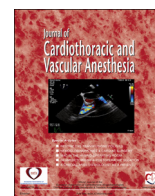


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Original Article

## Modified Tricuspid Annular Plane Systolic Excursion Using Transesophageal Echocardiography and Its Utility to Predict Postoperative Course in Heart Transplantation and Left Ventricular Assist Device Implantation

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**Objectives:** Perioperative right ventricular (RV) function is important for determining the postoperative course in heart transplantation (HT) and left ventricular assist device (LVAD) implantation. The authors describe a modified tricuspid annular plane systolic excursion (m-TAPSE) using transesophageal echocardiography and assessed its clinical utility in HT and LVAD.

**Design:** Retrospective medical record review.

**Setting:** A single tertiary-care medical center.

**Participants:** Forty-eight patients who underwent successful HT and 80 patients who underwent successful LVAD placement.

**Measurements and Main Results:** Statistically significant correlation between m-TAPSE and RV fractional area change (FAC) was seen for HT and LVAD ( $r = 0.462$ ,  $p < 0.01$  and  $r = 0.597$ ,  $p < 0.01$ , respectively). For HT, receiver operating characteristics curve analysis yielded that m-TAPSE  $< 0.64$  cm provides 100% specificity and 57.1% sensitivity in predicting postoperative nitric oxide (NO) use, whereas RV FAC  $< 24.1\%$  provides 95.1% specificity and 71.4% sensitivity in predicting postoperative NO use (area under the curve 0.798 [95% confidence interval (CI), 0.595-1]  $v$  0.826 [95% CI, 0.581-1],  $p = 0.397$ ). For LVAD, m-TAPSE  $< 0.71$  cm provides 66.7% specificity and 87.5% sensitivity in predicting postoperative NO use, whereas RV FAC  $< 16.3\%$  provides 79.4% specificity and 62.5% sensitivity in predicting postoperative NO use (area under the curve 0.829 [95% CI, 0.732-0.927]  $v$  0.691 [95% CI, 0.54-0.842],  $p < 0.05$ ).

**Conclusions:** m-TAPSE validated a good correlation to RV systolic function as reflected by RV FAC for both HT and LVAD. For HT, m-TAPSE was helpful for predicting postoperative NO use; whereas for LVAD, m-TAPSE was helpful for predicting postoperative NO use and RV assist device implantation. m-TAPSE should be considered as a useful parameter to decide postoperative management for these cases.

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**Key Words:** tricuspid annular plane systolic excursion (TAPSE); transesophageal echocardiography; heart transplantation; leftventricular assist device; outcomes

FOR END-STAGE HEART FAILURE, heart transplantation (HT) or implantation of a left ventricular assist device (LVAD) is lifesaving and provides a significant improvement in quality of life. On the other hand, perioperative right

ventricular (RV) function during HT and LVAD implantation has been valued as an important prognostic factor recently, and attempts have been made to predict postoperative course in these procedures with RV function assessment, which may lead to early intervention and better outcomes.<sup>1-3</sup> The American Society of Echocardiography (ASE) guidelines describe tricuspid annular plane systolic excursion (TAPSE), RV fractional area change (FAC), and other indices for the

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assessment of RV function.<sup>4</sup> Morita et al described modified TAPSE (m-TAPSE) using a transesophageal echocardiography (TEE) midesophageal four-chamber view (ME 4CV) and discussed its correlation with RV FAC.<sup>5</sup> Given these previous findings, the authors investigated the clinical application of m-TAPSE in HT and LVAD implantation, and assessed its ability to predict subsequent RV failure in which RV support could be done early prior to end-organ damage.

