New Cardiac Magnetic Resonance Imaging Methods for Evaluating Patients with Pulmonary Hypertension; CMR-TAPSE, %FSATD

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Aims and objectives

Pulmonary hypertension (PH) is a general term that includes all clinical conditions in which chronic pulmonary hypertension is present for a number of different reasons. Clinically, PH is defined as a resting mean pulmonary artery pressure of 25 mmHg or more. In PH, the pulmonary vascular resistance is increased for various reasons, resulting in an increase in pulmonary artery pressure that may lead to right heart failure. As PH progresses, the pulmonary vascular resistance and pulmonary artery pressure are further increased to levels that cannot be functionally compensated by the right ventricle. This leads to a decrease in cardiac output and to right heart failure, as well as to right ventricular dilatation and hypertrophy, which cause a number of signs and symptoms. Treatment is particularly challenging in patients with associated right heart failure, and the presence of right heart failure is an important prognostic factor in patients with PH. According to a report published before 1990, when there was no cure for PH, the prognosis of PH was extremely poor. Although therapy with drugs such as prostacyclin preparations has been the mainstay in the care of patients with PH, revascularization procedures employing pulmonary thromboendarterectomy and/or percutaneous balloon pulmonary angioplasty have recently been developed. These new therapeutic options can significantly improve hemodynamics and exercise tolerance. Given this background, there is even greater need to develop methods for the early diagnosis of PH, to improve the accuracy of clinical assessment, including the evaluation of treatment effects.

Although cardiac magnetic resonance imaging (CMR) is useful for the evaluation of PH in patients with right heart failure, it still suffers from limitations in accuracy and reproducibility. For example, the results of right heart volume evaluation vary depending on the imaging plane. It would be desirable to identify CMR parameters with higher reproducibility that can be measured more conveniently and show good correlation with the results of right heart catheterization (RHC), which can accurately evaluate the hemodynamics and characteristics of PH.

We therefore propose two new CMR parameters: tricuspid annular plane systolic excursion (CMR-TAPSE) and percent fractional shortening of the apical-tricuspid annulus distance (%FSATD). These parameters can be obtained by measuring the changes in the distance between the apex of the heart and the tricuspid annulus due to cardiac contraction in 4-chamber cine images acquired with SSFP. The clinical usefulness of these parameters was evaluated.
Methods and materials

# Subjects

The subjects were 16 patients with chronic thromboembolic pulmonary hypertension (CTEPH) (43 examinations; 12 women and 4 men, age: 68.1±12.8 years) who underwent CMR, RHC, and echocardiography (UCG) examinations.

# CMR imaging

A 1.5-T superconductive MRI system (Excelart Vantage powered by Atlas, Toshiba Medical Systems Corporation, Otawara, Japan) was used in combination with an Atlas SPEEDER body coil and an Atlas spine coil (Toshiba).

The steady-state free precession (SSFP) scanning technique was used to acquire cine images, with a TR/TE of 4.2/2.1 ms, a slice thickness of 10 mm, an FOV of 35 × 35 cm, a scan matrix of 192 × 256, a voxel size of 1.8 × 1.8 × 1.6 mm, and a flip angle of approximately 80 degrees. Breath-hold scanning was performed for about 25 seconds with ECG gating.

# CMR-TAPSE and %FSATD

Based on the 4-chamber cine images, the distance between the apex of the heart and the tricuspid annulus was measured at end diastole (ED) and at end systole (ES). (Fig.1)

CMR-TAPSE was calculated as (distance at ED) - (distance at ES),

and %FSATD was calculated as (CMR-TAPSE)/(distance at ED).

# Evaluation methods

The correlations between each of CMR-TAPSE, %FSATD, and UCG-TAPSE and the mean pulmonary arterial pressure (mPA) and pulmonary vascular resistance (PVR), which are hemodynamic parameters used to assess PH in RHC, were evaluated.
Fig. 1: The distance between the apex of the heart and the tricuspid annulus

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**Results**

CMR-TAPSE showed a statistically significant correlation with both mPA and PVR (mPA: $p = 0.03 \ [<0.05]$, PVR: $p = 0.008 \ [<0.01]$).

%FSATD also showed a statistically significant correlation with both mPA and PVR (mPA: $p = 0.005 \ [<0.01]$, PVR: $p = 0.018 \ [<0.05]$).

(Fig.2)

On the other hand, UCG-TAPSE showed no significant correlation with either mPA or PVR (mPA: $p = 0.31$, PVR: $p = 0.35$). UCG-TAPSE was not measured in 10 imaging studies (23.2%).

(Fig.3)

**#Discussion**

Right ventricular function is a prime determinant of survival in patients with PH, and CMR, which has been recently been used for right ventricular volume analysis, is expected to provide reliable prognostic information. However, as of this time, there have been few reports on the use of CMR for prognosis.

The previous study has shown that the right ventricular volume measurements obtained by CMR are strongly dependent on the plane used for analysis and that interobserver reproducibility is still insufficient. Since volume measurement is a very complicated procedure, it is necessary to identify reproducible and easily measured indices that allow us to accurately assess the severity of PH.

The two indices evaluated in this study, CMR-TAPSE and %FSATD, are very simple and easy-to-use indices that can be obtained by simply measuring the distance between the apex and the tricuspid annular plane in the four-chamber image. Simple measurement means less variation between observers and between examinations. The findings of this study have shown that CMR-TAPSE and %FSATD are well correlated with the indices for estimating the severity of PH obtained by RHC.

UCG-TAPSE, for which a correlation with prognosis has been reported for patients with scleroderma, showed no significant correlations with mPA or PVR in this study. This may be because UCG-TAPSE was not obtained in a sufficient number of patients in this study. As well as because UCG-TAPSE measurements obtained in M-mode tend to depend on the skill of the operator. One technical challenge in particular should be considered: the tricuspid annular plane, which moves due to the twisting motion of the heart as it contracts, was not always captured on the linear M-mode cursor, so other
highly echogenic tissues may have been mistakenly identified as a part of the tricuspid annular plane, leading to considerable variation in the measurement results.
**Fig. 2:** The correlations between each of CMR-TAPSE, %FSATD and the mPA, PVR

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**Fig. 3:** The correlations between UCG-TAPSE and the mPA and PVR

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Conclusion

CMR-TAPSE and %FSATD showed good correlation with the results of RHC, indicating that these parameters are convenient and useful indices for the evaluation of PH using CMR.
References


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