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Myocardial functional changes in transfemoral *versus* transapical aortic valve replacement

Niraj Asthana, BS,[a] *Aditya Mantha, MS,*[a] *Eric H. Yang, MD,*[b] *William Suh, MD,*[b] *Olcay Aksoy, MD,*[b] *Richard J. Shemin, MD,*[a] *Gabriel Vorobiof, MD,*[b] *and Peyman Benharash, MD*[a,*]

[a] *Division of Cardiac Surgery, David Geffen School of Medicine, University of California Los Angeles, Los Angeles, California*
[b] *Division of Cardiology, David Geffen School of Medicine, University of California Los Angeles, Los Angeles, California*

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ABSTRACT

Background: Transcatheter aortic valve replacement (TAVR) has greatly expanded the treatment options available for patients with severe aortic stenosis at high surgical risk.
Materials and methods: We compared changes in myocardial function in TAVR with a transfemoral (TF) *versus* a transapical (TA) approach at a major tertiary hospital from 2012-2016. Traditional echocardiographic measures of cardiac structure and function were tracked, alongside the use of two-dimensional speckle tracking echocardiography to measure myocardial strain and strain rates.
Results: For the entire cohort with complete data at all time points ($n = 42$), between the pre-TAVR baseline (mean: 20.1 d) and the post-TAVR 1-mo follow-up (mean: 32.7 d), global longitudinal strain significantly increased (from −15.6% to −18.2%, $P < 0.001$). When comparing the TF ($n = 31$) and TA ($n = 11$) groups, TA patients showed persistently impaired apical longitudinal strain at the 1-mo follow-up (−15.9% *versus* −22.3%, $P < 0.05$). In terms of clinical outcomes, both groups ($n = 131$ for TF, $n = 53$ for TA) were similar in terms of 30-d mortality, readmission rate, and risk of post-TAVR acute kidney injury. However, TA patients experienced significantly longer length of hospitalization (7.58 *versus* 3.92 d, $P = 0.02$), intensive care unit hours (105.4 *versus* 47.1 h, $P = 0.02$), and were at a greater risk of long-term (>72 h) intensive care unit stay (45% *versus* 25%, $P = 0.01$).
Conclusions: Patients undergoing TA-TAVR exhibit impaired apical longitudinal strain, although global myocardial function is similar to TF-TAVR otherwise. Myocardial strain measured by two-dimensional speckle tracking echocardiography appears to be a sensitive method to detect subtle cardiac remodeling after TAVR.

Introduction

Untreated severe aortic stenosis (AS) is characterized by a mortality of approximately 50% within 2 y of the onset of symptoms and is the most common reason for hospitalization among all valvular pathologies.[1-3] While surgical aortic valve replacement remains the gold standard for the treatment of AS, encouraging results have been obtained using

* *Corresponding author*. UCLA Center for Health Sciences, 10833 Le Conte Avenue, Room 62-249, Los Angeles, CA 90095. Tel.: +1 310 206 6715; fax: +1 310 206 5901.
E-mail address: pbenharash@mednet.ucla.edu (P. Benharash).
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transcatheter aortic valve replacement (TAVR). The Placement of Aortic Transcatheter Valves (PARTNER) trial established that in patients at high surgical risk, TAVR significantly reduces mortality in AS patients and has outcomes superior to surgical aortic valve replacement.[3,4] While a transfemoral (TF) approach is typically used, in patients with limited peripheral vascular access due to factors such as vessel tortuosity, caliber, or atherosclerosis, a transapical (TA) route can be used. Interestingly, TA-TAVR is associated with higher overall periprocedural mortality but lower risk of cardiovascular death. Nonetheless, both TF and TA approaches have comparable mortality rates by 2 y after TAVR.[5,6]

While TAVR has widely been associated with acceptable clinical outcomes, few have examined acute changes in cardiac function with this procedure and reported conflicting results. Schattke *et al.* found immediate improvements in global left ventricular (LV) function after TAVR.[7] However, a study of 1661 TAVR patients using conventional echocardiographic parameters found no change in left ventricular ejection fraction (LVEF), a parameter that is commonly used to assess postprocedural outcomes in cardiac patients.[8,9] Interestingly, the validity of LVEF in predicting clinical outcomes has been recently challenged and supplanted with parameters obtained from speckle tracking echocardiography (STE). In particular, long-axis shortening of the LV chamber measured as global longitudinal strain (GLS) has garnered attention as a sensitive marker of cardiac performance. In the Phosphodiesterase-5 Inhibition to Improve Clinical Status and Exercise Capacity in Diastolic Heart Failure (RELAX) trial[10] which examined patients with heart failure and preserved ejection fraction, GLS was significantly reduced and associated with biomarkers of wall stress and collagen synthesis as well as diastolic function. Additionally, the Treatment of Preserved Cardiac Function Heart Failure with an Aldosterone Antagonist (TOPCAT) study demonstrated that abnormal GLS had important prognostic implications in patients with an apparently normal ejection fraction.[11]

