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The Impact of Tricuspid Annular Plane Systolic Excursion (TAPSE) After Mitral Valve Surgery on Long Term Mortality

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Abstract

Background: Heart valve disease is still a significant health burden in the world, including Indonesia. The postoperative outcome of mitral valve surgery is influenced by many things, including decreased right ventricular (RV) function, which is the most common complication. Several studies have shown that decreased RV function after mitral valve surgery is associated with long-term outcomes. TAPSE is a routine and easy measurement of RV systolic function. A decrease in TAPSE after cardiac surgery is common because of the effects of pericardiotomy, and does not necessarily reflect a decrease in RV ejection fraction (RVEF). Regardless of whether postoperative TAPSE values indicate right ventricular systolic function or only due to the effects of pericardiotomy, it is still not clear whether postoperative TAPSE values have a prognostic value to long-term mortality after mitral valve surgery. Therefore, the objective of this study is to obtain information regarding the relationship of TAPSE echocardiographic parameters after mitral valve surgery with long-term mortality.

Methods: This is a retrospective cohort study, looking at the effect of TAPSE on outcome after mitral valve surgery. The analysis starts from the starting point of the study when the patient was discharged alive from the hospital after mitral valve surgery (operation period January 2016 – February 2017) to the end point of the study, which was June 30th, 2021 and the observed outcome was mortality from any cause.

Results: Of the 266 study subjects, 11 subjects died within 4-5 years after mitral valve surgery, the mortality is 4%. Bivariate analysis was performed on several factors and no relationship was found between the analyzed variables and mortality.

Conclusion: There is no relationship between mortality and TAPSE after mitral valve surgery.

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Keywords: TAPSE, Mitral Valve Surgery, Mortality.

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Introduction

Valvular heart disease is still a significant health burden in the world, including Indonesia.[1] Data at the National Cardiovascular Center Harapan Kita Hospital (NCCHK) as the national heart referral center in Indonesia shows that the most common valve abnormality is the mitral valve. Valvular registry data by the Non-Invasive Diagnostic Division of the NCCHK, in the 2015-2016 period showed 789 patients underwent heart valve surgery, with the majority of these valve surgeries being mitral valve surgery with 565 surgeries (71.6%).[2,3]

The outcome after mitral valve surgery is affected by many things. One of these things is a decreased function of right ventricle, which is the most common complication after mitral valve surgery.[4,5] A study conducted by Callista et al in 2017 at NCCHK concluded that from 280 subjects, 75% of patients had reduced TAPSE after surgery.[6] Many studies stated that a decrease in right ventricle function after heart surgery had an impact on long term mortality.[7,8] However it is not quite adequately correlated with TAPSE parameter. This one become as a gap and important to be elaborated to confirm clinical decisions.

There are multifactorial basic causes of changes in the contraction of right ventricle after heart surgery. Zanobini et al concluded that a decrease in TAPSE after heart surgery happened as the result of pericardiotomy.[9] It did not depict a real decrease of right ventricular ejection fraction just like what Tamborini et al stated in their study. Tamborini et al showed that reduction of TAPSE was caused by geometrical changes rather than functional.[10]

Regardless of whether postoperative TAPSE values indicate right ventricular systolic function or only due to the effects of pericardiotomy, it is still not clear whether postoperative TAPSE values have a prognostic value on long-term mortality after mitral valve surgery. It may be beneficial as a marker for cardiologist to predict patients further outcome. Therefore, the objective of this study is to obtain information regarding the relationship of TAPSE as an echocardiographic parameter after mitral valve surgery with long-term mortality.

Methods

This study was a cohort retrospective study to evaluate the impact of TAPSE after mitral valve surgery on long-term mortality in patients who underwent mitral valve surgery from January 2016 – February 2017 in NCCHK so that it can be followed up for 4 years later. The number of samples has been calculated to meet the minimum number of samples so that they can be used for bivariate and multivariate analysis. The Inclusion criteria for this study were patients who underwent replacement or repair of mitral valve and were discharged alive after mitral valve surgery from January 2016 – February 2017, TAPSE pre-operation >1.6 cm, and age >18 years-old. Exclusion criteria were patients who underwent coronary artery bypass surgery, patients with coronary artery disease, patients with congenital heart disease, patients with chronic obstructive pulmonary disease, patients with aortic or pulmonary valve disease who needed intervention, patients who still had residual leakage, and new stenosis or patient-prosthetic mismatch after replacement of the valve, and patients who could not be reached out.

