Prognostic value of right ventricular dysfunction on clinical outcomes for patients undergoing surgical interventions for mitral valve

Original Article

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ABSTRACT

Background: Between 40 and 60% of individuals following cardiac surgery report having postoperative right ventricular dysfunction (RVD), which is a manifestation of decreased septal function (paradoxical septal motion).

Aim and objectives: To investigate the association between RVD and the outcome of cardiac surgery for mitral valve intervention including morbidity and mortality up to 3 months after surgery.

Patients and Methods: A total of 47 patients were included in the prospective observational comparative evaluation, which was split into two groups, group 1 [high risk group tricuspid annular plane systolic excursion (TAPSE) less than 1.6] and group 2 (low risk group TAPSE more than 1.6). The study took place from August 2019 to August 2021 at the National Heart Institute (NHI) and the Cardiothoracic Surgery Department of Ain Shams University.

Results: There were nonsignificant differences demonstrated between the groups in terms of age, gender, body mass index (BMI), mitral pathology, the duration of mechanical ventilation, ICU length of stay, the incidence of postoperative bleeding, the volume of postoperative bleeding, the composite endpoint of complications, the type of complication, or the lengths of ICU stay.

The high-risk group's TAPSE scores were found to be considerably lower at the 3-month evaluation ($P<0.001$).

Only two variables, preoperative TAPSE and cross-clamp time, were found to be statistically significant in predicting the risk of all-cause death, according to the findings of the multivariate regression analysis.

Conclusion: RV dysfunction was detected by a thorough preoperative echocardiographic evaluation. Reducing surgical adverse events and mortality may be possible with the identification of preoperative RV dysfunction.

Key Words: Mitral valve, right ventricular dysfunction, surgical interventions.

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INTRODUCTION

Impaired left ventricular (LV) function has been identified as a separate risk factor for morbidity and death in cardiac surgery. There are, however, few data regarding the effect of right ventricular (RV) function on mortality following cardiac surgery[1].

Evaluating the function of the RV is crucial for managing different types of cardiovascular illness. Due to its intricate design, accurately determining RV volume and systolic function is a problem in routine clinical practice[2].

Measuring the RV function is difficult due to the intricate three dimensional form and RV geometry. The tricuspid annular plane systolic excursion, or Tricuspid Annular Plane Systolic Excursion (TAPSE), is a quick and repeatable measure as it mimics the action of the longitudinal fibers. It gauges how far the apex tucks the tricuspid annulus. Conditions related to loading have little effect on it. It depends on the angle. A prognosis of poor and poor RV performance is indicated by a longitudinal displacement of 17 mm or less[3].

Large hearts are associated with right ventricular dysfunction (RVD), and as long as the septum is not damaged during surgery, LV volume reduction will reduce longitudinal strain. The majority of people who have cardiac surgery have been shown to have postoperative RVD, which is a manifestation of decreased septal function (paradoxical septal motion) in 40% to 60% of patients[4].

Treatment strategies for RV failure following cardiac surgery are based on theories of hemodynamic pathology. Several fundamental therapies are necessary in cases with RVD of any severity. A suitable intravascular volume guarantees an ideal preload; the ability to reach high oxygenation levels, sustain the acid-base balance, and the

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ventilator's synchronization avoids pleural overcharge, and bronchospasm stops abrupt increases in the RV's post-charge[5].

This study looked at the relationship between RVD and the morbidity and mortality that occur up to three months following mitral valve intervention cardiac surgery outcomes.

PATIENTS AND METHODS:

The 50 patients with MV disease included in the study were part of a prospective observational comparative review; three patients were lost during the follow-up period. The patients were then split into two groups: group I was made up of 24 patients who underwent mitral valve replacement and had RVD (TAPSE less than 1.6), and group II had no RVD (TAPSE more than 1.6). The National Heart Institute (NHI) and the Cardiothoracic Surgery Department of Ain Shams University served as the study sites. August 2019 to August 2021 was the study period.

The Institutional database was interrogated with the set given criteria and a follow-up survey at 3-month intervals within the first postoperative year.

