Right Ventricular Reverse Remodeling, but not Subjective Clinical Amelioration, Predicts Long-Term Outcome After Surgery for Isolated Severe Tricuspid Regurgitation

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Background: Subjective clinical improvement does not always go hand-in-hand with right ventricular (RV) reverse remodeling after surgery for isolated severe tricuspid regurgitation (TR). This study aimed to evaluate the level of agreement between clinical improvement and echocardiographic RV reverse remodeling, and determine the relative prognostic powers of these 2 factors in terms of long-term prognosis for patients with isolated TR surgery.

Methods and Results: Sixty-one consecutive patients (58±8 years) were included. During a median follow up of 55 months (IQR, 36.5–71.5 months), a composite endpoint including death and admission for right heart failure was investigated. Extents of reductions in RV end-systolic area (RV-ESA) and subjective clinical improvement at 6 months were examined. There were 6 deaths and 5 admissions for right heart failure. A reduction in RV-ESA of >20% effectively predicted event-free survival, with a sensitivity of 90.9% and a specificity of 72.0% (AUC 0.81, P=0.001). With this cut-off, the agreement between a clinical and echocardiographic response was only 57.4% (35 patients). On Cox regression analysis, RV-ESA change emerged as the only independent predictor of event-free survival, whereas subjective clinical improvement did not.

Conclusions: A discrepancy between subjective and echocardiographic improvement at 6 months after isolated TR surgery was observed in 42.6% of the patients. Echocardiographic RV reverse remodeling, but not subjective clinical amelioration, was a strong prognosticator after surgery. (Circ J 2014; 78: 385–392)

Key Words: Echocardiography; Functional class; Surgery; Tricuspid regurgitation

Although tricuspid regurgitation (TR) has long been neglected based on the false belief that it is extremely rare and not clinically significant, recent studies have shown that it is not a rare disease, and that its prevalence is progressively growing, especially long after left-sided valve surgery. In addition, TR development, long after left-sided valve surgery, is closely linked to exercise intolerance and presages a poor outcome, even in the absence of left ventricular (LV) dysfunction or pulmonary hypertension. In this respect, corrective surgery for TR is considered a reliable therapeutic option if it is performed in a timely manner. In addition to improvements in symptoms and survival, timely performed corrective TR surgery can cause right ventricular (RV) reverse remodeling. However, the response to corrective TR surgery varies significantly among patients; some patients experience a significant improvement in subjective symptoms such as exertional dyspnea along with RV reverse remodeling, whereas other patients show no improvement or deterioration of subjective symptoms, but with evident echocardiographic RV reverse remodeling, or vice versa. Thus, we do not know which factor (subjective symptoms or objective RV reverse remodeling) is more trustworthy for predicting the long-term outcome after corrective TR surgery.

Hence, the aim of this prospective study was 2-fold: (1) to evaluate the degree of (dis)agreement between subjective and echocardiographic improvement at 6 months after isolated TR surgery; and (2) to investigate which of the 2 factors is more predictive of a better long-term
clinical outcome.

Methods

Study Patients
We prospectively recruited consecutive patients who underwent corrective surgery for isolated severe TR (ie, without any other valvular dysfunction) between March 2003 and November 2010. All patients underwent a preoperative and a 6-month, follow-up echocardiographic study to assess potential RV reverse remodeling. Patients who had any clinical events before the 6-month follow up were systematically excluded (10 patients; 8 died before discharge, 1 died of hemorrhagic stroke and 1 experienced unexpected sudden death). To be included in the present study, the following 3 preoperative echocardiographic criteria for severe TR were required: (1) TR jet ≥30% of the right atrial (RA) area; (2) inadequate cusp coaptation; and (3) systolic flow reversal in the hepatic vein.7,8 Inadequate coaptation of the tricuspid valve was determined to be present when the gap between the septal and anterior leaflets of the tricuspid valve that was measured using zoomed images of the modified apical 4-chamber view was visually identified and estimated to be ≥5 mm. Inadequate coaptation was linked to tricuspid annular dilation and apical tethering of the leaflets in all patients. All patients enrolled in this study were free of significant coronary artery disease, as evidenced by a preoperative invasive coronary angiography. Ultimately, a total of 61 patients (mean age 58±8 years; women 54 (89%)) were included in the current study. In all patients, clinical and echocardiographic follow ups were performed at our institution. The study protocol was approved by the institutional review board of our hospital.