All of the subjects underwent transthoracic echocardiography before being discharged from the hospital. TAPSE was measured from apical four-chamber. It is a longitudinal right ventricular systolic function parameter. TAPSE was measured from the lateral tricuspid annulus. TAPSE has been shown to have a good correlation with other parameters such as Fractional Area Change (FAC) in assessing right ventricular systolic function globally. The normal value of TAPSE is 1.6 cm values <1.6 cm means that there has been a decrease in right ventricular systolic function.[11] M-mode cursor was placed at the lateral tricuspid valve annulus, obtaining an M-mode tracing and measuring the height of the annulus movement during systole. Mortality was defined as all-cause mortality in 4-5 years after the surgery.

Statistical analysis was performed using SPSS software (version 20, 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 a t-test for continuous

data and a 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. The variables which were included in the multivariate analysis were those that in bivariate analysis had a p-value of less than 0.25 and which were theoretically or from previous references associated with mortality.

Results

This study was performed using patients' data who underwent mitral valve surgery from January 2016 – February 2017 and were discharged alive after surgery. Out of 506 subjects, there were 45 subjects who underwent double valve replacement, 10 subjects who underwent redo operation and 17 subjects with congenital heart disease. These subjects were excluded. Out of 461 subjects were screened based on exclusion and inclusion criteria. There were 24 subjects who died, 9 patients couldn't meet inclusion criteria, 49 subjects with missing data, 75 patients had pre-operative TAPSE <1.6cm. Research subject recruitment flow is shown in **Figure 1**.

Out of 266 subjects, there were 11 subjects (4%) who died in 4-5 years after mitral valve surgery. There is no statistically significant relationship between mortality and identified variable (**Table 3**).

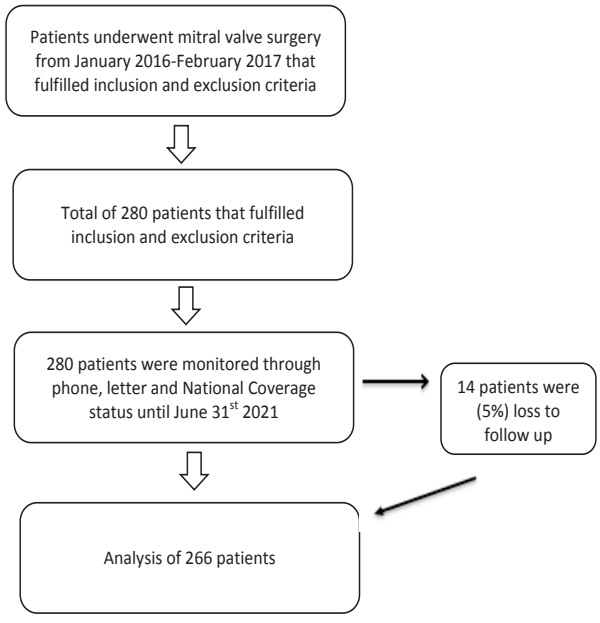

Figure 1. Research subject recruitment flow.

The variables which were included in the multivariate analysis were those that in bivariate analysis had a p-value of less than 0.25 and which were theoretically or from previous references associated with mortality. Based on the bivariate analysis that had been done previously, the variables that could enter the multivariate analysis were: Male (p = 0.211), NYHA class 3-4 (p = 0.108), LVEF post <55% (p = 1.000), post-operative moderate to severe tricuspid regurgitation (p = 0.196), TAPSE post <1.6cm (p = 0.733) dan PVAccT post <105ms (p = 0.204). Logistic regression with Enter method was the preferred method of multivariate analysis in this study (**Table 4**).

