

A Comparative Study of Myocardial T1 Maps and PSIR Images in Measuring Extracellular Volume Fraction at 3T

Mao-Yuan Marine Su¹, Lian-Yu Lin², Chin-Cheng Chang³, Jiunn-Lee Lin², and Wen-Yih Isaac Tseng^{1,4}

¹Department of Medical Imaging, National Taiwan University Hospital, Taipei, Taiwan, ²Department of Internal Medicine, National Taiwan University Hospital, Taipei, Taiwan, ³Department of Internal Medicine, National Taiwan University Hospital, Taipei, Taiwan, ⁴Center for Optoelectronic Biomedicine, National Taiwan University College of Medicine, Taipei, Taiwan

Introduction

The extracellular volume fraction (ECV) in myocardium may be estimated from the ratio of concentration of Gd-DTPA in the myocardium to that in the blood (1). It has been shown to correlate well with diffuse myocardial fibrosis (2). Previous study has showed that measurement of signal intensity (SI) from reconstructed images of phase-sensitive inversion recovery (PSIR) to indicate ECV might detect diffuse myocardial fibrosis (3). Although this method is readily available for use in the clinical context but its accuracy still requires validation. T1 measurement of myocardium is a promising quantitative method to estimate ECV since its change of relaxation rate ($1/T1$) is directly proportional to concentration of Gd-DTPA. In this study, we examined the compatibility of myocardial T1 maps and PSIR images in measuring ECV at 3T by performing both techniques in patients with heart failure and normal controls.

Materials and Methods

Twenty-two patients with diastolic heart failure (DHF), seven patients with systolic heart failure (SHF) and eleven healthy volunteers (Control) were enrolled in this study. Myocardial T1 maps and PSIR images were acquired before and 10 minutes after the infusion of 0.1mmole/kg of Gd-DTPA on a 3T MR system (Siemens, Erlangen, Germany). Myocardial T1 maps were obtained from merged images by using an EKG-triggered modified Look Locker Inversion Recovery (MOLLI) pulse sequence. The MOLLI protocol used two inversion-recovery blocks to acquire 7 images over 9 heart beats (TR/TE/FA=740ms/1.1ms/35°, inversion time increment=80ms, matrix=256x192, slice thickness=6mm, spatial resolution=1.41mm and GRAPPA acceleration factor=2). Five short-axis planes were acquired to cover the whole LV. EKG-triggered PSIR images were following acquired (TI/TR/TE/FA=250ms/800ms/4.18ms/25°, spatial resolution=1.33mm) at the same short-axis slices as those in the myocardial T1 maps. For both T1 maps and PSIR images, the cavity and myocardium of the LV were segmented manually in the central area of the LV cavity and the septal myocardium on each image. The averaged T1 values and SI of the segmented regions were then computed. After subtraction with measurements from pre-contrast, the change of relaxation rate ($1/T1$) or SI in the LV cavity and in the myocardium were obtained. The ECV values were calculated using the ratio of the change in relaxation rate or SI in the myocardium to that in the LV cavity, and corrected for the heart rate and hematocrit. We averaged each ECV value over five short-axis slices for each subject, and compare them among each group. Data was presented in mean \pm SD. Differences from ECV among each group were compared using Dunn's multiple comparison test. The correlation between ECV measured from T1 maps and PSIR images was tested by Pearson correlation. A value of $p < 0.05$ was considered significant.

Results

For group comparison, SHF showed significant higher ECV than DHF and Control from T1 maps (0.31 ± 0.03 vs. 0.28 ± 0.02 , $p=0.004$; 0.31 ± 0.03 vs. 0.27 ± 0.03 , $p=0.003$) and PSIR images (0.30 ± 0.03 vs. 0.22 ± 0.03 , $p<0.001$; 0.30 ± 0.03 vs. 0.22 ± 0.04 , $p<0.001$). (Fig 1) There was no significant difference on ECV measurement between DHF and Control for both methods. A significant correlation was found on ECV measurement between two methods ($r = 0.50$, $p = 0.001$). (Fig 2)

Conclusion

The ECV measurement from myocardial T1 maps has been proposed as quantitative method for detection or quantification of diffuse myocardial fibrosis. In this study, we used the reconstructed image of PSIR to measure the myocardial ECV and examined the compatibility with T1 maps. Our data showed that ECV measured from PSIR images revealed equivalent results with that from T1 maps. The benefits of the PSIR reconstructed image include reduction of sensitivity in B1 field inhomogeneity, increased tolerance of T1, background noise reduction and nearly complete magnetization recovery (4). These benefits allow us to measure myocardial ECV directly from SI instead of T1 measurement. Therefore, we conclude that PSIR images provide compatible measurement of myocardial ECV as T1 maps at 3T.

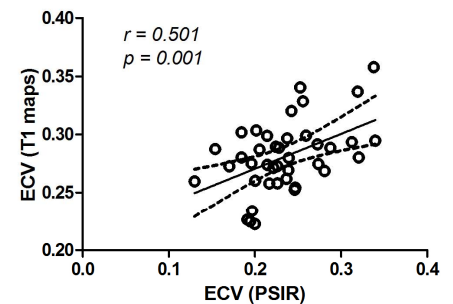
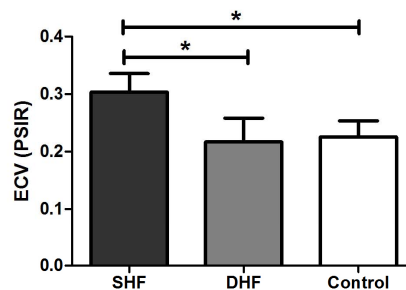
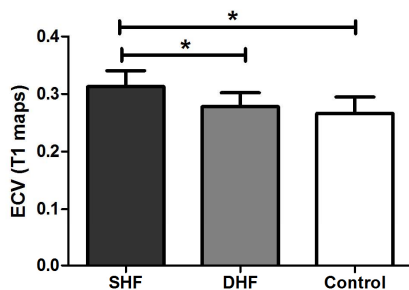


Fig 1. Group comparison among the patients with SHF, DHF and control subjects in ECV measured from T1 maps (left) and PSIR images (right).

Fig 2. Significant correlations between the ECV measured from T1 maps and the ECV measured from PSIR images.

References

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