Echocardiographic Examinations
Comprehensive echocardiographic evaluation was performed before and after corrective TR surgery in all patients using commercially available equipment (Sequoia, Siemens Medical Solutions; Vivid 7, GE Medical Systems; or i33, Philips). LV end-diastolic and end-systolic diameters and LV ejection fraction (LV-EF) were measured by M-mode in the parasternal short-axis view at the papillary muscle level. Measurements of RV end-systolic area (RV-ESA) and end-diastolic areas (RV-EDA) were made in the apical 4-chamber view, and RV fractional area change (RV-FAC) was calculated using the following formula: RV-FAC=(RV-EDA−RV-ESA)/RV-ESA×100%.10 The RV-free wall was traced from the base to the apex, and the RV areas were calculated from an average of 3–5 measurements. Great care was exercised not to procure foreshortened images of the apical 4-chamber view. The RA area was measured at the end-systole in the apical 4-chamber view. The tricuspid annular diameter was defined as the widest diameter that could be measured from an end-diastolic-still frame. Systolic tricuspid annulus velocity was obtained by placing the sample volume of the pulse-wave Doppler tissue imaging at the lateral side of the tricuspid annulus. Pulmonary artery systolic pressure was measured by summing the peak systolic trans-tricuspid pressure gradient and the estimated RA pressure. The diameter of the inferior vena cava and its respiration variation were measured 1.0–2.0 cm from the RA junction in the subcostal view during the cardiac cycle to estimate RA pressure. The percentage of decrease in inferior vena cava diameter was used to determine mean RA pressure; the RA pressures were categorized as normal (at least 50% decrease), mildly elevated (dilated more than 17 mm with 50% decrease), moderately elevated (dilated more than 17 mm with less than 50% decrease), or severely elevated (dilated more than 17 mm without any collapse), as recommended by current guidelines.13 All echocardiographic examinations were performed by a skilled sonographer and interpreted by experienced cardiologists (K.-H.K., K.-Y.J.) without knowledge of the clinical status of the patients. All echocardiographic measurements were averaged from 3 consecutive beats in patients with sinus rhythm and from 5 consecutive beats in patients with atrial fibrillation.

Long-Term Follow up and Assessments of Clinical Events
Medical histories and the results of clinical examinations were obtained at baseline by attending physicians and a dedicated research nurse. All patients were regularly followed, with clinical and echocardiographic assessments, by their operating surgeons or attending physicians at our institution. Clinical events were defined as a composite of death and admission due to right-sided heart failure (as assessed by 2 experienced cardiologists (K.-H.K., K.-Y.J.)) during follow up. The followings were mainly considered objective evidences of right-sided heart failure: jugular venous engorgement, hepatomegaly (newly developed or progressed), ascites, and pedal or lower extremity edema. Causes of death were ascertained by reviewing medical records or by undertaking telephone interviews with close relatives. No patient was lost to follow up.

Statistical Analysis
Data are expressed as mean±standard deviation for normally distributed variables and as medians with interquartile range (IQR) for variables not normally distributed for continuous variables, and as numbers (%) for categorical variables. Differences in continuous variables between patients who did and did not experience clinical events were compared using the Student’s t-test or the Mann-Whitney test, depending on the results of normality testing conducted using the Shapiro-Wilk test. For comparison of categorical variables, the χ² test was used. A Cox proportional hazards model, with the use of a forward selection process based on the likelihood ratio test, was implemented for multivariate analysis to determine which factors identified in the univariate analysis were significantly related to long-term clinical events. Receiver-operating characteristic (ROC) curves were analyzed to assess the best cut-off value of RV-ESA for the best prediction of clinical events. The optimal cut-off value was defined as the value giving the maximal sum of sensitivity and specificity. Probabilities of event-free survival were obtained by Kaplan-Meier estimates according to the presence or absence of RV-ESA reduction of >20% and then compared by the use of a 2-sided log-rank test. All statistical analyses were performed using SPSS version 17.0 for Windows (SPSS, Chicago, IL, USA). A P-value of <0.05 was taken as a cut-off value for statistical significance.

