate cardiac $T_{1\rho}$-mapping in patients with dilated cardiomyopathy (DCM), and correlate with ECV-mapping.

Background

It has been shown that quantitative methods such as T_1 mapping and extracellular volume (ECV) mapping provide information on diffuse fibrosis formation in patients with DCM[1]. The main drawback of these methods is the need of a gadolinium based contrast agent, with the need for a substantial delay between injection and image acquisition and possible adverse renal effects. The $T_{1\rho}$ relaxation time is known to be sensitive to changes in macromolecular content, and recently it was shown that a significantly higher $T_{1\rho}$ is found in compact myocardial fibrosis after chronic myocardial infarction[2,3]. In this study we show the feasibility of native $T_{1\rho}$-mapping for the detection of diffuse myocardial fibrosis, without the use of a contrast agent.

Methods

Ex vivo study: Three explanted hearts from DCM patients, who received heart transplantation, were sectioned in slices and scanned within 24 hours on a clinical 3T MR scanner (Philips Healthcare). $T_{1\rho}$-mapping was performed using a $T_{1\rho}$-prepared 3D gradient echo sequence. 5 images with different spin-lock (SL) preparation times with an amplitude of 500 Hz were acquired (SL = 1, 10, 20, 30, 40 ms). Other parameters: TE/TR = 1.66/3.3 ms, resolution = 0.75 x 0.75 mm^2, slice thickness = 0.75 mm, flip angle = 10 degrees. After MR Imaging heart slices were formalin-fixed, cut into small pieces, and stained with Masson's Trichrome for collagen assessment. Histological fibrosis in each piece were quantified in Matlab, and compared to the corresponding $T_{1\rho}$ value. *In vivo* study: Six DCM patients underwent a MRI exam before implantation of a left ventricular assist device (LVAD), on a Philips Achieva 1.5 T MR scanner, using a 5-channel cardiac receive coil. Five healthy young control subjects (5 male, age 25 ± 3 years) were scanned to confirm measurement of the remote tissue. Written informed consent was obtained from all subjects. A $T_{1\rho}$-map was obtained by acquiring 4 images with different SL preparation times (amplitude 750 Hz, 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^2, 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. In the patients corresponding T_1 maps were acquired before and 15 minutes after contrast injection (0.2 ml/kg Gadovist), using MOLLI 3(3)5 scheme[4] and blood was drawn to determine hematocrit.

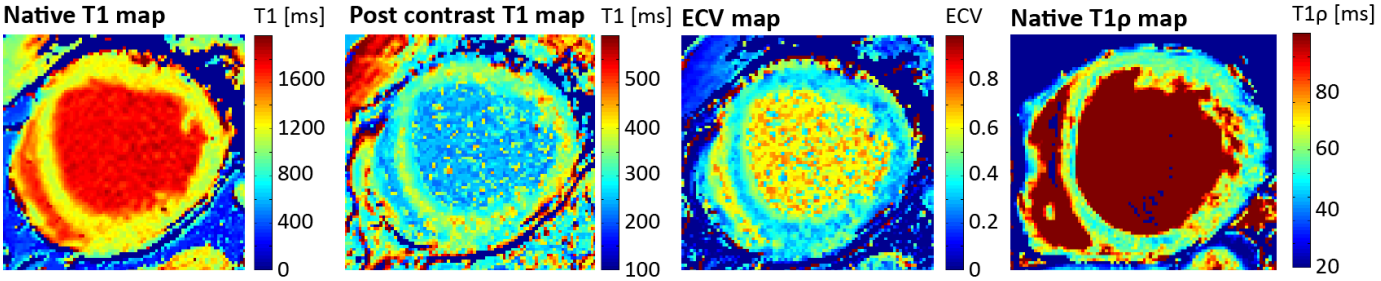

Figure 1: *In vivo* short axis pre- and post-contrast T1-map and resulting ECV-map, with corresponding $T_{1\rho}$-map in a DCM patient.

Results

$T_{1\rho}$ relaxation time was significantly higher in the DCM patients (59.5 ± 4 ms), compared to healthy young controls (50 ± 3 ms), p<0.0001. Mean left ventricular ejection fraction in the DCM patients was 23.7 ± 10%, and mean ECV was 0.25 ± 0.06. Positive trends for the *ex vivo* $T_{1\rho}$-relaxation time vs. the fibrosis fraction and for the *in vivo* $T_{1\rho}$-relaxation time vs ECV were found (Fig 2), however, these were not significant (P=0.12 *ex vivo*, and P=0.45 *in vivo*).

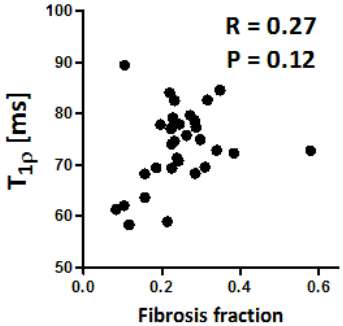

Fig. 2a: Pearson correlation $T_{1\rho}$ time and *ex vivo* fibrosis in explanted DCM hearts

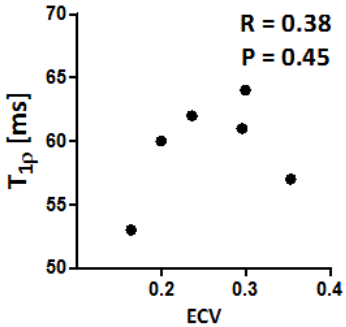

Fig 2b: Pearson correlation $T_{1\rho}$ time and *in vivo* ECV in DCM patients

Discussion

A significant higher $T_{1\rho}$-relaxation time was found in DCM patients, compared to healthy subjects. This increase in $T_{1\rho}$-relaxation time might be caused by diffuse myocardial fibrosis. However, no significant correlation was observed between the $T_{1\rho}$-relaxation times *and ex vivo* histology and *in vivo* ECV values. This may partly be due to the difficulty in exact matching of the ex vivo histology results with the MRI results. We do however observe a trend in the relation, and believe that this could become significant in a larger study with more statistical power. Native $T_{1\rho}$ –mapping requires no separate pre- and post-contrast scan with corresponding waiting delays, and no hematocrit measurement. It is, therefore, easier to incorporate in a clinical protocol, compared to ECV-mapping.

Conclusion

The $T_{1\rho}$ relaxation time was significantly higher in DCM patients, compared to healthy control subjects. We believe that $T_{1\rho}$ mapping could provide additional information on diffuse myocardial fibrosis formation.

References: [1]Kellman et al. JCMR (2012) [2]Oorschot et al. Proc. ISMRM (2012) [3]Musthafa et al. MRM (2012) [4]Messroghli et al. JMRI (2007)