Discussion

Overall mortality in this study was 4% in the period of 4-5 years. Meyer et al showed overall mortality of 12.6%, nevertheless right ventricular function wasn't included in this study.[12] Furthermore, in the study conducted by Hellgren et al showed 5 years mortality was 75% in patients who underwent mitral valve surgery with or without bypass surgery. However, this research was carried out in year 1980-2000 when at that time surgical techniques were not as developed as they are today.[13]

In this study, there was no correlation between TAPSE within 5-year mortality using bivariate analysis (p=0.733). In a study conducted by Sun et al, the same results were also found which showed that TAPSE was not associated with postoperative outcomes, even though in this study the TAPSE value was 1.4cm.[14] In contrast, Khan et al showed higher mortality in patients with TAPSE <1.5cm (14%), compared to patients with TAPSE ≥1.5cm (4%). However, this study was conducted in patients who underwent all types of valve surgery and the outcome was assessed directly after surgery.[15] Various causes have been proposed to explain the decrease in right ventricle function such as geometrical changes in right ventricle, intraoperative ischemia, pericardial disturbances, and suboptimal cardioprotection. A decrease in a longitudinal function occurs immediately after the opening of the pericardium which supports the hypothesis of the important role of the pericardium in maintaining the physiology and

Table 1. Baseline Characteristics of the Subjects.

Variables	N=266
Demographic	
Age (median, min-max)	43 (18-71)
Female (value, n(%))	154 (57.9)
Laboratory	
Hb level , gr/dl (median, min-max)	13 (9-17)
CCT,ml/min (median, min-max)	80 (11-154)
Pre-operative echocardiographic parameter	
Left ventricular ejection fraction (%) (median, min-max)	65 (23-85)
TAPSE (cm) (median, min-max)	2.1 (1.6-3.7)
TR V Max (m/s) (median, min-max)	3.1 (0-5.40)
PV accT (ms) (median, min-max)	100 (40-184)
Post Operative	
TAPSE (cm) (median, min-max)	1.3 (0.5-2.6)
Etiologic	
Rheumatic (value, n(%))	156 (58.6)
Degenerative (value, n(%))	110 (41.4)
Mitral Valve Disease	
Mitral Stenosis (value, n(%))	93 (35.0)
Mitral Regurgitation (value, n(%))	173 (65.0)
Clinical Parameter	
Functional Class	
NYHA 1 (value, n(%))	1 (0.4)
NYHA 2 (value, n(%))	251 (94.4)
NYHA 3 (value, n(%))	8 (3.0)
NYHA 4 (value, n(%))	6 (2.3)
Diabetes Mellitus (value, n(%))	16 (6.0)
Hypertension (value, n(%))	47 (17.7)
Active Endocarditis (value, n(%))	27 (10.2)
Pre-operative atrial fibrillation (value, n(%))	160 (60.2)
Pre-operative echocardiographic parameter Degree of Tricuspid regurgitation	
Mild, and Trivial (value, n(%))	158 (59.4)
Moderate and severe (value, n(%))	108 (40.6)
Pulmonary Hypertension Probability	
Low and Moderate (value, n(%))	129 (48.5)
High (value, n(%))	137 (51.5)
INTRA-OPERATIVE	
Type of Surgery	
Mitral Valve Repair (value, n(%))	133 (50.0)
Mitral Valve Replacement (value, n(%))	133 (50.0)
Tricuspid Surgery (value, n(%))	101 (38.0)
POST-OPERATIVE	
TAPSE <1.6cm (value, n(%))	196 (73.7)
TAPSE ≥1.6cm (value, n(%))	70 (26.3)
Residual of Tricuspid Regurgitation	
Trivial, and Mild (value, n(%))	246 (92.5)
Moderate and Severe(value, n(%))	20 (7.5)
Pulmonary Hypertension Probability	
Low and moderate (value, n(%))	127 (47.7)
High (value, n(%))	138 (51.9)
Missing data (value, n(%))	1 (0.4)
Left Ventricular Ejection Fraction	
<55% (value, n(%))	91 (34.2)
≥55% (value, n(%))	175 (65.8)
PVAccT	
<105ms (value, n(%))	94 (35.3)
≥105ms (value, n(%))	172 (64.7)

Note: Hb (hemoglobin); CCT (creatinine clearance test); TAPSE (Tricuspid annular plane systolic excursion); TR Vmax (The maximal tricuspid regurgitation velocity); PV AccT (Pulmonary Artery Acceleration Time)

Table 2. Baseline Characteristics Subject Based on TAPSE.