Results
The median follow-up duration after corrective TR surgery was 55 months (IQR, 36.5–71.5 months). Fifty-four of the 61 patients (89%) were female, and preoperative electrocardiography showed atrial fibrillation in 52 (85%) patients. Prior left-sided valve surgery had been performed in 53 patients (87%). At the time of previous left-sided valve surgery, tricuspid annuloplasty was concomitantly performed in 8 patients (13.1%). The causes of TR were functional in 50 patients (82.1%), rheumatic in 10 patients (16.3%) and congenital in 1 patient (1.6%). In terms of functional capacity, 23 patients (37.8%) were classified as New York Heart Association (NYHA) class II, 31
(50.8%) as class III, and 7 (11.5%) as class IV. The type of medication used was unchanged within the first 6 months after TR surgery, except for warfarin based on prothrombin time and dose reductions in diuretics. Preoperative echocardiographic examinations yielded an average LV end-diastolic diameter of 46.2±7.6 mm, a LV-EF of 57.2±9.2%, a tricuspid annulus diameter of 43.7±6.9 mm, a RA area of 51.9±19.3 cm², a TR area of 23.0±9.8 cm², a RV-EDA of 33.5±6.9 cm², a RV-ESA of 19.5±5.3 cm², and a RV-FAC of 42.2±7.9%. The mean pulmonary artery systolic pressure was 40.5±8.6 mmHg. Echocardiography conducted at the 6-month follow up clearly demonstrated RV reverse remodeling. Both RV-ESA and RV-EDA decreased significantly by 29.1±20.1% and 36.9±13.7%, respectively (all P<0.001).

With regard to surgical procedures, 9 patients (15%) underwent tricuspid valve repair, and 52 (85%) underwent tricuspid valve replacement with tissue (n=5) or mechanical (n=47) valves. A concomitant Maze procedure was performed in 15 patients.

**Table 1. Comparison of Baseline Clinical and Echocardiographic Parameters Between Patients With Clinical Events and Those Without After Corrective Surgery for Isolated Tricuspid Regurgitation**

| Clinical characteristics | No event (n=50) | Event (n=11) | P value |
|--------------------------|----------------|-------------|---------|
| Age (years)              | 57±8           | 62±8        | 0.06    |
| Median (IQR)             | 57 (42, 73)    | 64 (56, 67) |         |
| Female gender (%)        | 44 (88%)       | 10 (91%)    | 0.63    |
| Atrial fibrillation (%)  | 42 (84%)       | 10 (91%)    | 0.91    |
| NYHA class               | 2.6±0.6        | 3.2±0.6     | 0.01    |
| Prior left-sided valve surgery (%) | 44 (88.0%) | 9 (81.9%) | 0.63 |
| HR (beats/min)           | 66±11          | 67±8        | 0.59    |
| Median (IQR)             | 69 (58, 73)    | 69 (65, 74) |         |
| SBP (mmHg)               | 119±15         | 118±17      | 0.79    |
| Median (IQR)             | 120 (108, 130) | 120 (107, 130) |     |
| DBP (mmHg)               | 67±9           | 65±8        | 0.29    |
| Median (IQR)             | 70 (60, 73)    | 61 (59, 70) |         |
| Preoperative echocardiographic parameters |                |             |         |
| Tricuspid annular diameter (mm) | 44.0±6.6   | 42.4±8.5    | 0.50    |
| RA area (cm²)            | 50.2±18.9      | 58.9±20.4   | 0.18    |
| TR area (cm²)            | 21.6±8.5       | 29.1±12.9   | 0.09    |
| Inferior vena cava (mm)  | 26.6±5.9       | 28.2±7.8    | 0.43    |
| Pulmonary artery systolic pressure (mmHg) | 40.0±8.5 | 42.7±9.3 | 0.38 |
| LV end-diastolic diameter (mm) | 46.2±7.7  | 48.3±7.5    | 0.99    |
| LV-EF (%)                | 58.8±7.7       | 55.3±10.1   | 0.35    |
| RV-EDA (cm²)             | 33.1±6.3       | 35.2±9.4    | 0.38    |
| RV-ESA (cm²)             | 19.1±4.6       | 21.2±8.1    | 0.42    |
| RV-FAC (%)               | 42.4±7.6       | 40.9±9.6    | 0.57    |
| S' (cm/s)                | 9.3±2.3        | 8.8±3.3     | 0.58    |
| Diuretics                | 37 (74.0%)     | 9 (81.8%)   | 0.59    |
| Aldosterone antagonists   | 40 (80.0%)     | 10 (90.9%)  | 0.67    |
| Diuretics                | 30 (60.0%)     | 9 (81.8%)   | 0.34    |
| β-blockers               | 8 (16.0%)      | 0 (0%)      | 0.16    |
| ACE inhibitors or ARBs   | 3 (6.0%)       | 3 (27.3%)   | 0.07    |

