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Editorial

Right ventricular outflow tract assessment: Identification of right ventricle dysfunction in heart failure

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Heart Failure (HF) is a condition in which the ability of the heart to pump appropriately enough blood to the body is impaired. It may involve either right ventricle (RV) or left ventricle (LV) or more often, defect on both sides of the heart, which causes an altered pathological condition. Regardless of the heart chamber involved, the normal function of the heart is compromised and eventually it fails and results in death. Since the ventricles of the heart are inter-dependent and share the same septal wall, any dysfunction in LV can influence the normal function of RV. Heart failure due to LV dilation or hypertrophy can potentiate afterload on RV by increasing pulmonary venous pressure[1] and ultimately pulmonary arterial pressure. In the past, much attention has been given to study the function of LV and as a result, significant improvement has been made in the treatment of left HF. This advancement is partly due to the feasibility to measure several strong reliable and reproducible parameters, such as ejection fraction (EF), estimated left ventricular end-diastolic pressure (LVEDp), and LV wall thickness (LVED), using non-invasive and affordable methods such as echocardiography. However, this is not the case when measuring right ventricle function. Diagnosing RV dysfunction by non-invasive procedure is challenging and often inaccurate.

In addition, the systematic evaluation of right heart structure and function is not uniformly carried out, especially due to the complexity in RV imaging and temporal and spatial arrangement of RV. Moreover, there is no isolated non-invasive ultrasound-related parameter that can completely assess right heart function with high fidelity and accuracy. A comprehensive evaluation through a multi-parameter approach of RV structure and function is recommended and needed.

Evaluation of RV structure and function in patient is key not only to rule out an existence of RV dysfunction, secondary to LVHF (left ventricle heart failure), but also for the possibility of co-existence of fatal diseases such as pulmonary hypertension, pulmonary embolism, and others. Studies indicate patients classified as WHO functional class I and II have improved long-term survival rate than patients in class III and IV stages of PAH.[2] This functional evidence urges and rationalizes the need for an early diagnosis of right heart disease such as PAH in patients with LV failure.

Pulmonary hypertension could arise either as a primary PAH or idiopathic PAH or, most frequently, secondary to left failing heart. The latter belongs to Group II of Dana Point Classification and is determined by left heart diseases, including abnormalities such as systolic and/or diastolic dysfunction and valvular heart disease. Such extensive pathological changes in blood vessels and ventricles of heart lead to maladaptation and result in increased pulmonary vascular resistance (PVR). In spite of a strong positive co-relation between an early intervention of RH failure (e.g. PAH) and prolonged extension of survival rate[3,4] efforts to identify these diseases in its preliminary stages remain poor.

Current available procedures for a reliable measurement of RV function depend on advanced equipment (e.g. MRI, 3D Echo) and complex invasive methods, such as right heart catheterization (RHC), which involves potential complications mostly related to the venous access (e.g., hematoma, pneumothorax), followed by arrhythmias, hypotensive episodes (related to vagal reactions or pulmonary vasoreactivity testing), and more rarely pulmonary embolism.[5] Although these techniques remain the golden standard for an accurate and trustworthy evaluation of right heart hemodynamics, they often require admission of patients in the hospital facility or associated with high medical expenses.

