

iVIEW

EDITOR'S PAGE



The Right Ventricle: Unforgettable With Imaging



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The right ventricle has been described as the “forgotten chamber,” and despite better awareness of its importance, current heart failure (HF) guidelines have taken little cognizance of the right ventricle. In part, this reflects the limitations of the evidence regarding the determinants of right ventricular (RV) dysfunction and its relation to outcomes in HF. This special issue of *JACC* seeks to redress this in some part through a collection of focused reports.

RV dysfunction has an important and independent effect on cardiac mortality in nonischemic cardiomyopathy (1). Although RV dysfunction is strongly associated with left ventricular (LV) function, increased afterload from pulmonary vascular dysfunction, and systolic blood pressure, RV ejection fraction by cardiac magnetic resonance imaging is also a strong independent predictor, independent of age, LV ejection fraction, and other likely confounders. RV function is sensitive to increased afterload, and this is important in HF, in which increased left atrial (LA) pressure is conducted to the right ventricle through increased pulmonary pressures. Guazzi et al. (2) sought to stratify clinical phenotypes and outcomes on the basis of RV contractile function and its coupling with the pulmonary circulation in 387 patients with HF with preserved ejection fraction (HFpEF). Tertiles of tricuspid annular plane systolic excursion/pulmonary artery systolic pressure ratio (<0.35, >0.57, and levels in between) were associated with natriuretic peptides, systemic and pulmonary hemodynamic status, exercise aerobic capacity,

ventilatory inefficiency, and outcomes. These results reemphasize the heterogeneity of the HFpEF group and might cause us to reconsider pulmonary vasodilator therapy for patients in whom RV dysfunction is related to afterload.

Most of our measurements are done in the resting state, but many of the symptoms and indeed complex pathophysiological components of HF manifest under stress (either during exercise or during increased loading). Two papers in this issue try to unmask stress- and load-induced changes in the left atrium and right ventricle. The involvement of the left atrium as the link between LV pathology and pulmonary congestion and RV dysfunction in HF is important, but what happens under stress? Sugimoto et al. (3) addressed the hypothesis that LA dynamic impairment during exercise might trigger uncoupling of RV-pulmonary circulation in 49 patients with HF with reduced ejection fraction, 20 patients with HFpEF, and 32 healthy control subjects. They show that the normal response of LA strain is to increase during exercise and recovery. Patients with HFpEF showed some LA strain increase during exercise and recovery, but no changes occurred in those with HF with reduced ejection fraction. In HF, LA strain at rest, exercise, and recovery significantly correlated with pulmonary artery systolic pressure/tricuspid annular plane systolic excursion. The left atrium is thus more than a passive chamber and is a critical dynamic link between the dysfunctional left ventricle and its pulmonary and RV consequences. The difficulty in clearing an additional LV volume load is a hallmark of HFpEF. Pre-load augmentation can be achieved by volume loading, leg elevation, and leg positive pressure (4). In HFpEF, reduced stroke volume index, global longitudinal strain, and RV strain

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during pre-load augmentation are associated with severely reduced exercise capacity. Impaired RV strain (<17%) during pre-load augmentation is the most powerful predictor of severely reduced exercise capacity, with 81% sensitivity and 88% specificity.

It is particularly problematic that despite the importance of afterload to RV function, the exact measurement of pulmonary pressure is sometimes difficult with echocardiography. However, the spectral display of RV ejection (namely, midsystolic flow deceleration and notching) reflects both resistance of the pulmonary vasculature and RV adaptation to the increased load. Takahama et al. (5) document the association of transplantation-free survival in pulmonary artery hypertension with 4 patterns of pulmonary flow (non-notched, long-deceleration time profile, high notch velocity, and low notch velocity). A notched RV outflow tract flow profile integrates indicators of pulmonary vascular load and RV function and serves as a marker for adverse outcomes. Inaccuracy in the assessment of right atrial pressure is a contributor to the potential inaccuracy of echocardiography in assessing pulmonary artery pressure. The estimation of liver stiffness with shear-wave elastography can be used to estimate central venous pressure (6), with sensitivity of 89% and specificity of 86% for the detection of central venous pressure >10 mm Hg.

The prognostic power of conventional RV markers (such as RV fractional area change and tricuspid annular plane systolic excursion) is compromised by the nongeometric nature of the right ventricle, as well as load dependency. A different approach to RV assessment is proposed by Hulshof et al. (7). These

investigators show that the strain-area loop (the relation between RV longitudinal strain and RV area across the cardiac cycle) relates to pulmonary vascular resistance in patients with pulmonary artery hypertension and distinguishes these patients from control subjects.

Finally, despite the availability of new modalities (such as RV strain) for RV assessment, some familiar markers are underused. Septal motion is an important clue to the presence of pulmonary hypertension and RV dysfunction. The normal interventricular septum maintains the concave curvature of the LV wall, but the degree of septal motion is influenced by the relative LV and RV pressure, septal contraction, and stiffness. The iPIX by Dwivedi and Axel in this month's issue (8) emphasizes the spectrum of conditions mediating such changes. Although the exact implications of paradoxical septal motion are still unclear, it is conceivable that inefficient septal action contributes in some part to suboptimal pump function.

Sophisticated imaging might surely unravel finer details of this complex and difficult-to-image chamber. As we learn more and more about the role of the right ventricle, one can see this less famous chamber finally getting the respect it deserves, and this field is becoming ripe for fruitful investigation.

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