Prognostic Value of Right Ventricular Two-Dimensional Global Strain in Patients Referred for Cardiac Surgery

Julien Ternacle, MD, Matthieu Berry, MD, Thomas Cognet, MD, Martin Kloeckner, MD, Thibaud Damy, MD, PhD, Jean-Luc Monin, MD, PhD, Jean-Paul Couetil, MD, PhD, Jean-Luc Dubois-Rande, MD, PhD, Pascal Gueret, MD, PhD, and Pascal Lim, MD, PhD, *Creteil and Toulouse, France*

Background: Right ventricular (RV) function is a strong predictor of patient outcome after cardiac surgery. Limited studies have compared the predictive value of RV global longitudinal strain (RV-GLS) with tricuspid annular plane systolic excursion (TAPSE) and RV fractional area change (RVFAC) in this setting.

Methods: The study included 250 patients (66 ± 13 years old, LVEF = 52% ± 12%) referred for cardiac surgery (EuroSCORE-II = 4.8% ± 8.0%). RV function before surgery was assessed by RV-GLS by using speckle-tracking analysis (3-segment from the RV free wall), RVFAC and TAPSE was compared with postoperative outcome defined by 1-month mortality.

Results: Overall, 19 patients (7.6%) had RVFAC < 35%, 34 (13.6%) had TAPSE < 16 mm, and 99 (39.6%) had impaired RV-GLS > −21% (35% with normal RVFAC ≥ 35%). Postoperative death (n = 25) was higher in patients with abnormal RV-GLS > −21% (22% vs 3%; P < .0001), TAPSE < 16 mm (24% vs 8%; P = .007), and RVFAC < 35% (32% vs 9%; P = .001). Mortality was 3% in patients with preserved RV-GLS. In patients with preserved RVFAC ≥ 35% but abnormal RV-GLS, mortality was similar to that of those with RVFAC < 35% (20% vs 32%; P = .12). Among RV systolic indexes, only RV-GLS was associated with patient outcome by multivariate analysis adjusted to EuroSCORE-II and cardiopulmonary bypass duration.

Conclusions: RV-GLS is a sensitive marker of RV dysfunction and correlates with postoperative mortality. (J Am Soc Echocardiogr 2013;26:721-6.)

Keywords: Tricuspid annular plane systolic excursion, Right ventricular fractional area change, Speckle-tracking, Outcome, Cardiac surgery

Postoperative mortality risk is determinant in the decision to refer patients for cardiac surgery. Current guidelines recommend the use of surgery risk scores, such as the logistic EuroSCORE to predict mortality after cardiac surgery.[1] These risk scores only include left ventricular systolic function in the risk assessment,[2] whereas, in clinical practice, both right ventricular (RV) and left ventricular (LV) systolic function[3] are considered in the decision to refer patients for cardiac surgery. The impact of RV function on postoperative outcome has been reported in previous studies, which mainly used RV fractional area change (RVFAC) to quantify RV function.[4,5] RVFAC provides a global assessment of RV function but may be less sensitive than longitudinal RV markers to detect early RV dysfunction. Recent studies demonstrated that longitudinal markers, i.e., tricuspid annular plane systolic excursion (TAPSE), peak systolic tricuspid annular velocity by tissue Doppler imaging (TDI)[6] and, more recently, RV-global longitudinal strain (RV-GLS) by speckle-tracking may be superior to RVFAC in predicting outcome of a patient with heart failure.[7-9] In the present study, we compared the accuracy of RV systolic function indexes for the assessment of patient outcome after cardiac surgery.

METHODS

Study Population

This retrospective study included 250 consecutive patients (mean [SD], 66 ± 13 years) referred with a comprehensive echocardiography that included a modified 4C view for an RV function study. These patients were selected among the 467 patients referred for cardiac surgery from November 2010 to November 2011. Overall, 200 patients were previously included in a recent published study (n = 425) that aimed to demonstrate the impact of LV longitudinal global strain on the postoperative outcome. The protocol only included patients referred for mitral and/or aortic valve surgery and

From AP-HP for Assistance-Publique Hôpitaux de Paris, Henri Mondor University Hospital, Cardiovascular Department and INSERM U955, Team #3, Creteil, France (J.T., M.K., T.D., J.-L.M., J.-P.C., J.-L.D.-R., P.G., P.L.); and CHU Rangueil, Cardiovascular Department, Toulouse, France (M.B., T.C.).

Reprint requests: Pascal Lim, MD, PhD, Henri Mondor University Hospital, Department of Cardiovascular Medicine and INSERM U955, Team #3, 51 Av de Lattre de Tassigny, 94100 Creteil, France (E-mail: *lim.pascal.hmn@gmail.com*).

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Abbreviations

AUC = Area under curves

CABG = Coronary artery bypass graft

CPB = Cardiopulmonary bypass

LV = Left ventricular

LVEF = Left ventricular ejection fraction

OR = Odds ratio

RV-GLS = Right ventricular global longitudinal strain

RVFAC = Right ventricular fractional area change

S-lat-TDI = Systolic right ventricular lateral wall velocity tissue Doppler imaging

TAPSE = Tricuspid annular plane systolic excursion

TDI = Tissue Doppler imaging

those candidates for coronary artery bypass graft (CABG). Patients referred for cardiac tumor resection, isolated or associated severe tricuspid regurgitation (n = 18), tamponade, cardiac transplantation, or assistance for end-stage heart failure were excluded because the postoperative outcome of this population cannot be assimilated to the remaining cohort. All the patients provided written informed consent approved by our local ethics committee.

