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Editorial

TAPSE: A Red Herring After Cardiac Surgery

IT IS WELL KNOWN that right ventricular dysfunction portends increased risk and worse outcomes for patients in multiple clinical scenarios: solid organ transplant, noncardiac surgery, heart transplant, and ventricular assist device surgery, among other cardiac surgeries. Accurate quantification of right ventricular function therefore is paramount for risk stratification and adequate therapy and intervention. Because of the rapid availability and relatively limited invasiveness of echocardiography perioperatively, both transthoracic and transesophageal echocardiography often are the go-to modalities for right ventricular functional assessment.

However, multiple challenges exist with both modalities in their assessment related to the differences between the left ventricle (LV) and the right ventricle (RV) as well as difficulties in imaging the RV. The LV, which is cylindrical or bullet shaped, can be approximated relatively easily by geometric assumptions. Most commonly, the LV is assessed echocardiographically via volume estimation via a method of calculated stacked discs in systole and diastole and subsequently calculation of ejection fraction. Additionally, the LV contracts in a predictable fashion, primarily concentric contraction with components of longitudinal contraction. The RV, however, does not have a geometric shape that best approximates its chamber. This is seen echocardiographically: The RV is triangular in the midesophageal four-chamber view, has a "wrap around" appearance in the midesophageal RV inflow-outflow view, and a crescent shape in the transgastric short-axis view. Additionally, RV contraction is complex with a peristaltic-like contraction. A large contributor to contraction is the longitudinal descent of the tricuspid annulus toward the apex (forming the basis of tricuspid annular plane systolic excursion [TAPSE] and Tissue Doppler S' measurements); however, the contraction then involves the inward motion of the free wall and apex and finally a contribution of the infundibular or outflow tract portion. Imaging with echocardiography is challenging because no single view can image all portions of the RV at once; therefore, assessment of RV function often uses visualization of 1 segment and extrapolates that finding to the entire RV. Adding to the difficulties, with transesophageal echocardiography imaging, the RV is in the far field with an oblique alignment further challenging accurate visualization and evaluation.

TAPSE, an assessment of the excursion of the lateral tricuspid annulus toward the RV apex, is a commonly used echocardiographic tool for RV assessment for several reasons. The major contributor to RV contraction is the longitudinal contraction and descent of the TV annulus; this motion is assessed easily by transthoracic echocardiography via an apical four-chamber view aided by m-mode echocardiography. The technique is easily deployable, reproducible, and generally agrees with other methods of RV assessment including the clinical gold standard of cardiac magnetic resonance imaging.

However, a problem appears to arise with the use of TAPSE and likely with other methods involving longitudinal motion assessment of the RV after cardiac surgery, noting that they are universally decreased despite other indices of unchanged RV function. The mechanism for this has been postulated as being due to cardiac stunning, cardiopulmonary bypass, cardioplegia, or myocardial hypothermia.[1,2] Tamborini et al, however, measured TAPSE at multiple intervals throughout cardiac surgery and noted the decrease in longitudinal contraction occurs within minutes of pericardiotomy.[3] This finding was further corroborated by Zanobini et al, who compared patients undergoing MV repair via conventional median sternotomy with a vertical pericardiotomy to a minimally invasive approach via lateral thoracotomy with a smaller lateral pericardiotomy.[4] It was noted that TAPSE decreased after vertical pericardiotomy but remained unchanged with the smaller lateral pericardiotomy. Of note, RV fractional area of change (FAC) remained unchanged despite the pericardiotomy technique involved. These findings have led to the idea that the pericardium provides structural support to the RV, allowing the bulk of contraction to be contributed by longitudinal contraction. When removed, the reduced longitudinal RV contraction is supplemented by increased RV free wall and concentric contraction, thereby maintaining RV systolic function.

Although RV assessment is important in many clinical arenas, it is particularly important in the perioperative assessment of chronic thromboembolic pulmonary hypertension (CTEPH) patients undergoing pulmonary thromboendarterectomy (PTE).

