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Letters to the Editor

A Simplified Quantitative Evaluation of Right Ventricular Anatomy and Function by Intracardiac Echocardiography

We read with interest the report by Ujeyl et al. (1), which concluded that despite low left ventricular (LV) ejection fraction, patients with recurrent ventricular tachycardia (VT) who had good right ventricular (RV) function without elevated pulmonary artery systolic pressure (PASP) had a good prognosis after VT ablation, whereas RV dysfunction, tricuspid regurgitation (TR), and elevated PASP identified a high-risk group of VT survivors in whom additional interventions may be necessary to improve survival. Unfortunately, in the current study, no quantitative echocardiographic parameters of RV function and LV diastolic function were shown. In this retrospective study, RV dysfunction was dichotomized as 2 categories, no/mild and moderate/severe, on the basis of a qualitative description.

With routine clinical application of intracardiac echocardiography (ICE) in more than 2,500 cases of left heart ablation, a simplified quantitative evaluation of RV anatomy and function can be obtained from an RV inflow view, including RV annulus/outflow tract diameter, RV area at end-diastole (RVAd) and end-systole (RVAs), area EF (fractional area change, [RVAd − RVAs]/RVAd), RV length from midannulus to apex at end-diastole (Ld) and end-systole (Ls), and shortening fraction (tricuspid annular motion, [Ld − Ls]/Ld) (Fig. 1). The ICE transducer right atrium (RA) location can provide very stable views during the cardiac cycle as compared with those obtained from transthoracic RV views with the angulation of the ultrasonic transducer. In addition, semiquantitative TR (using color Doppler TR score: trace = 0.5; mild = 1; mild to moderate = 1.5; moderate = 2; moderate to severe = 2.5; severe = 3) and continuous wave Doppler recording of TR for estimating PASP can be performed from this RV inflow view (2). The basic measurements of these parameters were obtained in 65 patients (age: 57 ± 12 years) undergoing left heart ablation for tachyarrhythmias with relatively normal RV function including trace or mild TR, normal PASP <35 mm Hg, and normal LVEF (Group 1, n = 32) as compared with those with moderate/severe TR regurgitation and abnormal PASP ≥35 mm Hg, even if the majority of them had normal LVEF (Group 2, n = 33). The RV area EF (33.8% ± 9.2% vs. 17.2% ± 9.5%) and length shortening fraction (26.0% ± 7.7% vs. 14.0% ± 7.8%) provide a quantitatively effective evaluation of the degree of RV dysfunction (Group 1 vs. 2, $p < 0.001$). To further examine the role of these ICE quantitative parameters in defining RV anatomic change and/or systolic dysfunction, the patients in Group 2 were subdivided into patients with arrhythmogenic RV cardiomyopathy, which is representative of worsened RV anatomic and systolic dysfunction (Group 2A, n = 7), and patients undergoing ablation of LV VT or atrial fibrillation ablation (Group 2B, n = 26). Compared with patients in Group 2B, patients in Group 2A had significantly increased RVAd (41.3 ± 6.3 cm^2 vs. 29.4 ± 7.4 cm^2),

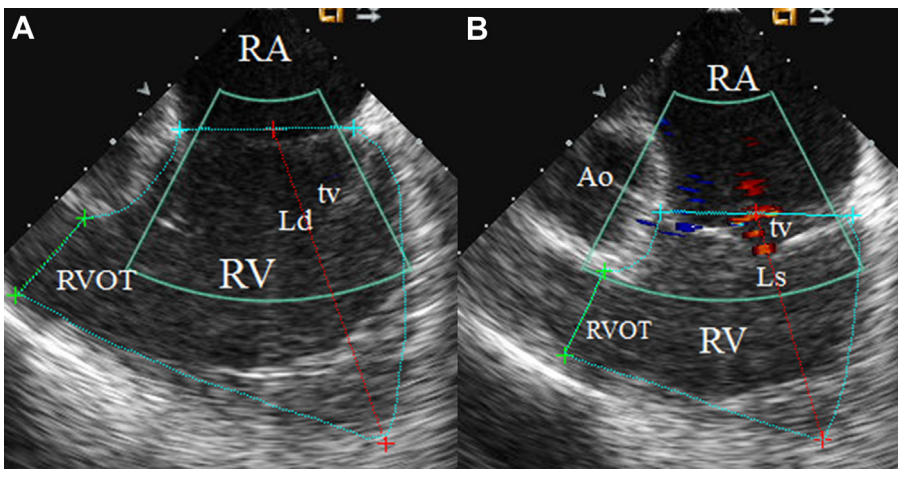

Figure 1 Intracardiac Echocardiographic Imaging With the Transducer Placed in the Right Atrium Showing a Right Ventricular Inflow View

(A) At end-diastole, the **dotted line** encloses the RV end-diastolic area (RVAd = 51.2 cm^2, with the endocardial border traced along the tricuspid annulus, pulmonary valvular annulus, and RV apex) and the RV length (Ld = 8.5 cm). **(B)** At end-systole, the **dotted line** encloses the RV end-systolic area (RVAs = 31.1 cm^2) and the length (Ls = 6.1 cm). The tricuspid annulus diameter measured 4.5 cm and the RV outflow tract (RVOT) measured 2.6 cm at end-diastole. The RV area ejection fraction (RVAd − RVAs/RVAd × 100) and length shortening fraction (Ld − Ls/Ld × 100) are 39.2% and 28.2%, respectively. Ao = aortic root; RV = right ventricular; tv = tricuspid valve.

