学 位 論 文 の 要 旨

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学　位　論　文　名　Increased Apical Rotation in Patients With Severe Aortic Stenosis Assessed by Three-dimensional Speckle Tracking Imaging

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論 文 内 容 の 要 旨

INTRODUCTION

Aortic stenosis (AS) is the most common native valve heart disease. The therapeutic management of patients with AS depends on the hemodynamic severity of the stenosis and the presence of symptoms (angina, syncope, dyspnea), since the onset of symptoms and left ventricular (LV) systolic dysfunction determine a poor prognosis. Once LV ejection fraction (EF) is decreased, outcome after surgical aortic valve replacement is worse, and it may thus be preferable to detect subclinical systolic LV dysfunction before LVEF becomes reduced. LV myocardial deformation measured by speckle-tracking echocardiography (STE) has emerged as a reliable measure of subtle LV systolic dysfunction. Global longitudinal strain (GLS) impairment is associated with symptoms, the likelihood of symptom recovery after aortic valve implantation, and overall survival. Another parameter of myocardial deformation that can be measured by STE is apical rotation. Previous studies have shown apical rotation to be increased in patients with severe AS. Currently available two-dimensional (2D) STE methodology is complicated by its 2D imaging-based method. The out-of-plane problem inherent in short-axis imaging is caused by longitudinal heart motion during the cardiac cycle. In addition, circumferential rotation contributes to three-dimensional (3D) wall deformations and affects tracking accuracy. 3D-STE technique can estimate LV regional circumferential, longitudinal, and radial strain components simultaneously. We evaluated LV GLS and apical rotation in severe AS patients with preserved LVEF by using 3D speckle tracking imaging (STI).

MATERIALS AND METHODS

The study population comprised 20 patients with severe AS and 11 hypertensive patients with left ventricular hypertrophy (LVH) and 12 controls subjects (healthy individuals), who gave their informed consent for the study. Exclusion criteria included mitral stenosis or moderate-to-severe mitral regurgitation, depressed LVEF (<50%), previous valve replacement, previous myocardial infarction, and atrial fibrillation. All patients and control subjects underwent standard 2D echocardiographic study and 3D-STE. 3D data sets were displayed as multiplanar reconstruction (MPR) images corresponding to apical two-chamber and four-chamber views and three short-axis levels, and measured GLS and apical rotation. Global strains were calculated by averaging the peak systolic value of 16 segment measurements (six LV basal, six mid, and four apical) of LV. Apical rotation value was computed by the software for apical level as the mean of the segments within this level and expressed as the degree (°) of rotation around the LV center of cavity. As viewed from the apex, counterclockwise rotation was expressed as a positive, and clockwise rotation as a negative value. To determine the intraobserver variability, the analysis was repeated 1 month later by the same observer in ten randomly selected study patients.

Continuous data were expressed as mean ± standard deviation. Data obtained by 2D echocardiography and 3D-STE were compared among three groups (AS, LVH, and controls) using one-way analysis of variance (ANOVA). In all statistical tests, values of $p < 0.05$ were considered to indicate statistical significance. The study protocol was approved by the Ethics Committee of Shimane University and written informed consent was obtained from all subjects.

RESULTS AND DISCUSSION

There were no significant differences in blood pressure and heart rate among the three groups. The patients with AS had a mean aortic valve area (AVA) of 0.7 ± 0.2 cm^2 and a mean pressure gradient (PG) of 59 ± 18 mmHg. The average age was 79 ± 8 years and 40% were men. Left ventricular mass index (LVMI) was larger in patients with AS compared to hypertensive LVH patients (141 ± 38 vs. 134 ± 16 g/m^2). RV systolic pressure was also higher in patients with AS compared to hypertensive LVH patients (38 ± 8 vs. 33 ± 4 mmHg). There was no significant difference in stroke volume index between three groups. In the three groups including controls, severe AS patients had significantly decreased values of GLS (ANOVA, $p < 0.0001$) and increased apical rotation ($p < 0.0001$). There was significant relationship between GLS and LV apical rotation ($p < 0.0001$). LVEF was not significantly different among those groups. In AS group, ten patients (mean age, 77 ± 8 years) were in New York Heart Association (NYHA) class I or II and ten patients (mean age, 82 ± 7 years were in NYHA class III or IV. There were no significant differences in GLS and LV apical rotation between NYHA class I or II group and NYHA class III or IV group.

The present study demonstrated that patients with severe AS and preserved LVEF have decreased values of GLS and increased apical rotation compared with controls and hypertensive patients with LVH. In the normal heart, myocardial fiber helices in the subendocardial and

subepicardial myocardial layers of the LV wall exert opposite torques. Torques caused by the subepicardial layers are larger than torques due to the subendocardial layers because of the longer arm of movement. Subendocardial ischemia has long been recognized as an early sign of the myocardium suffering from pressure overload caused by AS. Apical rotation was increased in AS patients, possibly because subendocardial ischemia diminishes the counteraction of the subendocardial myofibers. In our study patients, LVMI was slightly larger in AS compared to hypertensive LVH. Another potential mechanism for increased apical rotation in AS patients may be LV hypertrophy with an increased arm of force over which the subepicardial fibers work. Nevertheless, both mechanisms may be expected to lead to increased apical rotation. Standard parameters do not analyze subendocardial and subepicardial layers. High apical rotation values in patients with AS showed a compensatory activity of subepicardial compared to subendocardial fibers, when the latter are influenced by the high values of after-load with worsening of longitudinal function.

At present, the best predictor of cardiac mortality in patients with AS is the development of symptoms. AS related symptoms may, however, be overlooked because of the gradual changes in lifestyle, patients slowly adapt to the severity of AS. Early detection of myocardial fibrosis can possibly lead to the early identification of patients at risk for cardiac mortality. Decreased GLS and increased LV rotation assessed by 3D strain echocardiography could detect subtle LV subendocardial fibrosis in patients with severe AS.

CONCLUSION

In severe AS patients, impaired GLS existed, although LVEF was preserved. However, LV rotation was increased in patients with severe AS probably to maintain the LV stroke volume.