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Right ventricle to pulmonary artery coupling as a predictor of perioperative outcome in patients with secondary mitral valve insufficiency

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Abstract

Background: *The aim of the study was to assess some parameters of right ventricle (RV) function as predictors of short-term mortality in patients with severe secondary mitral regurgitation (SMR) after mitral valve surgery.*

Methods: *We conducted a retrospective analysis of 112 consecutive patients with severe SMR who had undergone mitral valve repair or replacement with or without concomitant coronary artery bypass surgery. We assessed RV to pulmonary artery coupling by calculating the ratio of tricuspid annular plane systolic excursion (TAPSE) to non-invasively estimated RV systolic pressure (RVSP). The study endpoint was 30 days post-procedural mortality.*

Results: *Overall, the 30-day mortality was 6%. TAPSE/RVSP ratio < 0.42 mm/mmHg was a significant predictor of mortality and remained so after adjusting for age and sex. The Kaplan-Meier survival analysis showed that patients with RVSP > 55 mmHg and those with TAPSE/RVSP ratio < 0.42 mm/mmHg had a lower survival probability.*

Conclusions: *TAPSE/RVSP < 0.42 mm/mmHg is a strong predictor of short-term mortality in patients with SMR when considered for valve surgery.* (Cardiol J 2024; 31, 5: 731–739)

Keywords: secondary mitral regurgitation, mitral valve surgery, TAPSE/RVSP ratio

Introduction

Severe secondary mitral regurgitation (SMR) is the second most common indication for valve surgery and affects about 2% of the total population [1]. Our patients with severe SMR represented about 28% of all patients operated on due to severe mitral regurgitation (MR) [2]. Preoperative risk assessment plays an important role in selecting patients for a given intervention, particularly in the era of transcatheter procedures. Currently, only a few models estimating the risk of adverse events during cardiac surgery are available. The most commonly used include the Society of Thoracic Surgeons (STS) and the European System for Cardiac Operative Risk Evaluation II (EuroSCORE II) surgical risk scoring models. However, none of them includes preoperative right ventricle (RV)

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size and function parameters. Preoperative RV dysfunction, assessed by a composite of echocardiographic variables, is independently associated with a 3.5-fold increased risk of 30-day mortality after left-sided heart valve surgery [3]. The aim of this study was to assess the prognostic value of RV function parameters such as fractional area change (FAC), right ventricle systolic pressure (RVSP), and tricuspid annular plane excursion to right ventricle systolic pressure ratio (TAPSE/ /RVSP) as a predictors of 30-day mortality in patients with SMR.

Methods

This research was designed as a retrospective cohort study that included 112 consecutively enrolled patients with severe SMR who underwent elective mitral valve (MV) surgery in John Paul II Hospital in Krakow, between 2015 and 2019. The exclusion criteria were urgent and emergency surgery, redo-surgery, coexisting severe tricuspid regurgitation, or aortic valve disease.

Patients underwent detailed clinical evaluation and were qualified for MV repair or replacement as suggested by the appropriate guidelines [4]. High-risk patients with severe SMR and suitable valve morphology were qualified for MitraClip procedure, but this group was not considered in this study. Clinical and laboratory test results and procedural data were collected. Patients with concomitant arterial hypertension or heart failure were treated in accordance with current guidelines.

The primary endpoint of the study was 30-day postoperative mortality, regardless of whether the patient was discharged within this period. In the case of discharged patients, the follow-up was conducted via a face-to-face interview, through medical records (if the patient was re-hospitalized), or via a telephone interview with the patient or the patient's guardian (if the patient was discharged). The study population was divided into two groups: group A (n = 105) — patients who survived over 30 days after surgery; and group B (n = 7) — patients who died within 30 days of surgery. The follow-up period in the present study was 4–30 days (mean 29.2 ± 4.1 days; median 30 days, interquartile range [IQR] 30–30 days). In group A, the mean, median, Q1, and Q3 of follow-up were 30 days. The follow-up period in group B was 4–30 days (mean 16.9 ± 10.9 days; median 14 days, IQR 7–28 days).

The study was approved by the regional Ethical Review Committee, and the study protocol complied with the Declaration of Helsinki.

Echocardiography

Preoperative transthoracic echocardiography (TTE) was performed according to the guidelines in all patients, using either iE33 or EPIQ7 machines (Philips Healthcare, Andover, USA) [5]. Mitral regurgitation (MR) severity assessment included the flow convergence method (proximal isovelocity surface area [PISA]); a volumetric method was used in cases with multiple MR jets [6].