The study was approved by research ethics committee (MD3122018)

Inclusion criteria were patients with Mitral valve disease with or without Tricuspid valve disease.

Exclusion criteria were patients with ischaemic mitral valve who needed CABG, patients with concomitant aortic valve who required surgery, patients with concomitant congenital surgical disease requiring surgical correction and patients with infective endocarditis requiring surgical correction.

Diagnostic echocardiography was used to record the TAPSE scores and valvular lesions in each patient. Regardless of whether many surgeons performed the repair or replacement of the mitral valve, all patients underwent open heart surgery. Antigrade cardioplegia with cold crystalloid was administered. The posterior leaflet was preserved, the mitral valve was accessible by a left atriotomy utilizing Syndergaard's groove, and in mitral valve replacement a mechanical prosthesis with pledges resting on the atrial surface of the mitral valve was placed using 2–0 interrupted Ethibond sutures and in mitral valve repair, the repair was done by placing annuloplasty ring using 2–0 interrupted Ethibond sutures.

Statistical analysis

SPSS (version 26.0, IBM, NY, USA) was used for data collection and analysis, and the ggpubr package (Version 4.3.1, R Foundation for Statistical Computing, Vienna, Austria) was used for data visualization. In order to obtain trustworthy results, the community, environmental, and occupational medicine department at Ain Shams University recommended using a minimum sample size of 20 patients in each group. The clinical and demographic features of the patients were compiled using descriptive statistics. The categorical data were reported as frequencies and percentages, whereas the continuous variables were expressed as mean±standard deviation. A comparison was made between the low-risk group (TAPSE>1.6 cm) and the high-risk group (TAPSE<1.6 cm). Fisher's exact test, the χ^2 test, or the independent t-test were applied. The patients were stratified by all-cause mortality. Longitudinal analysis of TAPSE profiles was performed using Friedman ANOVA for paired data. Multiple logistic regression analysis was performed using the forward inclusion method. A priori alpha of 0.05 was set for all of the subsequent analysis.

RESULTS:

Table 1: Comparing baseline demographic and clinical characteristics among the study groups

Characteristic	TAPSE<1.6 cm, *N*=24[1]	TAPSE>1.6 cm, *N*=23[1]	*P* value[2]
Age (y)			0.449
Mean (SD)	39.8 (13.9)	36.7 (14.0)	
Median (IQR)	38.5 (29.5, 49.5)	35.0 (25.0, 46.0)	
Range	20.0, 69.0	19.0, 69.0	
Sex, female	7 (29.2%)	6 (26.1%)	0.813
Body mass index (BMI)			0.756
Mean (SD)	28	27.6	
Range	25.5, 30.5	25.1, 30.1	
Weight (Kg)			0.598
Mean (SD)	78.9 (17.6)	74.4 (12.7)	
Median(IQR)	75.0 (69.0,85.0)	72.5 (70.0, 76.2)	
Range	55.0,125.0	55.0, 100.0	
Height (cm)			0.077
Mean (SD)	168.3 (6.7)	163.1 (5.9)	

Median (IQR)	170.0 (164.0,175.0)	165.0 (158.8, 166.2)	
Range	155.0, 180	155.0, 170.0	
Mitral pathology			
Mitral regurgitation	16 (66.7%)	15 (65.2%)	0.917
Mitral stenosis	8 (33.3%)	8 (34.8%)	
Society of Thoracic Surgeons (STS) predicted morbidity and mortality score			0.50
Mean	6.1	5.2	
Range	1.9, 10.3	2.8, 7.6	
[1]n (%)			

2Wilcoxon rank sum test; χ^2, Pearson's Chi-squared test.

Comparing the high-risk (TAPSE<1.6 cm) versus low-risk (TAPSE>1.6 cm) groups, nonsignificant differences were demonstrated between the groups in terms of age (*P=0.45*), sex (*P=0.8*), BMI (*P=0.8*), or mitral pathology (*P=0.92*). (Table 1).

Table 2: Comparing postoperative characteristics between the study groups.

