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Tricuspid annular plane systolic excursion is correlated with poor outcome in surgery for rheumatic heart valvular disease

Imran Khan[1], Ahmad Shahbaz[2], Madeeha Iqbal[3], Abdul Rehman Khan[4], Waseem Riaz[5], Muhammad Sabeeh Sayyed[4], Kamran Khan[6]

Original Article

Abstract

BACKGROUND: Right ventricular (RV) function is a major determinant of clinical outcome, but its function indices have not been studied well in surgery for rheumatic valvular heart disease. The aim of this study was to determine the correlation of tricuspid annular plane systolic excursion (TAPSE) with outcome of rheumatic heart valve surgery.

METHODS: A prospective comparative study was conducted including 100 eligible patients who were divided into two groups based on RV function as assessed by TAPSE measured by two-dimensional (2D) echocardiography preoperatively. Those with TAPSE less than 15 mm were included in group 1 and those with TAPSE of 15 or more were included in group 2.

RESULTS: 50 patients were included in group 1 and 50 patients in group 2. Mean age of the patients was 56.78 ± 15.21 years in group 1 and 54.46 ± 15.03 years in group 2 (P = 0.444). 34 (34%) patients underwent aortic valve replacement (AVR), 35 (35%) underwent both aortic and mitral valves replacement, and 31 (31%) ones had mitral valve replacement (MVR). A significant difference was found between the duration of ventilation (5.15 ± 2.80 hours in group 1 vs. 3.72 ± 2.71 hours in group 2, P = 0.001), postoperative inotropic requirement [more than 24 hours in 18 (36%) patients in group 1 vs. 7 (14%) patients in group 2, P = 0.003], total intensive care unit (ICU) stay (8.92 ± 3.62 days in group 1 vs. 5.20 ± 2.06 days in group 2, P = 0.001), and mortality [7 (14%) in group 1 vs. 2 (4%) in group 2, P = 0.038].

CONCLUSION: TAPSE less than 15 mm in patients undergoing surgical correction for rheumatic valvular heart disease leads to poor outcomes. These patients need special attention perioperatively.

Keywords: Rheumatic Heart Diseases, Right Ventricle, Cardiac Surgery

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Introduction

Rheumatic heart disease (RHD) is still a public health issue in underdeveloped countries especially Indo-Pak subcontinent and Africa. It has been estimated recently that worldwide 15.6 million people have RHD and there are 470000 new cases of rheumatic fever and 233000 deaths attributable to rheumatic fever or RHD each year.[1] The severe forms of the disease will ultimately require surgical intervention in the form of repair or replacement of the affected valve.

Various parameters of surgical outcome have been studied in these patients. The function of right ventricle (RV) affects outcome in valvular heart diseases. Pinzani et al. reported that the presence of RV failure led to an increase in mortality from 5% to 11% in the perioperative period and from 8% to 22% during follow up.[2] However, the knowledge about indices of dysfunction of the RV and surgical outcome is limited.[3]

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1- Senior Registrar, Department of Cardiac Surgery, Punjab Institute of Cardiology, Lahore, Pakistan
2- Associate Professor, Department of Cardiac Surgery, Punjab Institute of Cardiology, Lahore, Pakistan
3- Senior Biostatistician, Department of Continuing Medical Education, Punjab Institute of Cardiology, Lahore, Pakistan
4- Medical Officer, Combined Military Hospital, Lahore, Pakistan
5- Assistant Professor, Department of Cardiac Surgery, Punjab Institute of Cardiology, Lahore, Pakistan
6- Senior Resident, Department of Cardiac Surgery, Punjab Institute of Cardiology, Lahore, Pakistan
Correspondence to: Imran Khan, Email: imran_kmc@hotmail.com

Variables of RV function have not yet been included in large-scale risk stratification models like Parsonnet score (PS) and EuroECORE. Variables studied in various studies are enlarged RV, tricuspid regurgitation (TR), pericardial effusion, and myocardial performance index (Tei index) as well as fractional area change (FAC).[4] Tricuspid annular plane systolic excursion (TAPSE) is a simple feasible marker of RV dysfunction (RVD). It is a valuable prognostic marker in various cardiac diseases including heart failure (HF). It is also a valuable marker of measuring the function of RV.[5] A rise in pulmonary hypertension (PH), secondary to aortic or mitral valve disease, leads to dilatation of the RV and decreased function. This eventually leads to enlargement of the tricuspid annulus (TA) and TR.

