



## Tricuspid annular plane systolic excursion inaccuracy to assess right ventricular function in patients with previous tricuspid annuloplasty



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### ABSTRACT

**Objectives:** The clinical and prognostic usefulness of tricuspid annular plane systolic excursion (TAPSE) is well established. However, the ability of TAPSE to assess right ventricular (RV) function in patients with previous tricuspid valve annuloplasty is controversial. This study examined the TAPSE suitability in patients with previous tricuspid valve annuloplasty using right ventricular fractional area change (RVFAC) as reference method.

**Methods:** We retrospectively analyzed 53 patients who underwent tricuspid valve annuloplasty at our hospital between 2013 and 2016. TAPSE and RVFAC were obtained in preoperative and postoperative periods using standard methodology.

**Results:** Mean age was  $68 \pm 12$  years and 34 patients (64.1%) were women. TAPSE decreased significantly after surgery in comparison with pre-surgical values ( $17 \pm 4.2$  Vs  $12.9 \pm 4.1$  mm,  $p < 0.001$ ). On the contrary, RVFAC did not change significantly after surgery ( $37 \pm 9.2$  Vs  $36.2.9$ ,  $p = 0.25$ ). The correlation between RVFAC and TAPSE was better in the preoperative ( $r = 0.63$ ,  $p < 0.0001$ ) than in the postoperative period ( $r = 0.38$ ,  $P = 0.005$ ). Good intra- and interobserver agreement for TAPSE and RVFAC was obtained, with intraclass correlation coefficients of 0.97 and 0.92 for TAPSE; and 0.90 and 0.85 for RVFAC, respectively.

**Conclusions:** These findings suggest that TAPSE is not suitable after tricuspid valve annuloplasty and it leads to an underestimation of RV systolic function. It seems to be appropriate to rely on echocardiographic parameters of global RV function such as RVFAC in this context.

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### 1. Introduction

The role of right ventricular (RV) function as a prognostic determinant in many cardiovascular diseases and its important prognostic value in the evaluation of the surgical outcome have been demonstrated in several studies [1–2]. In routine clinical practice, RV systolic function is commonly assessed by measuring tricuspid annular plane systolic excursion (TAPSE) using standard M-mode transthoracic echocardiography (TTE). The clinical and prognostic usefulness of this parameter as well as his relation with RV ejection fraction (RVEF) are well established [3–5]. TAPSE has been proved to be accurate, feasible, simple, and reproducible in both normal and pathological patients [6]. However, the ability of TAPSE to assess RV function in patients with previous tricuspid valve annuloplasty is controversial, because this surgical

procedure could decrease the systolic excursion of the tricuspid annular plane. However TAPSE has been widely used in this context and its use is not discouraged by the current guidelines [7].

Recently, right ventricular fractional area change (%) (RVFAC) has gained credit as a useful index for assessment of RV systolic function in the context of cardiac surgery [8]. While TAPSE primarily reflects the function of longitudinal myocardial fibers, RVFAC is influenced by both the contractility of longitudinal and concentric myocardial fibers. The present study examined whether TAPSE is a suitable method to assess the RV systolic function in patients with previous tricuspid valve annuloplasty, using RVFAC as reference method.

### 2. Material and methods

#### 2.1. Study population

We retrospectively analyzed patients who underwent tricuspid valve annuloplasty at our hospital between 2013 and 2016, and which it was available a comprehensive pre and postoperative echocardiogram (within 3 months following surgery). Exclusion criteria were inadequate echocardiographic acoustic apical window, history of coronary artery disease or of previous cardiac surgery. The initial full sample comprised 87 patients. Nine patients were excluded because they didn't undergo postoperative echocardiogram, 8 by the presence of poor acoustic window, 5 by history of coronary artery disease, and 12

**Abbreviations:** DTIS', tissue Doppler derived tricuspid lateral annular systolic velocity; ICC, intraclass correlation coefficient; RV, Right ventricular; RVEF, Right ventricular ejection fraction; RVFAC, Right ventricular fractional area change (%); TAPSE, tricuspid annular plane systolic excursion; TTE, transthoracic echocardiography; 2D, two-dimensional; 3D, three-dimensional.