Characteristic	TAPSE<1.6 cm, *N*=24[1]	TAPSE>1.6 cm, *N*=23[1]	*P*-value[2]
Mechanical ventilation duration (h)			0.880
Mean (SD)	9.1 (4.3)	10.7 (9.1)	
Median (IQR)	8.0 (7.2, 10.0)	8.0 (7.5, 10.0)	
Range	4.0, 24.0	4.0, 48.0	
ICU length of stay (h)			0.970
Mean (SD)	54.5 (18.9)	55.2 (21.4)	
Median (IQR)	48.0 (48.0, 72.0)	48.0 (48.0, 72.0)	
Range	12.0, 96.0	12.0, 120.0	
Postoperative bleeding	5 (20.8%)	8 (34.8%)	0.285
Postoperative bleeding volume (ml)			0.286
Mean (SD)	77.1 (157.4)	215.2 (431.5)	
Median (IQR)	0	0.0 (0.0, 300.0)	
Range	0.0, 500.0	0.0, 1,500.0	
Composite endpoint of complications			0.118
Complication	8 (33.3%)	3 (13.04%)	
No complications	16 (66.7%)	20 (86.9%)	
Composite complication type			0.222
AKI	1 (4.3%)	0	
Hepatic injury	1 (4.3%)	0	
Multiorgan failure	4 (17.4%)	2 (8.6%)	
Wound dehiscence	1 (4.3%)	1 (4.3%)	
Wound dehiscence + Multiorgan failure	1 (4.3%)	0	
[1]n (%)			

2Wilcoxon rank sum test; χ^2, Pearson's Chi-squared test; Fisher's exact test.

Comparing the high-risk (TAPSE<1.6 cm) versus low-risk (TAPSE>1.6 cm) groups regarding post-operative characteristics, non-significant differences were demonstrated between both groups in terms of the duration of mechanical ventilation (*P=0.88*), ICU length of stay (*P=0.97*), the incidence of postoperative bleeding (*P=0.29*), the volume of postoperative bleeding (*P=0.29*), the composite endpoint of complications (*P=0.12*), or the type of complication. (Table 2).

Table 3: Comparing postoperative characteristics stratified by the incidence of complications

Characteristic	Complication, N=11[1]	No complications, N=36[1]	*P* value[2]
Mechanical ventilation duration (h)			0.028
Mean (SD)	14.6 (12.2)	8.3 (3.6)	
Median (IQR)	12.0 (8.0, 14.0)	8.0 (7.0, 9.0)	
Range	5.0, 48.0	4.0, 24.0	
ICU length of stay (h)			0.075
Mean (SD)	64.4 (30.5)	51.2 (14.3)	
Median (IQR)	72.0 (48.0, 72.0)	48.0 (48.0, 48.0)	
Range	12.0, 120.0	12.0, 72.0	
Overall mortality			0.001
Alive	5 (45.5%)	33 (94.3%)	
Dead	6 (54.5%)	2 (5.7%)	
[1]n (%)			

2Wilcoxon rank sum test; Fisher's exact test.

Comparing our study group stratified by the incidence of the composite endpoint of complications regarding the postoperative characteristics, complicated cases demonstrated a significantly higher duration of mechanical ventilation (*P=0.028*), the incidence of postoperative bleeding (*P=0.022*), the postoperative bleeding volume (*P=0.012*), and the overall mortality (*P=0.001*). Alternatively, there were no significant differences in the lengths of ICU stay between both groups (*P=0.08*). (Table 3).