Measurement of TAPSE involves the displacement of tricuspid valve (TV) ring in the longitudinal direction of the RV during systole using an M-mode ultrasound technique through an apical four-chamber view. It has low dependence on the ultrasound image quality and requires no specific ultrasound equipment and analysis software for its measurement.

Our study investigates the usefulness of TAPSE as a tool for outcome measures in surgery for rheumatic valvular disease. A better understanding of the predictors of outcome can lead to changes in operative and postoperative strategies.

Materials and Methods

A prospective comparative study was conducted at the Department of Cardiac Surgery, Punjab Institute of Cardiology, Lahore, Pakistan, from August 2015 to August 2016. The study protocol was approved by the ethical review board and individual consent from the patients was waivered. A total of 100 consecutive patients who underwent surgery for rheumatic valvular disease, both mitral and aortic, were included in the study through purposive sampling. Patients who had an additional procedure, were operated in emergency, and those with atrial fibrillation (AF) and redo procedures were excluded from the study. All the patients underwent valve replacement with either mechanical or bioprosthetic valves. The choice of the type of valve prosthesis was left to the operating surgeon. All the surgeries were performed by the two senior authors, Ahmad Shahbaz and Waseem Riaz.

Patients were divided into two groups based on the function of the RV as assessed by TAPSE measured by two-dimensional (2D) echocardiography preoperatively. TAPSE was measured through an apical four-chamber view; placing the cursor of the M-mode through the junction of the TV plane and RV free wall, and the difference in the displacement of RV base during systole and diastole was noted. Those with TAPSE less than 15 mm were included in group 1 and those with TAPSE of 15 mm or more were included in group 2. All the important demographic variables and important echocardiographic parameters were recorded on preformed proformas. The two groups were followed up till discharge. The in-hospital outcomes were recorded and compared statistically.

Data were analysed using SPSS software (version 17, SPSS Inc., Chicago, IL, USA). Continuous variables were summarized as mean ± standard deviation (SD) and categorical variables were summarized as frequency and percentage.

Differences in baseline demographic characteristics, and echocardiographic and operative data between patients in both groups were assessed using t-test for continuous data and chi-square test for categorical data. Fisher's exact test was used for categorical variables where the frequencies were small. A two-tailed P-value less than 0.050 was considered significant.

Preoperative and major postoperative outcome variables were recorded and data were analysed using SPSS software. Shapiro-Wilk test was used to ascertain the normality of the data because of the relatively small number of patients.

Results

50 patients were included in group 1 and 50 patients in group 2. Mean age of the patients was 56.78 ± 15.21 years in group 1 and 54.46 ± 15.03 years in group 2. 34 (34%) patients underwent aortic valve replacement (AVR), 35 (35%) patients underwent both aortic and mitral valves replacement, and 31 (31%) patients underwent mitral valve replacement (MVR). Groups 1 and 2 had similar demographic and clinical variables (Table 1). Patients presenting with New York Heart Association (NYHA) class IV dyspnoea were 12 (24%) in group 1 and 9 (18%) in group 2. Overall, the P-value for various degrees of NYHA class in both groups was 0.687.

Preoperative echocardiographic data of patients in both groups is shown in table 2. The left ventricular ejection fraction (LVEF) was 56.32 ± 6.90% in group 1 and 53.98 ± 9.52% in group 2 (P = 0.162). Preoperative RV size was 25.71 ± 7.44 mm in group 1 and 26.10 ± 5.02 mm in group 2 (P = 0.759).

Table 1. Demographic variables of the two study groups

Variable		Groups		P
		Group 1 (TAPSE < 15) (n = 50)	Group 2 (TAPSE ≥ 15) (n = 50)	
Gender [n (%)]	Male	20 (40)	27 (54)	0.228
	Female	30 (60)	23 (46)	
NYHA class [n (%)]	I	9 (18)	8 (16)	0.687
	II	29 (58)	33 (66)	
	III	12 (24)	9 (18)	
Hypertension [n (%)]		4 (9)	3 (6)	> 0.999
Diabetes [n (%)]		17 (34)	9 (18)	0.110
Weight (kg) (mean ± SD)		62.00 ± 10.31	57.66 ± 9.70	0.032
BSA (m^2) (mean ± SD)		4.90 ± 2.30	2.30 ± 5.40	0.002
Preoperative creatinine (mg/dl) (mean ± SD)		0.85 ± 0.21	0.81 ± 0.24	0.377
Age (year) (mean ± SD)		56.78 ± 15.21	54.46 ± 15.03	0.444
Height (cm) (mean ± SD)		156.09 ± 19.30	154.12 ± 20.30	0.620

P-value less than 0.050 was considered significant
TAPSE: Tricuspid annular plane systolic excursion; NYHA: New York Heart Association; BSA: Body surface area; SD: Standard deviation

Preoperative pulmonary arterial pressure was significantly high in group 1 (38.00 ± 13.44 mmHg) compared to group 2 (32.90 ± 12.30 mmHg) (P = 0.051).