Echocardiography Measurements

All data were acquired before surgery by using a commercially available Vivid 7 system (GE Vingmed, Horton, Norway), and analysis was performed offline by using Echo-PAC software (GE Vingmed, Horton, Norway). Comprehensive transthoracic echocardiography included LV apical views (4C, 2C, 3C) and a modified 4C view with a high frame rate (mean, 74 ± 17) for RV strain quantification. All measurements were performed offline by an experienced investigator (J.T.), blinded to postoperative outcome. LV volumes and LV ejection fraction (LVEF) were computed by using Simpson biplane method from 2C and 4C apical views. Systolic pulmonary arterial pressure was computed by using a conventional Doppler method from the tricuspid regurgitation. Tricuspid annular plane systolic excursion (TAPSE) was measured from 4C apical view by using M-mode. RV fractional area change (RVFAC) was calculated from 4C apical view by using the conventional formula, i.e., ([end-diastolic area − end-systolic area]/end-diastolic area). According to recent guidelines, RV systolic dysfunction was defined by TAPSE < 16 mm, RVFAC < 35%.[10] RV global longitudinal strain (RV-GLS) was computed from the 4C modified apical view focused on the RV free wall by using two-dimensional speckle-tracking software (automated function imaging, EchoPAC; GE Vingmed).

Briefly, after manual initialization of the end-systolic endocardial border, the region of interest was automatically positioned to track frame by frame the RV free wall throughout the cardiac cycle. The endocardial contour and width were manually adjusted when necessary to provide optimal tracking. RV-GLS was calculated by averaging only strain curves from the RV free wall (3-segment model) to avoid interaction with LV function. According to a previous study,[8] RVGLS > −21% was used to define RV dysfunction. The study was performed in a blinded fashion because RV strain and RVFAC were not included in the echocardiography report.

End Point

Outcome was evaluated by postoperative death (in-hospital death or 1-month postsurgical death after hospital discharge) and the need of prolonged inotropic support (>48 hours). The decision to initiate inotropic support after cardiac surgery in our institution is only based on the presence of hemodynamic instability (mean blood pressure <65 mm Hg or systolic blood pressure < 90 mm Hg, oligoanuria). Outcome was obtained from medical records or direct patient interviews, or from the referring physician.

Statistical Analysis

Continuous variables with a normal distribution are expressed as mean (SD). Dichotomous data are expressed as percentages. To compare numerical data between two groups, paired and unpaired Student t tests were used, as appropriate. Nominal variables were compared by using either the χ^2 test or the Fisher test. Linear correlation was used to compare RV-GLS, RVFAC, and TAPSE. To identify independent factors associated with outcome, we included previously validated independent predictors (EuroSCORE-II and cardiopulmonary bypass [CPB] duration) and RV systolic indexes (TAPSE, RVFAC, and RV-GLS) in the multivariate stepwise analysis by using a logistic model. RV systolic indexes were included as continuous values in the stepwise analysis. Interaction test was used to compare the prognosis value of RV longitudinal strain in patients referred for CABG and valvular surgery. Reproducibility for TAPSE, RV strain, and RVFAC was performed by a second independent observer (T.C.) in 20 random patients. For intraobserver reproducibility, analysis was repeated with the 20 previous patients 1 month after the first measurement. Reproducibility was expressed by using the coefficient of variation. Two-tailed P values <.05 were considered statistically significant for all analyses, and, for adjustment comparison, P values were considered significant when <.1.

RESULTS

Of the 250 patients, 126 patients underwent CABG (83 without valvular surgery), 124 (49%) underwent a valvular surgery without CABG. The EuroSCORE- II averaged 4.8% ± 8.0% (range, 1.3%-89%). After cardiac surgery, prolonged inotropic support was required in 82 patients (33%), and postoperative death was reported in 25 patients (10%). Most deaths were related to refractory heart failure or septicemia. Baseline characteristics are shown in Table 1.

RV-GLS

TAPSE, RVFAC, and RV-GLS averaged 21 ± 5 mm (range, 5-33 mm), 51% ± 9% (range, 19%-72%) and −21% ± 7% (range, −46% to −3%), respectively. Of the 250 patients, only 19 had abnormal RVFAC < 35% and 34 had abnormal TAPSE, <16 mm. RVFAC and TAPSE correlated well (r=0.66; P<.0001) and were concordant (kappa = 0.62): 90% of patients with RVFAC < 35% had abnormal TAPSE < 16 mm, and 93% of patients with normal RVFAC had normal TAPSE. In contrast, RV-GLS was less correlated with RVFAC (r = −0.50, P < .0001) (Figure 1A) and with TAPSE (r = −0.43, P < .0001) (Figure 1B). All patients with abnormal RVFAC < 35%, had abnormal RV-GLS (>−21%), but 34% of patients with preserved RVFAC > 35% (n = 80/231) or with TAPSE > 16 mm (n = 73/216) had abnormal RV-GLS. Patients with RVFAC < 35% had more severely impaired RV strain than those with normal RVFAC and abnormal RV strain (−10% ± 4% vs −15% ± 3%; P<.0001) (mean [SD]).

RV Function and Postoperative Hemodynamic Stability

Patients who required prolonged inotropic support (n = 82 [33%]) had higher EuroSCORE-II and more prolonged CPB duration (Table 2). Prolonged inotropic support was more frequently required in patients with RVFAC<35% (Figure 2A), TAPSE < 16 mm