Quantitative Assessment of Aldosterone-induced Myocardial Fibrosis by Cardiac Magnetic Resonance

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Introduction

The importance of aldosterone on cardiac damage has been focused on the myocardial fibrosis which is believed to cause diastolic dysfunction (1). Excessive deposition of collagen within the myocardium is a pathological process for the development of myocardial stiffness, it adversely influences the passive diastolic filling of the left ventricle (LV)(2). Cardiac cine MRI can measure the LV volume-time curves over a cardiac cycle, from which the chamber stiffness can be inferred from the time interval between the peak diastolic filling and the onset of diastasis (3). Late gadolinium enhancement (LGE) MRI has been widely used to show the fibrosis of the myocardium in various cardiac diseases (4). However, aldosterone-induced myocardial fibrosis is diffuse and microscopic and cannot to be detected on the images of LGE. In this study, we aimed to investigate whether the diffuse and microscopic fibrosis of the myocardium could be quantitatively assessed using LGE, and to study the relationships between quantified myocardial fibrosis and chamber stiffness in patients with primary hyperaldosteronism (PA).

Materials and Methods

Study protocol Twenty-two patients with PA (age 49.1 ± 14.3 years) and twelve age-matched healthy volunteers (48.7 ± 14.0 years) were enrolled. Blood samples for plasma aldosterone level were drawn after suspending medications. All subjects underwent both cine and LGE MR studies on a 1.5T MR system (Siemens, Erlangen, Germany).

Imaging acquisition The LGE imaging was performed before and after the Gd administration by using an EKG-triggered phase-sensitive inversion-recovery (PSIR) prepared segmented TurboFLASH (TI/TR/TE/FA=250ms/800ms/4.18ms/25°, spatial resolution=1.33mm). Three short-axis planes were acquired at basal, mid LV and apical levels. After the baseline study, gadolinium-DTPA was given by slow infusion (0.5 cc/sec) amounting to a total dose of 0.2 mmole/kg body weight. Cine MRI was performed using an EKG-trigger multiphase segmented TrueFISP (TR/TE/FA=3ms/1.6ms/60°, spatial resolution=1.25mm). Contiguous short-axis slices were prescribed from the left atrium top to the LV apex with slice thickness of 7 mm. Fifteen minutes after the infusion of contrast medium, second LGE MRI was acquired at the same short-axis slices as those in the baseline study.

Image analysis For Cine images, the subendocardial contours of short axial view were determined and the area enclosed by each contours was computed. The LV volumes for each time were then measured by sum of the areas of the corresponding levels multiplied by the slice thickness to obtain the volume-time curve of the LV. LV diastolic filling pattern is determined from the derivative of ventricular volume of the LV (dV/dt), and the time for deceleration (tdec), as index of chamber stiffness, is measured from the peak diastolic filling to the onset of diastasis. For LGE 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 signal intensities of the segmented regions were then computed. After subtraction from the baseline signal, the enhancements in the LV cavity and in the myocardium were obtained. The index of myocardial fibrosis, enhancement value (EV), was computed from the enhancement in the myocardium, and normalized by the respective enhancement in the LV cavity. We averaged each fibrosis index over three short-axis slices for each subject, and compared each index between the patient and control groups.

Statistical Analysis Data were presented in mean±SD. Differences from myocardial fibrosis and chamber stiffness between patients and control groups were compared using unpaired t test. The correlation between myocardial fibrosis with plasma aldosterone level and chamber stiffness were tested by Pearson correlation. A value of p < 0.05 was considered significant.

Results

Our data showed that PA patients had a significantly higher EV (0.45±0.07 vs. 0.35±0.09; p=0.016) and a significantly shorter tdec (11.73±3.07 %RR vs. 15.33±2.35 %RR; p=0.004) as compared with the normal subjects. (Fig 1) The associations of myocardial fibrosis with the plasma aldosterone level and chamber stiffness were also demonstrated in our results. The EV values were significantly correlated with the plasma aldosterone level (r=0.48; p=0.031) and tdec (r= -0.55; p=0.042). (Fig 2)

Conclusion

As compared to the normal subjects, patients with PA have significantly increased EV. The increase in EV may be due to the increased microscopic myocardial fibrosis allowing more gadolinium to retain in the interstitial space of the myocardium. The amount of enhancement was found to be significantly correlated with the plasma aldosterone level, suggesting that the degree of myocardial fibrosis might be associated with the concentration of plasma aldosterone. Our results also showed that tdec was correlated with EV, implying that the degree of myocardial fibrosis adversely influences the passive diastolic filling of the LV. In conclusion, quantitative LGE MRI can indicate the degree of microscopic myocardial fibrosis in patients with PA. The measured index of myocardial microscopic fibrosis has functional impact on the LV diastolic function.
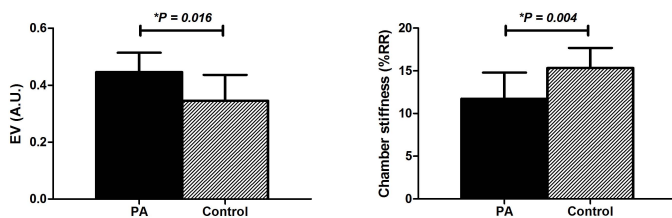

Fig 1. Significant differences between the patients with PHA and control subjects in enhancement value (EV) (left) and chamber stiffness index (right).
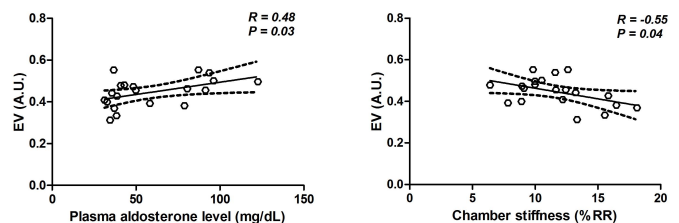
Fig 2. Significant correlations between the EV with plasma aldosterone level (left) and chamber stiffness index (right).

References

1. Bernhard MW et al., Am J Hypertension 2003;16:80-86.
2. Jalil JH et al., Circ Res 1989;64:1041-1050.
3. William CL et al., Circulation 1995;92:1933-1939.
4. Mahrholdt H et al., Circulation 2002; 106:2322-7.