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by previous cardiac surgery, resulting in a final sample of 53 patients included. All patients underwent echocardiography because of clinical indications and gave written informed consent before undergoing echocardiography in accordance with a protocol approved by the institutional review board.

## 2.2. 2D echocardiography

Transthoracic echocardiography was performed by experienced sonographers using a commercially available ultrasound machine (iE33; Philips Healthcare, Amsterdam, The Netherlands; Sonos 5500®; Philips Medical Systems, Andover, MA, USA; and Artida - Toshiba Medical Systems, Tokyo, Japan). A standard color Doppler two-dimensional (2D) TTE was performed in accordance with the American Society of Echocardiography recommendations [7]. Specifically, RV end-diastolic area and RV end-systolic area were calculated from the apical 4-chamber view, and the calculation of RVFAC used to determine global RV systolic function was performed using the following formula:  $\text{RVFAC} = [\text{RV end-diastolic area} - \text{RV end-systolic area}] / \text{RV end-diastolic area} \times 100\%$ . To determine TAPSE, the M-mode cursor was oriented to the junction of the tricuspid valve plane with the RV free wall using the apical 4-chamber RV-focused view. Maximal TAPSE was determined by the total excursion of the tricuspid annulus from its highest position after atrial ascent to the peak descent during ventricular systole. No angle correction method was used during the measurement. Tissue Doppler derived tricuspid lateral annular systolic velocity (DTI S') was also obtained when it was available. All echocardiographic measurements were averaged from five consecutive beats in patients with atrial fibrillation. All echocardiographic parameters were calculated offline using the commercially available software (Xcelera, Philips Health Care, Andover, MA, USA).

## 2.3. Reproducibility

To assess the effect of observer variability and the reproducibility a second independent observer analyzed 20 randomly selected cases. On the same 2D and M-mode acquisitions, each observer obtained the TAPSE and RVFAC as described above. Intraobserver variability was assessed by comparing the measurements given by the same observer after an interval of more than a week between the two measurements. Both readers were blinded to previous measurements.

## 2.4. Statistics

Continuous variables are expressed as means  $\pm$  standard deviations (S.D.). Categorical data are presented as absolute number or percentages. Correlations between TAPSE and RVFAC measurements were assessed by simple linear regression analysis. Inter- and intra-observer reproducibilities were evaluated by means of the intraclass correlation coefficient (ICC). Differences were considered statistically significant at  $p < 0.05$  (two-sided). Statistical analysis was performed with the SPSS 17.0 (SPSS Inc., Chicago, Illinois) and Medcalc 11.5 software (MedCalc, Belgium).

## 3. Results

### 3.1. Patient data

A comprehensive pre and postoperative TTE with adequate endocardial border resolution allowing determination of end-diastolic and end-systolic RV areas as well as tricuspid annular motion for M-mode was obtained in 53 patients. Clinical and echocardiographic baseline characteristics of patients studied are summarized in Table 1. Mean age was  $68 \pm 12$  years and 34 patients (64.1%) were women. Twenty-nine patients (54.7%) were in sinus rhythm and 24 (45.3%) in atrial fibrillation when studied. Three patients underwent isolated tricuspid annuloplasty for severe symptomatic tricuspid regurgitation; and 50 patients underwent concomitant tricuspid annuloplasty during left heart valve surgery (9 mitral valve repair, 17 mitral valve replacement, 4 aortic valve replacement, and 20 mitroaortic valve replacement). Indications for concomitant tricuspid annuloplasty during left heart valve surgery were as follows: 1) the presence of at least moderate tricuspid regurgitation on the preoperative echocardiogram; or 2) significant annular dilation assessed at end-diastolic diameter in the 4-chamber view as an annulus  $>40$  mm. Preoperative tricuspid regurgitation was mild in 7.5%, moderate in 39.6%, and severe in 52.8% of patients. Patients undergoing tricuspid valve annuloplasty received ring sizes ranging from 24 to 34.