The readily available point-of-care ultrasound equipment in the health care centers has facilitated the use of echocardiography as an alternative option to perform a non-invasive assessment of RV function, measurement of hemodynamics, and evaluation of structural abnormalities. Several parameters of right heart chambers that can be measured using echocardiography are approved as guidelines by WHO and American Society for Echocardiography[6] (ASE) and recommended for diagnosis and prognosis of treatment. Among them, tricuspid annular plane systolic excursion[7] (TAPSE), tricuspid valve regurgitation (TVR), eccentricity, and right ventricular free wall systolic strain are widely accepted right heart indices that manifest PAH disease severity and survival rate. Other useful parameter such as RV systolic pressure can be estimated by the analysis of tricuspid regurgitant jet by the Bernoulli equation: $4v^2$, where v is the maximum jet velocity of the tricuspid valve added to the estimated RA pressure by the dimension and collapsibility of the inferior cava vein. The mPAP, which is a strong indicator of PH, can also be measured using modified Bernoulli equation,[8] although as an indirect estimation and therefore should be confirmed with other advanced techniques. The tricuspid regurgitant velocity (TR Vel) is also used to estimate the systolic RV – right atrium gradient. The end diastolic pulmonic regurgitant velocity is used to estimate diastolic pulmonary artery pressure (PAPd). This measurement estimates the pulmonary artery systolic pressure, assuming there is no evidence of pulmonary valve stenosis or obstruction. Echocardiography can also be used to estimate PVR by taking the ratio of the tricuspid regurgitant jet velocity to the acceleration time of the RV ejection into the PA. Echocardiographic assessment also provides important information about the RV structure and hemodynamics, which can also suggest the presence of PH. More classical parameters are enlarged dimensions of right heart chambers, abnormal shape and function of the intraventricular septum, increased RV wall thickness, and a dilated main pulmonary artery. In summary, several parameters obtained using echocardiography can provide vital information about right heart function and aid the diagnosis of RV abnormalities.

Despite advances, there is still uncertain and unmet need for improvements in the diagnosis of RV failure and coexisting conditions such as pulmonary hypertension. Screening of patients at risk of developing RVF and/or PAH (e.g. LV HF) should be carried out on routine basis using commonly available methods such as echocardiography to diagnose the disease at an early stage.

In the recent issue of Indian Heart Journal, a cohort study by Deveci et al. shows a significant decrease of RVOT-FS (right ventricular outflow tract-fractional shortening) in 36 HF patients with a known dilated heart and LV systolic dysfunction. Interestingly, the authors also observed a positive correlation between RVOT-FS and TAPSE, a well-known predictor of RV dysfunction. The major advantage of this study is that it recommends an ultrasound derived non-invasive parameter that was previously validated and is easy to carry out. However, in this case, the authors recognized a potential clinical relevance for RVOT-FS in HF patients, giving insights to the classic discordance of LVEF at rest and functional class. The strong positive correlation found by the authors between RVOT-FS and TAPSE ensures that RVOT-FS provides information about RV function (i.e. contractility). In light of this observation, RVOT-FS could be very useful in assessing RV function in situations in which other commonly used parameters in the ultrasound assessment (i.e. TAPSE or annular velocity) fail to assess RV contractility (i.e. Severe tricuspid regurgitation). Though RVOT-FS is not a conclusive parameter, it offers a vital clue for RV dysfunction and should be confirmed with additional indices obtained by more precise and/or complex techniques (MRI, 3D Echo, strain imaging). Several previous studies have also demonstrated a correlation between RVOT and RV dysfunction[9] and found it as a useful parameter in the diagnosis of RV-related disease such as pulmonary embolism.

The authors also provided insights in understanding the existence of the classic discordance between LVEF and NYHA class. This explanation could not only help in the prompt recognition of the failing left heart-associated with RV dysfunction, but also offer important information concerning response to medical treatment and recommendation for further additional invasive or advanced diagnostic test.

As mentioned, by the authors, while measurement of this parameter does not require any additional skill, there are often technical difficulties in obtaining an accurate image of the RV walls owing to the complex geometry of RV wall. Nevertheless, echocardiographic measurement of RVOT along with FS can be extremely useful parameter to validate RV dysfunction, when combined with multiple indices such as TAPSE, PVR, and mPAP, especially in patients with known LV dysfunction. Addition of RVOT-FS as a standard parameter in routine echocardiography procedure and clinical practice can assist in early diagnosis of RV dysfunction-related disease such as PAH, secondary to left HF and also as a prognosis of treatment in patients with established HF.

Conflicts of interest

The authors have none to declare.

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