Mechanical valves were used in 37 (74%) of the group 1 patients and 42 (84%) of the group 2 patients. Bioprosthetic valves were used in 13 (26%) of the group 1 patients and 8 (16%) of the group 2 patients (Table 3). No significant difference was noted between the groups with respect to the type of prosthetic valves used (P = 0.210). The important intraoperative variables like cardiopulmonary bypass (CPB) time and cross-clamp time were non-significant between the two groups (P = 0.809 and P = 0.890, respectively). Among the major postoperative outcome variables, duration of ventilation was 5.15 ± 2.80 hours in group 1 vs. 3.72 ± 2.71 hours in group 2 (P = 0.001), postoperative inotropic requirement for more than 24 hours was 18 (36%) in group 1 vs. 7 (14%) in group 2 (P = 0.003), total intensive care unit (ICU) stay was 8.92 ± 3.62 days in group 1 vs. 5.20 ± 2.06 days in group 2 (P = 0.001) and mortality was 7 (14%) in group 1 vs. 2 (4%) in group 2 (Table 3).

Discussion

RVD carries a poor prognosis in patients undergoing open heart surgery. RVD particularly is a strong predictor of poor outcome in patients undergoing surgery for rheumatic valvular disease.[3]

Table 2. Preoperative echocardiographic variables

Variable		Groups		P
		Group 1 (TAPSE < 15) (n = 50)	Group 2 (TAPSE ≥ 15) (n = 50)	
Preoperative TR [n (%)]	Mild	18 (36)	22 (44)	0.230
	Moderate	17 (34)	15 (30)	
	Severe	15 (30)	13 (26)	
Preoperative RV size (mm) (mean ± SD)		25.71 ± 7.44	26.10 ± 5.02	0.759
Preoperative LVIDD (mm) (mean ± SD)		51.46 ± 4.20	49.32 ± 4.27	0.143
Preoperative LVIDS (mm) (mean ± SD)		36.87 ± 12.39	35.72 ± 11.93	0.637
Preoperative LVPWD (mm) (mean ± SD)		9.14 ± 2.56	9.43 ± 2.06	0.534
Pulmonary arterial pressure (mmHg) (mean ± SD)		38.00 ± 13.44	32.90 ± 12.30	0.051
LVEF (%) (mean ± SD)		56.32 ± 6.90	53.98 ± 9.52	0.162

P-value less than 0.050 was considered significant
TAPSE: Tricuspid annular plane systolic excursion; TR: Tricuspid regurgitation; RV: Right ventricle; LVIDD: Left ventricular internal diastolic dimension; LVIDS: Left ventricular internal dimension in systole; LVPWD: Left ventricular posterior wall dimension; LVEF: Left ventricular ejection fraction; SD: Standard deviation

Table 3. Intraoperative data and postoperative outcome variables

Variable		Groups		P
		Group 1 (TAPSE < 15) (n = 50)	Group 2 (TAPSE ≥ 15) (n = 50)	
Operation type [n (%)]	AVR	12 (24)	22 (44)	0.107
	DVR	20 (40)	15 (30)	
	MVR	18 (36)	13 (30)	
Type of valve used [n (%)]	Mechanical	37 (74)	42 (84)	0.210
	Bioprosthetic	13 (26)	8 (16)	
Postoperative inotropic requirement > 24 hours [n (%)]		18 (36)	7 (14)	0.003
Mortality [n (%)]		7 (14)	2 (4)	0.038
Cross-clamp time (minute) (mean ± SD)		70.85 ± 24.79	71.57 ± 27.30	0.890
Bypass time (minute) (mean ± SD)		107.89 ± 38.80	106.00 ± 39.57	0.809
Duration of ventilation (hour) (mean ± SD)		5.17 ± 2.80	3.72 ± 2.71	0.001
Total ICU stay (day) (mean ± SD)		8.92 ± 3.62	5.20 ± 2.06	0.001
Hospital stay (day) (mean ± SD)		11.72 ± 4.12	6.27 ± 3.46	0.001