Variable, n(%)	TAPSE		p
	<1.6cm (N=196)	**>1.6cm (N=70)**	
Gender,			
Male	79 (70.5)	33 (29.5)	0.320
Etiologic			
Rheumatic	123 (78.8)	33 (21.2)	0.023
Degenerative	73 (66.4)	37 (33.6)	
Valve Disease			
Stenosis	73 (78.5)	20 (21.5)	0.191
Regurgitation	123 (71.1)	50 (28.9)	
Endocarditis			
Yes	21 (77.8)	6 (22.2)	0.610
New onset AF			
Yes	11 (78.6)	3 (21.4)	1.000
Functional Class			
NYHA 1-2	186 (73.8)	66 (26.2)	0.765
NYHA 3-4	10 (71.4)	4 (28.6)	
Hypertension			
Yes	32 (68.1)	15 (31.9)	0.337
Diabetes Mellitus			
Yes	13 (81.3)	3 (18.8)	0.573
Type of Surgery			
Repair	93 (69.9)	40 (30.1)	0.164
Replacement	103 (77.4)	30 (22.6)	
Tricuspid Surgery			
Yes	89 (88.1)	12 (11.9)	0.000
Degree of Tricuspid Regurgitation post operative			
Moderate and severe	17 (85.0)	3 (15.0)	0.298
Mild, trivial, and none	179 (72.8)	67 (27.2)	
Degree of Pulmonary Hypertension Post Operative			
Severe	95 (68.8)	43 (31.2)	0.072
Mild-Moderate	100 (78.7)	27 (21.3)	

Note: AF (atrial fibrillation); NYHA (New York Heart Association)

Table 3. Bivariate Analysis of Mortality in Patients after Mitral Valve Surgery.

Variable, n(%)	Mortality		OR (CI : 95%)	p
	Yes (N=11)	**No (N=255)**		
Age (Years)	42 (18-62)	43 (19-71)		0.497
Hb (gr/dl)	13 (11-15)	13 (9-17)		0.987
CCT (ml/min)	83 (41-135)	80 (11-154)		0.618
TR V Max (m/s)	2.3(1.1-3.8)	2.40 (0-4.5)		0.868
Gender				
Male	7 (6.3)	105 (93.8)	2.50 (0.71-8.75)	0.211
Etiologic				
Rheumatic	6 (3.8)	150 (96.2)	0.84 (0.25-2.85)	0.766
Degenerative	5 (4.5)	105 (95.5)		

Valve Disease				
Stenosis	2 (2.2)	91 (97.8)	0.40 (0.085-1.89)	0.338
Regurgitation	9 (5.2)	164 (94.8)		
Endocarditis				
Yes	1 (3.7)	26 (96.3)	0.88 (0.11-7.16)	1.000
New Onset AF				
Yes	1 (7.1)	13 (92.9)	1.86 (0.22-15.65)	0.455
Hypertension				
Yes	32 (68.1)	15 (31.9)		0.337
Functional Class				
NYHA 1-2	9 (3.6)	243 (96.4)	0.25 (0.60-1.05)	0.108
NYHA 3-4	2 (14.3)	12 (85.7)		
Hypertension				
Yes	2 (4.3)	45 (95.7)	1.03 (0.22-4.96)	1.000
Diabetes Mellitus				
Yes	0 (0.0)	16 (100)		1.000
Type of Surgery				
Repair	5 (3.8)	128 (96.2)	0.83 (0.25-2.78)	0.758
Replacement	6 (4.5)	127 (95.5)		
Degree of Pulmonary Hypertension Post Operative				
Severe	95 (68.8)	43 (31.2)		0.072
Mild-Moderate	100 (78.7)	27 (21.3)		
Tricuspid Surgery				
Yes	5 (5.0)	96 (95.0)	1.38 (0.41-4.64)	0.753
Degree of Tricuspid Regurgitation Post Operative				
Moderate and severe	2 (10.0)	18 (90.0)	2.73 (0.63-11.80)	0.196
Mild, trivial, and none	9 (3.7)	237 (96.3)		
Degree of Pulmonary Hypertension Post Operative				
Severe	4 (2.9)	134 (97.1)	0.51 (0.15-1.79)	0.287
Mild to moderate	7 (5.5)	120 (94.5)		
LVEF post op				
<55%	4 (4.0)	87 (95.6)	1.10 (0.31-3.87)	1.000
PVAccT post op				
<105ms	6 (6.4)	88 (93.6)	2.28 (0.68-7.67)	0.204
TAPSE post op				
<1.6cm	9 (4.6)	187 (95.4)	1.64 (0.35-7.77)	0.733