ACE, angiotensin-converting enzyme inhibitors; ARBs, angiotensin receptor blockers; HR, heart rate; IQR, interquartile range; LV, left ventricle; LV-EF, left ventricle ejection fraction; NYHA, New York Heart Association; RA, right atrial; RV-EDA(S)/A, right ventricular end-diastolic (systolic) area; RV-FAC, right ventricular fractional area change; S(D)BP, systolic (diastolic) blood pressure; S', peak systolic tricuspid annulus velocity; TR, tricuspid regurgitation.

**Clinical Outcomes of Patients During Long-Term Follow up**

Of the 61 patients enrolled, 6 (9.8%) died of heart failure and 5 (8.2%) required admission due to decompensated heart failure. No heart failure event was attributed to the LV. There was no event related to artificial valve dysfunction like mechanical valve thrombosis or bioprosthetic valve degeneration. As illustrated in Table 1, all baseline clinical parameters were comparable between patients with and without clinical events, with the exception of the mean NYHA class, which was higher in patients with a clinical event (P=0.01). All preoperative echocardiographic parameters were also similar between these 2 groups. There was no difference in medication use in the 2 groups.

Table 2 illustrates changes in NYHA class and echocardiographic parameters 6 months after corrective TR surgery. When subjective clinical amelioration was defined as a ≥1-point NYHA class improvement, 52 patients (85.2%) showed subjective clinical amelioration, 8 (13.1%) reported no change, and 1 (1.6%) reported a subjective deterioration. Overall, there was no difference in subjective clinical amelioration between
What Level of RV Reverse Remodeling Predicts Long-Term Event-Free Survival?

In an attempt to determine a cut-off value for RV-ESA changes in predicting long-term outcome after corrective TR surgery, a ROC curve was generated in relation to RV-ESA. On ROC curve analysis, we found that a reduction in RV-ESA of >20% predicted event-free survival most effectively, with a sensitivity of 90.9% and a specificity of 72.0% (AUC 0.81, P=0.001) (Figure 1). Similarly, when each component of the composite end-point was considered separately, a reduction in RV-ESA of >20% had a sensitivity and a specificity of 100% and 67.2%, respectively (AUC=0.77, P=0.031) for predicting the absence of death, and a reduction in RV-ESA of <20% predicted admission due to heart failure, with a sensitivity of 90.9% and a specificity of 72.0% (AUC=0.81, P=0.001).

