Noninvasive assessment of myocardial fibrosis using Cardiovascular Magnetic Resonance (CMR) T1rho-mapping techniques in End-Stage Renal Disease (ESRD) hemodialysis patients

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TARGET AUDIENCE

This study is expected to provide information about myocardial fibrosis assessment to cardiologist as well as nephrologists.

PURPOSE

To determine whether T1rho imaging can be used as a noninvasive method with no contrast enhancement to detect myocardial fibrosis in End-Stage Renal Disease (ESRD) maintained on hemodialysis patients.

METHODS AND MATERIALS

The study was approved by the local Ethics Review Board. Forty volunteers (20 males and 20 females, with the mean age of 38.7 ± 13.1 years old, range 19 to 66) and 27 ESRD patients undergoing standard dialysis (13 males and 14 females, average 49.0 ± 12.6 years old, range 24 to 70, average dialysis duration 61.6 ± 58.3 months, range 3 to 216) were recruited. Patients with history of myocardial infarction and/or regional myocardial thinning as well as atrial fibrillation were excluded. All enrolled subjects gave their informed consent prior to the study. All sequences were triggered by ECG signal at end expiration breath-hold on a clinical 3T MR (Verio, Siemens Healthcare, Erlangen, Germany). A set of mid-ventricle slice T1rho weighted images of different spin lock time (TSL = 5, 12, 24, 36, 48ms respectively, spin lock amplitude (ν_1) = 400Hz) were acquired by a T1rho-prepared multi-shot gradient echo sequence from each subject. Then, a customized software was applied to generate T1rho map from each set of the T1rho weighted images (Figure1). T1rho value of the ventricular septum was measured by ImageJ (Version 1.47b 12 August 2012). Left ventricular (LV) short-axis cine sequences were also performed to acquire the LV mass which was normalized by body surface area on Siemens post-processing workstation. Statistics analyses were performed with SPSS version 18.0 for windows (SPSS Inc., Chicago, Illinois).

RESULTS

T1rho values had no correlation with age neither in control subjects group ($P = 0.491$) nor in patients group ($P = 0.061$), and had no relationship with dialysis duration ($P = 0.905$), while significant difference was observed between the two groups (patient：53.2 ± 4.2 versus control：48.7 ± 2.7, $P < 0.001$). The patients' LV mass was much higher than normal subjects (102.8 ± 24.7 VS 52.9 ± 9.6, $P < 0.001$) (Figure2).

DISCUSION

Autopsy studies[1] have revealed that interstitial myocardial fibrosis is pronounced in ESRD dialysis patients and the typical pathologic characteristic of the myocardium is left ventricular hypertrophy (LVH) and diffused collagen or fibrosis deposition in extracellular matrix. However, myocardial fibrosis is hardly evaluated with current modalities. Previous studies[2] manifest that extracellular volume (ECV), which is calculated based on T1-mapping techniques, can be applied to indirectly evaluate myocardial fibrosis, and becomes the most widely used biomarker. Moreover, Rudolph et al[3] employ late gadolinium enhancement Cardiovascular Magnetic Resonance (CMR) method to evaluate. These two methods are not appropriate to ESRD patients due to the contraindication of the contrast medium. Moreover, biopsy, the gold standard, is invasive and difficult to be accepted. Wang et al[4] confirm that T1rho can be used to assess the severity of the liver fibrosis in rat model, whilst Nishioka et al[5] demonstrate that the T1rho value changes was related to the cartilage degeneration. The advantage of T1rho is the sensitivity to detect the changes of the macromolecular substance content, such as collagen, fibrosis and proteoglycan. It is precisely because of the feature of the ESRD pathophysiology and mechanism of T1rho, myocardial fibrosis can be assessed in ESRD hemodialysis patients.

CONCLUSION

T1rho value is higher in ESRD dialysis patients than normal subjects and might be associated with myocardial fibrosis.

REFERENCE

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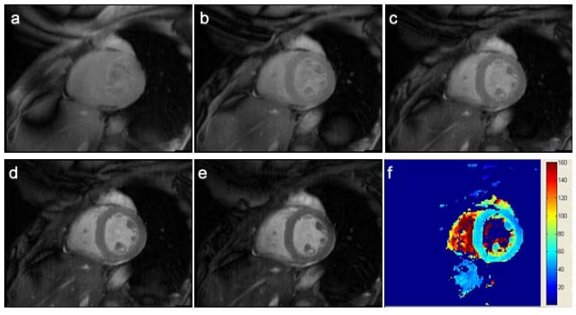

Figure 1. T1rho-weighted images of five TSL (5, 12, 24, 36, 48 ms, respectively, ν_1 = 400 HZ) in one representative patient (a – e). With the TSL increase, the SNR and CNR became better. T1rho map (f) is generated from multiple TSL images.

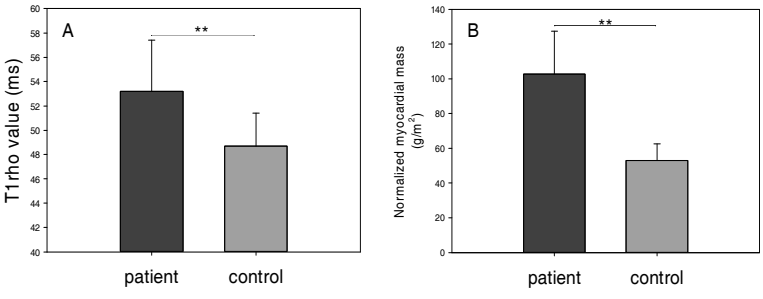

Figure 2. T1rho value (A) and normalized myocardial mass (B) are significantly different between the patient and control group ($P < 0.001$).