Note: Hb (hemoglobin); CCT (creatinine clearance test); TAPSE (Tricuspid annular plane systolic excursion); TR Vmax (The maximal tricuspid regurgitation velocity); PV AccT (Pulmonary Artery Acceleration Time); AF (atrial fibrillation); NYHA (New York Heart Association).

function of the right ventricle geometry. However, the longitudinal decrease may reflect only one aspect of the complex contraction pattern, therefore conventional measurements with M-mode and 2D are inadequate for postoperative assessment function. The PREPARE MVR study demonstrated that radial movement can compensate for the postoperative decrease in longitudinal movement to maintain RVEF. After 6 months, it was found that on successful surgery, the contraction pattern returned to normal in patients undergoing mitral valve replacement as in the normal longitudinal and radial controls.[16] On the other hand, the M-mode and 2D examination of the longitudinal function of the RV still did not improve as demonstrated by the study of

Table 4. Multivariate Analysis.

Variable	p	OR	CI : 95%
TAPSE post <1.6cm	0.507	1.734	0.34-8.82
Male	0.121	2.768	0.76-10.03
NYHA III-IV	0.081	4.765	0.83-27.51
Moderate to Severe TR Post Op	0.282	2.502	0.47-13.3
LVEF post <55%	0.680	0.754	0.196-2.89
PVAccT post <105ms	0.180	2.346	0.67-8.15

Note: OR : Odd Ratio; TAPSE (Tricuspid annular plane systolic excursion); LVEF (Left Ventricular Ejection Fraction); PV AccT (Pulmonary Artery Acceleration Time); NYHA (New York Heart Association).

Tamborini et al.[17]

The decrease in TAPSE in RV assessment in postoperative mitral valve patients seems to indicate a decrease in right ventricular function after surgery. Research conducted by Zanobini et al might explain this phenomenon. In a study conducted by Zanobini et al comparing patients undergoing mitral valve repair with a median sternotomy technique via vertical pericardiotomy with a minimally invasive technique via a lateral thoracotomy with a smaller lateral pericardiotomy. From this study, it was found that TAPSE decreased with vertical pericardiotomy, but did not change with lateral pericardiotomy. These findings suggest that the pericardium provides structural support to the right ventricle, and contributes to its longitudinal contraction.[9] There are multifactorial basic causes of changes in the contraction of right ventricle after heart surgery. Zanobini et al concluded that decrease of TAPSE did not depict a real decrease of right ventricular ejection fraction. Reduction of TAPSE was caused by geometrical changes rather than functional.[10]

In NCCHK, the technique that is often used is the median sternotomy technique and vertical pericardiotomy, this may cause a decrease in TAPSE in patients undergoing mitral valve surgery. This study then showed that the postoperative reduction in TAPSE did not have clinical implications for the long-term outcome of postoperative mitral patients.

Ethical Clearance

Ethical clearance for this study was approved and issued by Institutional Ethical Review Board of National Cardiovascular Center Harapan Kita Decision No. LB.02.01/ VII / 540 / KEP 029 / 2021

Publication Approval

All authors read and approved final version of manuscript

Conflict of Interest

None

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