Subjective Clinical Amelioration vs. Echocardiographic RV Reverse Remodeling (Figure 2)

Based on ROC curve analysis, a reduction in RV-ESA of >20% was defined as evidence of clinically relevant echocardiographic RV reverse remodeling after corrective TR surgery. According to the definitions of subjective clinical amelioration (a ≥1-point improvement in NYHA class) and of echocardiographic RV reverse remodeling, only 32 patients (52.5%) exhibited concomitant reductions in NYHA class and RV-ESA. In addition, 3 patients (4.9%) had no reductions in either NYHA class or RV-ESA. Accordingly, the discordance rate between subjective and echocardiographic definitions of improvement was 42.6% (26 of the 61 patients). Disagreement between the 2 definitions of improvement was mainly caused by patients with subjective improvement, but no reduction in RV-ESA of >20% (32.8%).

Predictors of Clinical Outcome in the Long-Term Follow up

Of the 61 patients recruited, 38 (62.3%) achieved a RV-ESA reduction of >20%. Only 2 (5.3%) of the 38 patients with a reduction in RV-ESA of >20% experienced a clinical event, as compared with 9 (30.1%) of the 23 with a reduction of ≤0% ($\chi^2=11.1, \ P=0.001$). However, a clinical improvement was unable to predict the long-term outcome in these patients (Table 2).

Cox proportional regression analysis, with the use of a forward stepwise selection process, demonstrated that the per-
RV-ESA was the only independent predictor of death (exp (β)=1.093, 95% confidence interval=1.041–1.148, P<0.001) or admission due to heart failure (exp (β)=1.076, 95% confidence interval=1.032–1.122, P=0.001). Kaplan-Meier survival anal-

percentage difference in RV-ESA (a marker of echocardiographic RV reverse remodeling) was the only independent predictor of the composite endpoint (exp (β)=1.062, 95% confidence interval=1.025–1.101, P=0.001). Furthermore, a change in RV-ESA was the only independent predictor of death (exp (β)=1.093, 95% confidence interval=1.041–1.148, P<0.001) or admission due to heart failure (exp (β)=1.076, 95% confidence interval=1.032–1.122, P=0.001). Kaplan-Meier survival anal-

Figure 2. Concordance between subjective clinical amelioration and a reduction in right ventricular end-systolic area (RV-ESA) of >20%.

Figure 3. Kaplan-Meier curves showing differences in (A) the composite endpoint (death and admission for heart failure), (B) death, and (C) admission for heart failure in relation to a change in right ventricular end-systolic area (RV-ESA) of >20%.
Analysis showed clear differences in the composite endpoint (Figure 3A), death (Figure 3B), and admission for heart failure (Figure 3C) according to the presence or absence of a RV-ESA reduction of >20%. Although the presence of subjective clinical amelioration failed to prove its independent contribution to the prediction of the composite endpoint or admission due to heart failure alone, it was able to predict death by Cox proportional regression analysis (exp (β)=0.226, 95% confidence interval=0.052–0.975, P=0.045).

When we divided the 61 patients into 4 subgroups according to the achievement or not of subjective clinical and/or echocardiographic improvement, the patients that did not achieve either were found to have the worst event-free survival, whereas patients that achieved both had the lowest rate of composite endpoint (Figure 4). Of note, patients with echocardiographic RV reverse remodeling but without subjective clinical amelioration had better event-free survival than those with subjective clinical amelioration but without echocardiographic RV reverse remodeling. All patients who had neither echocardiographic reverse remodeling nor subjective clinical amelioration died during follow up.

**Measurement Variability Analysis**

Intra-observer variability was assessed using 2 different blinded evaluations by 1 observer in 20 randomly selected patients at least 1 month apart, whereas inter-observer variability was assessed by 2 different observers on a different day. Inter-observer and intra-observer variabilities for RV-ESA were as follows: intra-class correlation coefficient for inter-observer variability=0.86; intra-class correlation coefficient for intra-observer variability=0.91.