**Table 1**  
Patient baseline characteristics (n = 53).

Age (years)	68 $\pm$ 12.9
Men/women	19/34
Atrial fibrillation	24 (45.3%)
<i>2D/Doppler echocardiography</i>	
4-chamber tricuspid annulus diameter (diastolic) (cm)	3.6 $\pm$ 6.8
Right ventricular end-systolic area (cm <sup>2</sup> )	27.3 $\pm$ 7
Right ventricular end-diastolic area (cm <sup>2</sup> )	17.0 $\pm$ 6
RVFAC (%)	37.8 $\pm$ 9.2
TAPSE (mm)	17 $\pm$ 3.1
DTI S'	12.0 $\pm$ 1.8
Right atrial area (cm <sup>2</sup> )	27.5 $\pm$ 10.1
Pulmonary artery systolic pressure (mmHg)	56.9 $\pm$ 16.9
<i>Preoperative tricuspid regurgitation severity:</i>	
Mid	4 (7.5%)
Moderate	21 (39.6%)
Severe	28 (52.8%)
<i>Surgical procedure:</i>	
Isolated tricuspid annuloplasty	3 (5.7%)
Mitral valve repair + tricuspid annuloplasty	5 (9.4%)
Mitral valve replacement + tricuspid annuloplasty	21 (39.6%)
Aortic valve replacement + tricuspid annuloplasty	4 (7.5%)
Mitroaortic valve replacement + tricuspid annuloplasty	20 (37.7%)

DTI S': Tissue Doppler derived tricuspid lateral annular systolic velocity, RVFAC: Right ventricular fractional area change (%), TAPSE: tricuspid annular plane systolic excursion.

### 3.2. RV systolic function measurements

In the population studied, the mean preoperative TAPSE was  $17.0 \pm 3.1$  mm (range 10 to 24), and RVFAC was  $37.8 \pm 9.2\%$  (range 16.5% to 59.0%). TAPSE decreased significantly after surgery ( $12.9 \pm 4.1$  mm,  $p < 0.001$ ) in comparison with pre-surgical values. On the contrary, RVFAC did not change significantly after surgery ( $36.2 \pm 9.2\%$ ,  $p = 0.25$ ). Fig. 1 shows box plot graphs illustrating the distribution of TAPSE and RVFAC in preoperative and postoperative periods. As expected, we found an acceptable linear correlation between preoperative RVFAC and TAPSE ( $r = 0.63$ ,  $p < 0.0001$ ) (Fig. 2). On the contrary in postoperative period TAPSE correlated weakly with RVFAC ( $r = 0.38$ ,  $p = 0.005$ ). Tissue Doppler derived tricuspid lateral annular systolic velocity (DTI S') could only be obtained in 19 patients. In the same line with TAPSE results DTI S' decreased significantly after tricuspid valve annuloplasty ( $12.0$  Vs  $8.2$ ,  $p = 0.003$ ).

### 3.3. Reproducibility

Good intra- and interobserver agreements for TAPSE and RVFAC were obtained, with intraclass correlation coefficients (ICCs) of 0.97 and 0.92 for TAPSE; and 0.90 and 0.85 for RVFAC, respectively.

## 4. Discussion

In the present study, we assessed RV systolic function before and after tricuspid valve annuloplasty using different 2D and M-mode echocardiographic methods (TAPSE and RVFAC), to determine if these different methods provided concordant or discordant results regarding postsurgical changes. Our study shows that the evaluation of RV systolic function after tricuspid valve annuloplasty by TAPSE results in reduced motion of tricuspid annulus movement. However, when RV global systolic function is estimated through RVFAC does not change after surgery. These findings suggest that TAPSE is not suitable after tricuspid valve annuloplasty and it leads to an underestimation of RV systolic function. As a consequence, the reliability of TAPSE as index of postsurgical outcome may be limited. Our study could not add any additional data in terms of the etiology of this phenomenon, but clearly demonstrates that only the long-axis function of the RV is impaired after tricuspid

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