Table 4: Comparing TAPSE profiles stratified by the baseline TAPSE risk groups

Characteristic	TAPSE<1.6 cm, *N*=24	TAPSE>1.6 cm, *N*=23	*P* value[1]
Baseline TAPSE score			<0.001
Mean (SD)	1.2 (0.2)	2.0 (0.2)	
Median (IQR)	1.2 (1.0, 1.3)	2.0 (1.8, 2.1)	
Range	0.9, 1.5	1.6, 2.5	
Postoperative TAPSE score			<0.001
Mean (SD)	1.0 (0.3)	1.8 (0.3)	
Median (IQR)	1.0 (0.8, 1.2)	1.9 (1.7, 2.0)	
Range	0.4, 1.6	1.4, 2.3	
Difference in TAPSE postoperatively relative to baseline			0.397
Mean (SD)	–0.2 (0.3)	–0.1 (0.2)	
Median (IQR)	−0.2 (−0.3, −0.1)	−0.1 (−0.2, −0.1)	
Range	−0.8, 0.6	−0.8, 0.2	
3-month TAPSE score			<0.001
Mean (SD)	1.4 (0.3)	1.9 (0.2)	
Median (IQR)	1.4 (1.2, 1.6)	2.0 (1.8, 2.0)	
Range	0.8, 1.7	1.7, 2.2	
Difference in TAPSE after 3 months relative to baseline			0.028
Mean (SD)	0.1 (0.3)	−0.1 (0.2)	
Median (IQR)	0.1 (−0.1, 0.3)	−0.1 (−0.2, 0.1)	
Range	−0.4, 0.7	−0.4, 0.2	

1Wilcoxon rank sum test

At the 3-month assessment, TAPSE scores were found to be significantly lower in the high-risk group (*P<0.001*). The reduction in TAPSE scores in the high-risk group was 0.1±0.3 cm, while it increased in the low-risk group by 0.1±0.2 cm (*P=0.028*), suggesting limited improvement in the high-risk group compared with the low-risk groupp. (Table 4).

Table 5: Univariate regression analysis predicting the risk of mortality

Characteristic	N	OR[1]	95% CI[1]	*P*-value
Age (years)	47	1.00	0.94, 1.06	0.98
Sex, female	47	3.33	0.67, 16.9	0.14
Weight (Kg)	47	0.98	0.92, 1.03	0.46
EF	47	0.96	0.92, 1.00	0.056
LVEDD (cm)	47	0.89	0.41, 1.68	0.74
Baseline TAPSE score	47	0.01	0.00, 0.22	<0.001
Cross clamp time (min)	47	1.11	1.04, 1.23	0.001

1OR, Odds Ratio; CI, Confidence Interval.

The increase in baseline TAPSE scores is significantly associated with a reduced risk of mortality, with a decrease in odds by 99% (OR = 0.01, *P<0.001*). Alternatively, longer cross clamp times are associated with an increased risk of mortality, with a 0.11-fold increase in odds of mortality with each increase of 1 min in cross clamp time (OR = 1.11, *P=0.001*). The results for age, gender, weight, EF, and LVEDD do not show a statistically significant association with the risk of mortality (*P>0.05*). (Table 5).

Table 6: Multivariate regression analysis predicting the risk of mortality

Characteristic	OR[1]	95% CI[1]	*P*-value
Cross clamp time (min)	1.14	1.03, 1.34	0.041
Baseline TAPSE score	0.01	0.00, 0.22	0.039

1OR=Odds Ratio, CI = Confidence Interval

The results of the multivariate regression analysis showed that only two predictors were found to be statistically significant in predicting the risk of all-cause mortality: cross clamp time (mins) and baseline TAPSE score. The odds ratio (OR) of 1.14 for clamp time (min) indicates that for each minute increase in operative time, the odds of mortality increase by 0.14 times (*P=0.041*). This result suggests that cross-clamp time is a strong predictor of mortality risk. The 95% confidence interval (CI) for this OR ranges from 1.03 to 1.34, suggesting that the result is statistically significant (*P value = 0.041*). (Table 6).

DISCUSSION

It has also been shown recently that worldwide RVD is a strong predictor of long-term prognosis, particularly when combined with LV dysfunction[6]. The RV has complicated three-dimensional (3D) shape, making it challenging to recognize and precisely categorize its function. While novel methods like as speckle tracking echocardiography (STE) and tissue Doppler imaging (TDI) are helping us understand RV function better, most of these modalities are experienced-only. RV function and volume have been evaluated by extensive research on 3D echocardiography[7].