**Discussion**

This is the first prospective study to investigate the presumed relationship between echocardiographic RV reverse remodeling and long-term clinical outcome in a sizable number of patients that underwent isolated corrective TR surgery. Patients who experienced death or admission for heart failure exhibited less echocardiographic RV reverse remodeling than those who did not. Furthermore, ROC curve analysis showed that a cut-off value of >20% reduction in RV-ESA most effectively predicted the composite endpoint. In addition, echocardiographic RV reverse remodeling, that is, a reduction in RV-ESA, was found to predict independently late event-free survival over a median follow up of 55 months, whereas subjective clinical amelioration was not predictive.

**Discrepancy Between Subjective Clinical and Echocardiographic Response After TR Surgery**

Subjective clinical amelioration has frequently been viewed as a well-accepted, soft clinical endpoint for the assessment of therapeutic efficacy in many heart failure clinical trials. \(^\text{14-16}\)

Echocardiographic LV reverse remodeling has been closely associated with a better prognosis in pharmacological clinical trials, such as trials on angiotensin-converting enzyme inhibitors and β-blockers. \(^\text{17-19}\)

However, subjective clinical improvement is not always accompanied by echocardiographic LV reverse remodeling, and thus, patients demonstrating subjective clinical amelioration sometimes experience heart failure progression and eventually symptomatic deterioration. \(^\text{17-19}\)

It is possible that a similar phenomenon might be observed in patients with right-sided heart failure driven by severe TR, but no previous study has systematically addressed the proportion of patients who show subjective clinical amelioration, but do not exhibit RV reverse remodeling and vice versa. We found, in the present study, that 26 (42.6%) of the 61 patients did exhibit discordant subjective clinical and echocardiographic responses. Of note, this disagreement was mainly associated with patients who responded clinically without displaying RV reverse remodeling, suggesting the possibility of a placebo effect resulting from TR surgery. Regardless of the reason, this finding could thoroughly confuse cardiologists or cardiothoracic surgeons who justifiably wish to know which of these 2 factors better predicts long-term, event-free survival. To decipher this enigma, an evaluation of the relative prognostic merits of these 2 factors should be conducted to aid in the management and follow up of patients undergoing TR surgery.

**Echocardiographic RV Reverse Remodeling vs. Subjective Clinical Amelioration in Predicting Long-Term Outcome**

We previously demonstrated that successful TR surgery can result in remarkable reductions in RV volumes. \(^\text{3}\)

In contrast to clinical trials regarding heart failure in the LV, \(^\text{17-19}\) no study has attempted to examine the potential link between echocardiographic RV reverse remodeling and long-term outcome.
and hence, it has not been established whether the close association between successful TR surgery and RV reverse remodeling is clinically relevant. The present study not only directly addresses this relationship, but also suggests a clinically relevant cut-off value for RV-ESA change. More specifically, ROC curve analysis showed that a reduction in RV-ESA of >20% is clinically meaningful, given the acceptable sensitivity and specificity for predicting a composite of death and admission for heart failure. Moreover, when the components of the composite endpoint were considered separately, this cut-off value consistently predicted death or admission for heart failure. These findings indicate that a simple planimetric assessment of RV-ESA by echocardiography not only provides a surrogate marker of favorable RV reverse remodeling, but that it also confers an objective marker of long-term outcome. Of note, we also found that subjective clinical amelioration failed to predict the long-term composite endpoint. Nevertheless, the presence of subjective clinical amelioration at 6 months after TR surgery was found to predict death, although not admission for heart failure, suggesting that we should not discount subjective clinical amelioration, per se, in the prediction of long-term outcome. Interestingly, when the presence or absence of subjective clinical amelioration was incorporated into echocardiographic RV-ESA reduction, a more sophisticated prediction of prognosis was possible (Figure 4). According to Figure 4, patients with echocardiographic RV reverse remodeling alone had better event-free survival than those with subjective clinical amelioration alone, again highlighting the finding that longitudinal, planimetric assessment of RV-ESA by echocardiography provides more powerful information than subjective clinical amelioration for the prediction of long-term outcome after TR surgery.