## Methods

### Study Population

The study adheres to the SQUIRE (Standards for Quality Improvement Reporting Excellence) checklist for reporting a quality improvement study. After institutional review board approval, the authors retrospectively analyzed 60 cases of HT and 123 cases of LVAD performed between 2014 and 2016 at a single institution. The need for informed consent was waived by the institutional review board. Patients with a suboptimal TEE image or lack of a timely TEE image (*timely* meaning measurement at the time of weaning from cardiopulmonary bypass [CPB]) were excluded. Patients with previous or concurrent tricuspid valve repair also were excluded because changes in tricuspid annular geometry may have significant effects on TAPSE as a marker of RV systolic function. Ultimately, a total of 48 cases of HT and 80 cases of LVAD met the authors' study criteria (Fig 1). All patients received general anesthesia with endotracheal intubation, standard American Society of Anesthesiologists monitoring, arterial blood pressure monitoring, central venous pressure monitoring, pulmonary artery (PA) pressure monitoring, and TEE. The demographics, perioperative hemodynamic indices, and postoperative outcomes of these patients were collected from the authors' computerized patient database. Indication of postoperative nitric oxide (NO) use was persistent pulmonary hypertension. RV failure was determined by comprehensive assessment of TEE, PA hemodynamics including PA

systolic/diastolic/wedge pressures and pulmonary vascular resistance, central venous pressure, and direct visualization of RV in the surgical field. Indication of intraoperative RV assist device (RVAD) was severe refractory RV failure.

### Preoperative Echocardiographic Parameters

Transthoracic echocardiography (TTE) was performed by National Board of Echocardiography (NBE) board-certified cardiologists on all patients as a routine preoperative evaluation within 1 year before surgery. Preoperative echocardiographic parameters, such as preoperative left ventricular ejection fraction and preoperative TAPSE were measured using the ASE guidelines.<sup>4</sup> Preoperative PA systolic pressure was obtained either directly from preoperative right heart catheterization or by echocardiographic estimation using the simplified Bernoulli's equation ( $RV \text{ systolic pressure} = 4 \times [\text{peak tricuspid regurgitation velocity}]^2 + \text{mean right atrial pressure}$ ).

### Postoperative Echocardiographic Parameters

TTE was performed on postoperative day 1 by NBE board-certified cardiologists on all patients as a routine postoperative evaluation. For HT, postoperative RV dysfunction was determined comprehensively with TAPSE, RV FAC, pulsed Doppler myocardial performance index, and tissue Doppler myocardial performance index by postoperative echocardiography assessment as described in the ASE guidelines.<sup>4</sup> For LVAD implantation, postoperative RV failure was defined as a requirement for mechanical right heart support; 14 days of inotropes; inhaled NO for more than 48 hours or discharge home with inotropes.<sup>6-8</sup> Postoperative echocardiographic parameters, such as postoperative left ventricular ejection fraction, postoperative TAPSE (postopTAPSE), and postoperative RV FAC (postopRV FAC), were measured using the ASE guidelines.<sup>4</sup> Postoperative PA systolic pressure was obtained either directly from postoperative right heart

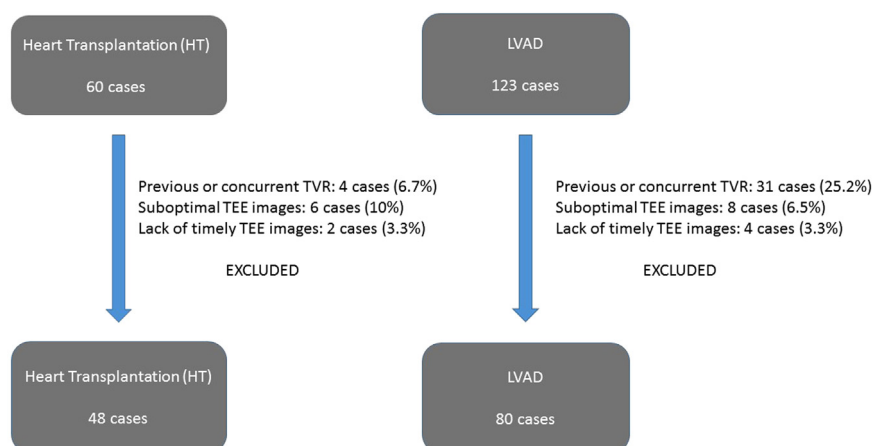


Fig 1. Inclusion/exclusion of heart transplantation (HT) and left ventricular assist device (LVAD) cases. CIED, cardiovascular implantable electronic device; HT, heart transplantation; LVAD, left ventricular assist device; TEE, transesophageal echocardiography; TVR, tricuspid valve repair.

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