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These patients often present to the operating suite with isolated right ventricular dysfunction from thromboembolic disease and resultant pulmonary hypertension. With a fixed right ventricular obstruction, varied levels of RV dysfunction frequently are observed. The objective of surgery is a complete endarterectomy of the proximal pulmonary arterial tree such that a significant reduction in pulmonary vascular resistance (PVR) is observed. With the dramatic reduction in right ventricular afterload, RV function, patient symptomatology, and mortality significantly improve.

In this issue of the Journal, Sullivan et al set out to evaluate commonly used echocardiographic parameters of RV function, TAPSE and RV FAC, the postulated echocardiographic PVR-surrogate parameter, pulmonary artery acceleration time, and pulmonary artery catheter (PAC) measurements pre- and post-PTE.[5] Additionally, variables were evaluated against a functional outcome, the 6-minute walk test. Despite a declining role of the PAC in other clinical venues, the PAC remains the clinical gold standard for determining a successful PTE operation, specifically the calculation of a reduced PVR postoperatively. Unsurprisingly, the authors note that PVR reduction correlated with improved functional capacity via the 6-minute walk test. However, Sullivan et al note that echocardiographic parameters did not exhibit an interchangeable status with that of parameters derived from the PAC. Upon further inspection of echocardiographic parameters, the authors note that while RV FAC along with cardiac index were preserved TAPSE was reduced post bypass eventually returning to baseline on echocardiography 6 months postoperatively.

Sullivan et al report a finding that further supports what Zanobini et al and Tamborini et al have reported previously and highlight that TAPSE, or perhaps any assessment of RV longitudinal contraction, may represent a red herring or a misleading clue about postoperative RV dysfunction. With TAPSE rendered inaccurate in RV functional assessment upon pericardiotomy, the utility of the technique after cardiopulmonary bypass is questionable. This finding is supported by the experience at the author's institution in the evaluation of CTEPH patients undergoing PTE. Using transthoracic echocardiography, it is noted that although TAPSE correlates inversely pre-PTE, the correlation is lost completely post-PTE such that TAPSE cannot be used as an early marker for successful surgery.[6] When evaluating additional markers of longitudinal contraction, similar results were observed for S' and basal RV free wall strain correlating well with PVR preoperatively, but the association falls apart after bypass.[7,8] However, with a more global evaluation of RV function, the right-sided index of myocardial performance (RIMP, or right Tei index), is used the correlation holds both before and after successful pulmonary thromboendarterectomy.[9] Simply, a reduction in right-sided index of myocardial performance correlated with a reduction in PVR.

Although these findings are specific to the CTEPH patient population undergoing PTE, perhaps some insight can be drawn regarding the general cardiac surgery population. Caution should be exerted when evaluating TAPSE after cardiac surgery. Extrapolation of longitudinal contraction data to global RV assessment after cardiac surgery is likely to lead to an inaccurate estimation of RV function and potentially an incorrect diagnosis of RV dysfunction. Future clinical utility and research should focus on more global estimates of RV function. The question still exists of which echocardiographic methods are optimal. Although Sullivan et al note that RV FAC from a midesophageal four-chamber view was preserved after bypass, this technique does not take into account the three-dimensional (3D) nature of the RV, ignoring the contribution of the infundibular or outflow tract portion. What is unknown is the percent of contribution of the outflow tract and other portions of the RV to contraction that are not visualized in a single two-dimensional plane before and after pericardiotomy. A potentially key modality to help answer this question would be 3D echocardiography and 3D RV volumetric analysis with RV ejection fraction determination, which would help to eliminate the poor assumptions of RV volume from two-dimensional echocardiography. Other potential modalities of interest include the use of strain techniques that incorporate more than just an assessment of RV basal strain. Examples include RV global longitudinal strain, which takes into account both free-wall and septal longitudinal contraction, or the advent of 3D speckle-tracking echocardiography strain using the combination of 3D techniques with strain assessment.[10] Although it is becoming apparent that TAPSE is a potential red herring after cardiac surgery, future study should include the aforementioned techniques or other novel global RV modalities to further explain the complex motion of the RV both before and after cardiac surgery.

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