Clinical Implications
The current study, for the first time, shed light on the link between echocardiographic RV reverse remodeling and long-term outcome after corrective TR surgery. As in the case of echocardiographic LV reverse remodeling, as reflected by a reduction in LV end-systolic volume, a reduction in RV-ESA could be a marker for better clinical outcome, indicating that echocardiographic RV reverse remodeling at 6 months after TR surgery not only reflects favorable RV structural changes, but also signifies the translation of this favorable RV structural change into better event-free survival. In particular, a RV-ESA cut-off value of 20% yielded the best results for predicting long-term, event-free survival. Therefore, echocardiographic RV-ESA change could take a central role in the clinical armamentarium available for the management and follow up of TR patients after surgery. Furthermore, this cut-off value could be adopted as an objective surrogate value of long-term outcome in future clinical trials involving isolated TR surgery.

Study Limitations
This study had a number of limitations. First, the number of patients recruited was low, and thus, definite conclusions are difficult to draw. However, as compared with prior studies, the size of the study population was relatively large, and the follow-up period adopted is the longest. Thus, we believe that the present study provides useful information on the relative advantages of assessments of RV reverse remodeling based on echocardiography over subjective clinical amelioration in predicting long-term prognosis. Second, TR etiologies were heterogeneous, although the source of TR was functional in origin in most of our study population. However, consecutive TR patients were prospectively recruited, and as such, we believe that the study cohort well represented many patients that undergo “isolated” TR surgery in a real clinical setting. Thus, we consider that the results of this study are clinically meaningful with respect to the evaluation and treatment of TR patients in real daily clinical practice. Third, the proportion of tricuspid valve replacements is relatively high as compared with previous studies. Two reasons can provide potential explanations. All study patients had inadequate coaptation of tricuspid valve leaflets preoperatively, mainly because of severe leaflet tethering and annular dilatation, which significantly decreased the success rate of tricuspid valve repair. Moreover, most patients had undergone mitral and/or aortic valve repair/replacement and thus the benefit of repair was partially reduced. The fact that atrial fibrillation was present in 85% of patients also contributed as well. Although tricuspid valve repair would be better for preserving RV function, it does not translate into a better survival rate.26 In addition, earlier studies found no difference favoring tricuspid valve repair over replacement in survival outcome.21,22 Therefore, it is unlikely that a high rate of replacement significantly affected the results of the current study. Fourth, the methodology adopted to quantify RV systolic function might be dependent on image section and was not a real volumetric-based approach. However, a RV planimetric approach by echocardiography was well correlated with the RV volumetric approach by cardiac magnetic resonance in a validation study.24 In addition, we tried our best to get the same image section to assess RV-ESA and RV-EDA in all patients by using 1 well-trained sonographer. Speckle tracking-based RV strain assessment might be helpful for the assessment of RV systolic function, which should be evaluated in a future study.24 Finally, our results cannot be extrapolated to structural tricuspid valve disease.25

Conclusions
In as much as 42.6% of patients, there was a discrepancy between subjective clinical and echocardiographic improvements 6 months after corrective TR surgery. Echocardiographic RV reverse remodeling (defined as a reduction in RV-ESA of >20%) was a strong prognosticator of the composite endpoint of death and admission due to heart failure, whereas subjective clinical amelioration was not. Therefore, our findings support the proposal that changes in RV-ESA of >20% at 6 months after corrective TR surgery hold promise as a surrogate of better long-term prognosis in these patients.

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Disclosures
Conflict of Interest: None.

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**Supplementary Files**

**Supplementary File 1**

Figure S1. Receiver-operating characteristic curve for predicting long-term, event-free survival in relation to a change in right ventricular fractional area change (RV-FAC).

Figure S2. Concordance between subjective clinical amelioration and a reduction in right ventricular fractional area change (RV-FAC) of ≥25%.

Figure S3. Kaplan-Meier curves showing differences in (A) the composite endpoint (death and admission for heart failure), (B) death, and (C) admission for heart failure in relation to a reduction in RV-FAC of ≥25%.

Please find supplementary file(s): http://dx.doi.org/10.1253/circj.CJ-13-0790