One well-known echocardiographic metric is TAPSE. It calculates the RV's systolic apex to base shortening. In comparison with LV, the transverse diameter of RV is substantially smaller. However, the RV has a far higher surface-to-volume ratio than the LV. Consequently, a significant increase in ejection will result from modest changes in the transverse dimension[8].

We discovered that in group I, there were 70.8% male patients and 29.2% female patients. It was 39.8±13.9 years old on average. The average height was 167.1±7.3 cm, and the average weight was 78.7±17.0 kg. In contrast, group II consisted of 73.9% male patients and 26.1% female patients. 36.7±14.0 years was the average age. The average height was 167.7±6.4 cm, and the average weight was 77.6±17.0 kg.

In contrast to Towheed *et al*.[9], 269 patients who had left-sided valve surgery performed at Toledo University between 2006 and 2014 had their RV function evaluated. Using the RV function as a criterion, the patients were split into two groups: RVD (N=53) and normal RV group (N=216). The mean age of the normal RV group was 68.1±14.6 years, with 58% of the participants being male. The mean age of the RVD group was 64±16.2 years, with 69.8% of the participants being male. Also, Erriyanti *et al*.[10] analyzed retrospectively 266 patient who underwent mitral valve surgery from January 2016 to February 2017 at National Cardiovascular Center Harapan Kita Hospital. The median age of the patients was 43 years with males represented 42.1% of the patients. The patients were stratified according to the preoperative TAPSE score into the group I (TAPSE<1.6 cm; N=196) and group II (TAPSE>1.6 cm; N=70).

Our present study where in group I, the mean amount of bleeding was 77.1±157.4 ml. The mean ventilation time was 9.1±4.3 h and the mean ICU stay was 54.5±18.9 h. The inotropes used in 20 (83.3%) patients. The complications occurred in eight (33.3%) patients as the following: AKI (4.3%) hepatic impairment (4.3%), multi-organ failure (17.4%) and wound dehiscence (8.6%). While in group II, the mean amount of bleeding was 215.2±431.5 ml. The mean ventilation time was 10.7±9.1 h and the mean ICU stay was 55.2±21.4 h. The inotropes used in 11 (47.8%) patients. The complications occurred in three (13.6%) patients as the following: multi-organ failure (4.3%) and wound dehiscence (8.6%). There was a significant statistical difference regarding the inotropes using (*P =0.010*). Khan *et al*.[8] the postoperative echo data of group I revealed that the mean ventilation time was 5.17±2.80 h and the mean ICU stay was 8.92±3.62 h. The inotropes used in 36% of the patients. In group II, the mean ventilation time was 3.72±2.71 h and the mean ICU stay was 5.20±2.06 h. The inotropes used in 14% of the patients.

There was significant statistical difference between both groups regarding inotropes using (*P =0.003*), duration of ventilation (*P<0.001*), total ICU stay (*P<0.001*) and total hospital stay (*P<0.001*).

In our study, we divided the patients according to the incidence of complications into complication group (n=11) and noncomplication group (n=36). There was significant statistical difference between both groups regarding duration of mechanical ventilation (*P =0.028*), postoperative bleeding (*P=0.022*) and mortality rate (*P =0.001*).

According to our study's univariate logistic regression analysis, preoperative TAPSE (OR=0.01, *P <0.001*) and cross clamp duration (OR=1.11, *P =0.001*) were associated with higher risk of death. The results of a multivariate logistic regression analysis showed that cross clamp time and preoperative TAPSE were predictive of death. The results of the univariate regression analysis showed that preoperative TAPSE did not predict the length of the ICU stay, the duration of mechanical ventilation, or the bypass time. Additionally, preoperative RVD, diabetes mellitus, atrial fibrillation, poor LVEF, and a higher STS score were all associated with an increased 30-day mortality, according to Towheed A *et al*.'s[9] univariate regression analysis. The main result was shown to be most strongly predicted by RVD (OR=3.0, *P=0.02*).

Using bivariate analysis, Erriyanti *et al*.[10] found no link between TAPSE and 5-year mortality (*P=0.733*).