RVAs (35.8 ± 6.7 cm^2 vs. 24.2 ± 7.1 cm^2), Ld (8.1 ± 1.2 cm vs. 6.1 ± 0.9 cm), Ls (7.0 ± 1.0 cm vs. 5.2 ± 0.8 cm), and RV outflow tract diameter (3.3 ± 0.3 cm vs. 2.7 ± 0.3 cm) ($p < 0.05$–0.01), with those parameters indicating RV systolic dysfunction (vs. Group 1). These results show that ICE imaging using an RV inflow view provides a simplified method for quantitatively evaluating RV morphological changes and systolic dysfunction. One of the advantages of the RV area EF or length shortening fraction is that the measurements are not squared or cubed, thus reducing the magnification of any error. Of note, like the other invasive hemodynamic parameters (such as RV stroke work) used for evaluation of RV function, these RV quantitative parameters are imperfect measures of RV function and reflect influences from both afterload and pre-load. However, they can be used clinically for serial studies and may have prognostic value from individual serial quantitative evaluation, especially in patients with heart failure and recurrent VT ablation.

Another factor that may be important for RV function that was not considered in the study by Ujeyl et al. (1) is the effect of RA-RV lead thrombus. Although there are some inconsistencies in Table 1 in their report (95% of patients were reported to have implantable cardioverter-defibrillators [ICDs], but the numbers calculate to 72%) (1), certainly a large proportion of this study group had pre-existing ICD leads. With the ICE transducer placed in the RA or RV, the course of intracardiac leads can be imaged from/in the right atrium RA to the RA appendage and detect any mobile echodensity/thrombus attached to the intracardiac leads (3). A greater number of patients with implanted ICDs and pacemakers (30%) have lead thrombus formation, which can contribute to an elevated PASP in these patients undergoing ablation if embolic phenomena are frequent (4).

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How Can We Improve Inpatient Management of Heart Failure?

We read with great interest the report by Kociol et al. (1) on the association between inpatient hospitalist care of patients with heart failure and clinical outcomes. Their results suggest that utilization of the hospitalist model for patient care did not improve 30-day outcomes. Although comanagement by hospitalists and cardiologists may improve adherence to some quality measures, the findings of Kociol et al. also beg the following question: is there a novel diagnostic and management tool that frontline physicians can use to improve inpatient management of decompensated heart failure?

Outpatient management of heart failure usually focuses on afterload reduction and myocardial remodeling prevention. In contrast, inpatient management of decompensated heart failure mainly requires optimization of intravascular volume status and pre-load management. Even though frontline clinicians can use physical examination findings, plasma electrolytes, biomarkers, and radiographic studies, accurate assessment of volume status is still complicated in many patients with obesity, chronic venous stasis changes, renal dysfunction, and underlying pulmonary disease. For example, the discordance between right and left heart filling pressures (R-L mismatch) can lead to either inadequate or excessive diuresis (2). Because it is still widely believed that failing hearts operate on the descending limb of the Frank-Starling curve, where increasing ventricular filling pressure decreases the ability of the heart to eject, the pre-load reduction remains the primary therapeutic strategy in these patients in our daily practice. Without reliable real-time tools to assess "true" intravascular volume status, inappropriately low cardiac pre-load/filling pressure due to overdiuresis is commonly found in patients with poor systolic function and low left ventricular ejection, which results in renal failure, reflex tachycardia (particularly with pre-existing atrial fibrillation), hemodynamic instability, and increase in the length of hospital stay and mortality.

Bedside echocardiography with Doppler/tissue Doppler technique can be used as a portable real-time tool to guide efficient volume therapy in patients with decompensated heart failure and gradually replace traditional invasive pulmonary artery catheterization (3). With serial Doppler and tissue Doppler measurements, the hemodynamics of both left and right cardiac chambers, including pulmonary arterial/venous pressures, can be determined and followed up dynamically during decompensated heart failure. Additionally, compared with other traditional clinical methods, such as body weight and jugular vein pressure measurement, serial Doppler/tissue Doppler echocardiographic assessment of volume status can better help with decisions on the timing of the transition from inpatient to outpatient service, thereby reducing the length of hospital stay and potentially the readmission rate.

Both inadequate and excessive therapy on volume status in decompensated heart failure cause high sympathetic nervous activity, resulting in adverse short-term and long-term outcomes. Evidence is mounting that volume status/ventricular pre-load might also be directly associated with myocardial remodeling through stretch-mediated activation of the signal transduction pathway (4). Because hand-carried echocardiographic Doppler