In the present study, we hypothesized that STE-derived GLS increases after TAVR before changes in LVEF, and we were interested in comparing differential changes in cardiac wall function between TF-TAVR and TA-TAVR. We utilized traditional echocardiographic methods as well as STE to better characterize the differences in cardiac functional changes after TF-TAVR and TA-TAVR. We further aimed to evaluate the preoperative characteristics and postoperative clinical outcomes of these groups.

Methods

The institutional Transcatheter Valve Therapy database was used to identify all patients who underwent TAVR at Ronald Reagan UCLA Medical Center from 2012-2016. Patients were selected for TAVR based on criteria set forth by the Centers for Medicare and Medicaid services. Included patients had a Society of Thoracic Surgeons Predicted Risk of Mortality score >7% or had significant frailty or other conditions that raised operative risk. Patients who had prior transplantation or those with incomplete data or unavailable echocardiograms were excluded. Patients were divided into the TF and TA cohorts based on procedural approach. Echocardiographic studies were evaluated in the preoperative, immediately postoperative, and short and/or intermediate follow-up time points. Parameters relevant to myocardial function included LVEF, left ventricular internal diameter (LVID), and parameters relating to ventricular mass regression: interventricular septal thickness at end-diastole (IVSd) and posterior wall thickness at end-diastole (PWd). Additionally, LV segmental longitudinal strains were measured using specialized 2D speckle tracking software (Philips QLAB v10.4, Philips Ultrasound, Bothell, WA). GLS was calculated as an average of longitudinal strains measured in the American Heart Association 17-segment model of the heart as assessed in the apical 2-chamber, 3-chamber and 4-chamber views. Clinical data were collected retrospectively from the institutional electronic health record. Statistical analysis was performed using Chi-square analysis of proportions, paired *t*-test and two-way repeated measures analysis of variance. Tabled results are presented in the format of patient count followed by percentage of total group size in parentheses or mean followed by 95% confidence interval in parentheses. This study was approved by the Institutional Review Board at the University of California, Los Angeles, and due to the retrospective nature of the study, an approved waiver of informed consent was also obtained.

Results

A total of 216 patients were identified as having received TAVR during the study period. After application of exclusion criteria, 184 remained: 131 in TF and 53 in the TA groups. Clinical characteristics of the groups are shown in Table 1. Compared to TF, TA patients had a higher incidence of peripheral vascular disease (32% *versus* 7%, $P < 0.001$). Despite this difference, both cohorts had similar surgical risk as predicted by the Society of Thoracic Surgeons Predicted Risk of Mortality (Table 1).

Various traditional echocardiographic parameters as well as myocardial strain via two-dimensional speckle tracking echocardiography (2D-STE) were recorded at three phases of the study: preoperative (20.1 ± 6.2 d), immediate postoperative (2.5 ± 3.4 d), and at a short and/or intermediate follow-up (32.7 ± 11.3 d) (Table 2). Comparing pre-TAVR and short and/or intermediate follow-up in patients with complete imaging at all three time points ($n = 42$, TF = 31, TA = 11): (i) there were no significant changes in LVEF, LVID, IVSd, or PWd ($P > 0.05$); (ii) longitudinal strain significantly increased in magnitude for the anterior (−15.5% to 18.3%, $P < 0.0001$), lateral (−14.0% to −17.1%, $P < 0.0001$), inferior (−14.9% to −18.1%, $P < 0.0003$), and septal segments (−14.2% to −16.9%, $P < 0.0002$); and (iii) GLS significantly increased over time (−15.6 to −18.2%, $P < 0.001$).

The TF and TA groups were similar with regards to postoperative LVEF, LVID, IVSd, PWd, GLS, and anterior, lateral, inferior, and septal segmental longitudinal strains ($P > 0.05$) (Fig). However, there was a significantly worse longitudinal