The same findings, demonstrating that TAPSE was unrelated to postoperative outcomes, were also reported in a research by Sun *et al*.[11]. This study's TAPSE value was 1.4 cm.

TAPSE is a well-established, practically applicable, and clinically beneficial measure of RVD. It has also been demonstrated to be a good prognostic marker in a number of cardiac conditions, including heart failure. We proposed that TAPSE, a straightforward assessment akin to LVEF, may serve as a therapeutic indicator. Consequently, the discovery of preoperative RVD, as reported in this work, may result in adjustments to the surgical approach or the treatment plan as a whole.

CONCLUSION

A thorough preoperative echocardiographic evaluation of RV was able to detect RVD in patients having mitral valve surgery, and RVD was an independent predictor of 3-month death. Our findings support the necessity of doing a thorough evaluation of RV function prior to heart surgery. Reducing postoperative adverse events and postoperative mortality may be possible with the identification of preoperative RVD. RVD measures should be further included in risk prediction models since they may offer helpful prognostic information (Fig. 1).

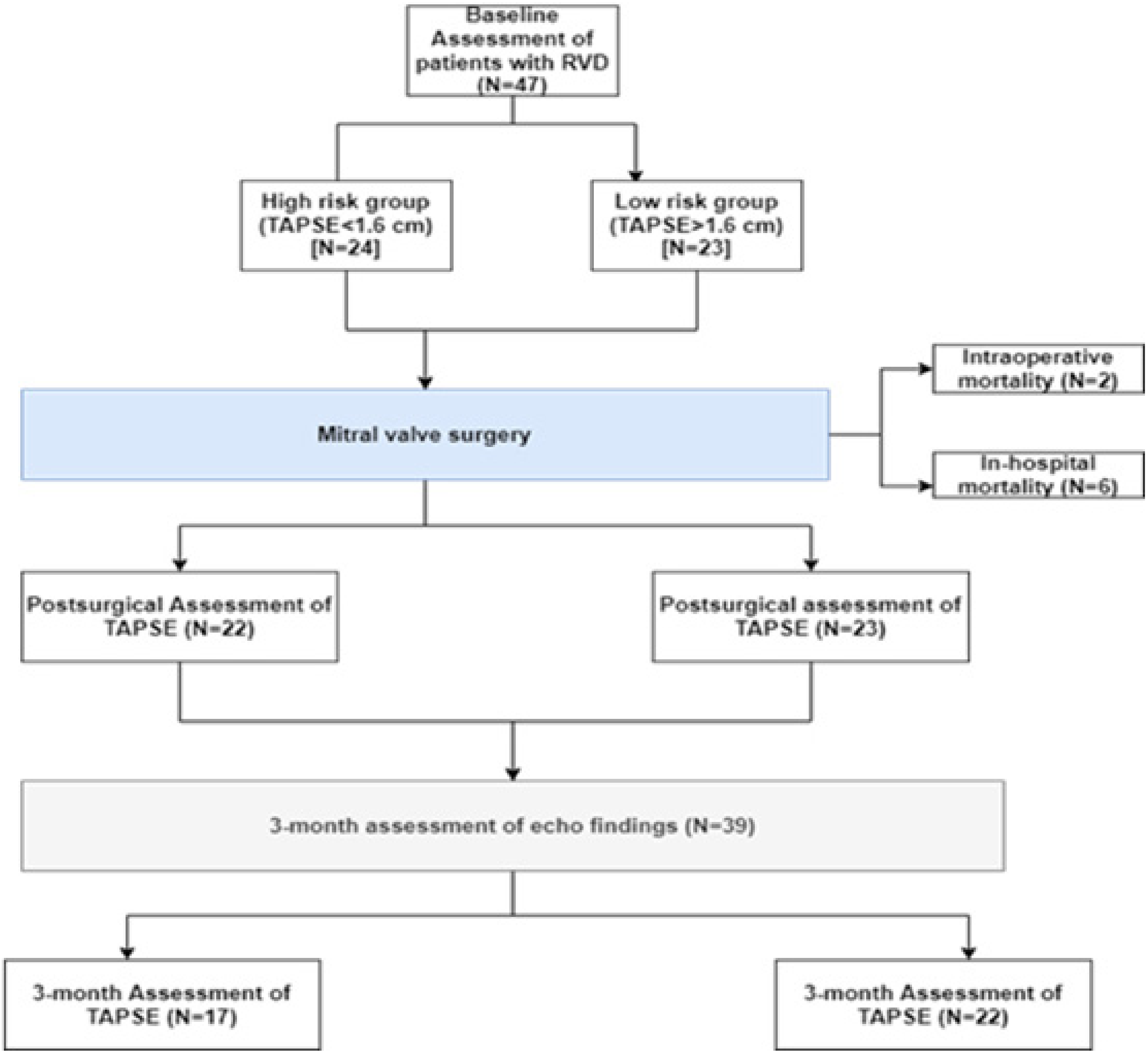

Fig. 1: Study flow chart.

CONFLICT OF INTEREST

There are no conflicts of interest.

REFERENCES

1. Gigorro RG, Carreño ER, Mayordomo S, Marín H, Vela JLP, Peiretti MAC, González JCM. Evaluation of right ventricular function after cardiac surgery: the importance of tricuspid annular plane systolic excursion and right ventricular ejection fraction. J Thorac Cardiovasc Surg 2016; 152:613–620.

2. Sato T, Tsujino I, Oyama-Manabe N, Ohira H, Ito YM, Sugimori H, Nishimura M. Simple prediction of right ventricular ejection fraction using tricuspid annular plane systolic excursion in pulmonary hypertension. Int J cardiovasc imaging 2013; 29:1799–1805.