P-value less than 0.050 was considered significant

TAPSE: Tricuspid annular plane systolic excursion; AVR: Aortic valve replacement; DVR: Double (both aortic and mitral) valve replacement; MVR: Mitral valve replacement; ICU: Intensive care unit; SD: Standard deviation

These patients present either a pressure overload or a volume overload scenario to the RV. In case of mitral stenosis (MS) and mitral regurgitation (MR), it is the PH that causes a pressure overload in the RV; while in TR, it is the volume overload that causes RVD. The RV adapts better to volume overload than pressure overload. RHD mostly presents a pressure overload context in the form of PH. A moderate to severe rise in pulmonary pressure leads to RV dilatation and in the long run to failure.[6]

Because of the complex three-dimensional (3D) geometry of the RV, identifying and accurately classifying its function can be difficult. The current markers are well studied for end stage disease only.[7]

Although our understanding of RV function is increasing with the advent of newer modalities like tissue Doppler imaging (TDI) and speckle tracking echocardiography (STE), most of these modalities, however, require good experience. 3D echocardiography has been widely studied as a method to assess RV volume and is used to evaluate RV function.[8] However, it also has limitations like limited acoustic windows for imaging because of an intricate 3D anatomical structure of the RV. Cardiovascular magnetic resonance (CMR) imaging has been useful for anatomical assessment of the RV. In a study by van Wolferen et al., the predictors of 1-year survival in patients with PH were RV volume, RV myocardial mass, and stroke index measured by CMR.[9]

TAPSE is a well-known echocardiographic parameter. It measures the apex to base shortening of RV during systole. The transverse diameter of RV is much smaller compared to LV. But the surface-to-volume ratio is much larger for the RV than LV. Therefore, smaller changes in the transverse dimension will cause large increase in ejection. For this reason, to achieve a normal ejection, the change in dimension will have to be in another dimension. Thus, changes in transverse dimensions did not correlate with RVEF, while TAPSE did in a study by Kaul et al.[10] TAPSE is simple to measure and it has low dependence on ultrasound image quality. It has been studied well in the context of HF and other conditions like pulmonary embolectomy.[11] However, TAPSE as a predictor for poor outcome in rheumatic valve surgery has not been studied well.

Various values or cut-off values for TAPSE have been studied by different investigators. Schmid et al. used 18 mm cut-off value.[11] Tamborini et al. suggested 17 mm value.[12] On the other hand, lower values have also been used in many studies. Foale et al. defined mild RVD as TAPSE Of 13-15 mm.[13] Horton et al. stated a TAPSE more than 15 mm as normal.[14] For this reason, we used 15 mm as the cut-off value for defining RVD.

Kjaergaard et al. demonstrated a worse median term outcome in terms of mortality for patients with decreased TAPSE in patients with HF.[15] Similar results were presented by Forfia et al. in patients with PH.[16] Samad et al. reported a significantly increased mortality in patient with TAPSE of less than 15 mm.[17] Our study also showed an increased early mortality when TAPSE was decreased in patients with RHD after surgery. The relation of TAPSE with worse outcome in

RHD was also demonstrated by Pande et al.[3] They noted that RVD could still exist in valvular patients even in the absence of significant PH. This can be attributed to ventricular interdependence and RV ischemia. This might be the reason why PH was non-significant between the two groups in our study.

RVD is associated with an increased ventilation time, more blood transfusions, and a longer stay in the ICU.[17]Our study also showed an increased postoperative ventilation time and ICU stay in patients with TAPSE less than 15 mm. Sun et al.[18] found no difference in outcome in terms of hospital stay. This is likely due to the variety of surgical pathologies in our patients compared to patients with only TV pathology in the study by Sun et al.[18]

This single centre experience with a comparatively small sample size certainly has limitations. We did not present any long-term follow up. It will certainly be interesting to see the long-term follow up of these patients dichotomized only based on TAPSE. Moreover, the small number of postoperative events did not allow the development of a regression model to see independent predictors of outcome and comparison with TAPSE. Moreover, bias cannot be ruled out in the reporting of echocardiographies as they were performed by different echocardiographers from our cardiology department.

Conclusion

TAPSE less than 15 mm in patients undergoing surgery for rheumatic valvular disease leads to poor outcomes. These patients need special attention perioperatively. TAPSE can be used to identify these patients early and so, can lead to changes in management strategies for a better outcome. Large-scale studies are needed for further understanding of the predictive value of TAPSE in rheumatic valvular disease.

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Conflict of Interests

Authors have no conflict of interests.

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