3. Kholdani C, Fares WH, Mohsenin V. Pulmonary hypertension in obstructive sleep apnea: is it clinically significant? A critical analysis of the association and pathophysiology. Pulm Circ 2015; 5:220–227.

4. Buckberg G, Nanda NC. Right Ventricular Changes after Left‐Sided Lesions: Underlying Cardiac Mechanics. Echocardiography 2015; 32:727–730.

5. Green EM, Givertz MM. Management of acute right ventricular failure in the intensive care unit. Curr heart fail rep 2012; 9:228–235.

6. Le Tourneau T, Deswarte G, Lamblin N, Foucher-Hossein C, Fayad G, Richardson M, Bauters C. Right ventricular systolic function in organic mitral regurgitation: impact of biventricular impairment. Circulation 2013; 127:1597–1608.

7. Schindera ST, Mehwald PS, Sahn DJ, Kececioglu D. Accuracy of real‐time three‐dimensional echocardiography for quantifying right ventricular volume: static and pulsatile flow studies in an anatomic in vitro model. J ultrasound med 2002; 21:1069–1075.

8. Khan I, Shahbaz A, Iqbal M, Khan AR, Riaz W, Sayyed MS, Khan K. Tricuspid annular plane systolic excursion is correlated with poor outcome in surgery for rheumatic heart valvular disease. ARYA atherosclerosis 2019; 15:130.

9. Towheed A, Sabbagh E, Gupta R, Assiri S, Chowdhury MA, Moukarbel GV, Khouri S. Right ventricular dysfunction and short‐term outcomes following left‐sided valvular surgery: an echocardiographic study. J Am Heart Assoc 2021; 10:e016283.

10. Erriyanti S, Soesanto AM, Sakidjan I, Atmosudigdo A, Lilyasari O, Ariani R, Siagian SN. The the impact of Tricuspid annular plane systolic excursion (TAPSE) after mitral valve surgery on long term mortality. Indonesian J Cardiol 2022; 43:1–8.

11. Sun X, Zhang H, Aike B, Yang S, Yang Z, Dong L, Wang C. Tricuspid annular plane systolic excursion (TAPSE) can predict the outcome of isolated tricuspid valve surgery in patients with previous cardiac surgery? J Thorac Dis 2016; 8:369.