In accordance with the European Society of Cardiology (ESC) guidelines at this time, MR was considered severe when effective regurgitant orifice area (EROA) was > 0.2 cm^2 or MR volume > 30 mL [4]. To verify the main mechanism of MR (annular dilatation or leaflet tethering) we assessed the tenting area, coaptation height, and annulus dimensions, both anteroposterior (AP) and intercommissural (CC).

Global left ventricle (LV) diameters were obtained from the parasternal long axis view, and LV function was assessed using the Simpson's biplane method [5]. Basal RV diameter (RVD) was measured in the basal third of the ventricle in a four-chamber RV — focused view. A fractional area change (FAC) was obtained in the same image by tracing the RV endocardium at both end-diastole and end-systole. Longitudinal function of the RV was assessed using tricuspid annular plane systolic excursion (TAPSE). It was determined using an M-mode cursor, placed through the lateral tricuspid annulus in the apical view, as an excursion of the annulus from the end-diastole to the peak systole. Peak tricuspid regurgitation (TR) jet velocity (V) was measured, and right atrial pressure (RAP) was estimated using the size and respiratory change of the inferior vena cava [7]. Pulmonary artery systolic pressure (PASP) was estimated as the sum of TR peak pressure gradient and right atrial pressure ($PASP = 4V^2 + RAP$).

The average values of 3 or 5 consecutive measurements were recorded in sinus rhythm and atrial fibrillation, respectively.

Surgical technique

The surgical approach to MV surgery was conventional median sternotomy or right minithoracotomy. Cardiopulmonary bypass was established by central cannulation of the ascending aorta and the right atrium in the case of median sternotomy or by peripheral cannulation of femoral artery and femoral vein in the case of a less invasive approach through the right minithoracotomy. Cardioplegic cardiac arrest was achieved by antegrade administration of warm blood or cold crystalloid cardioplegia into the ascending aorta. Standard surgical techniques of MV reconstruction or replacement were used. Patients from both groups received uniform postoperative care.

Statistical analysis

Categorical variables were presented as numbers and percentages. Continuous variables were expressed as median and IQR. The categorical variables were compared by Fisher's exact test, and continuous variables were compared by the Mann-Whitney U test. A logistic regression analysis was performed to determine the predictors of 30-day mortality in the study patients. The best cut-off value that maximized sensitivity and specificity, as well as showing those patients who died during the 30-day follow-up, was calculated with the use of the receiver operating characteristics (ROC) curve. The Kaplan-Meier method and the log-rank test were used to estimate 30-day overall survival. Two-sided p-values < 0.05 were considered statistically significant. All calculations were made using the STATISTICA 13.3 software package (TIBCO Software Inc., Palo Alto, CA, USA).

Reproducibility

A retrospective analysis of echocardiographic images was performed by the same observer (J.R.R.) and a second, blinded observer (K.G.G.). Intraobserver variabilities were 3%, and interobserver variabilities were 5%. For this purpose, we assessed the following echocardiographic parameters: EROA, TAPSE, RVSP, and LV ejection fraction (LVEF).

Results

Among the 112 patients included, 64 (57%) underwent MV repair, 48 (43%) had MV replacement, and 25 patients were treated surgically for functional tricuspid regurgitation receiving only annular repair. In the MV repair group, we observed a higher prevalence of men (79% vs. 60%, p = 0.025), larger LV end-diastolic diameters (60 vs. 56 mm, p = 0.025; 43 vs. 39 mm, p = 0.044, respectively), and lower LVEF (42% vs. 47%, p = 0.048) when compared with the replacement group (Table 1).

No significant differences between MV repair and replacement groups were observed in the operative and postoperative variables listed in Table 2, except for a permanent pacemaker implantation, which was higher in the MR replacement group (6.25% vs. 0%, p = 0.043).

In the MV repair group, we observed a slightly higher tenting area (1.8 vs. 1.3 cm^2, p = 0.027) and a tendency towards higher coaptation height (8.3 vs. 6.8 mm, p = 0.072) in comparison with the MV replacement group. However, annular dimension did not differ between these groups (AP dimension 40.5 vs. 39 mm, p = 0.346, CC dimension: 43 vs. 41.5 mm, p = 0.296, respectively).

In our study, all patients underwent echocardiography before hospital discharge, to assess the effectiveness of MV repair or replacement. In evaluating severity of MR, we used color flow Doppler: regurgitant jet area, vena contracta, and flow convergence. According to the American Society of Echocardiography (ASE) guidelines: Recommendations for Noninvasive Evaluation of Native Valvular Regurgitation, a small noneccentric jet with a narrow vena contracta < 3 mm and no visible convergence region usually indicates mild MR. In our patients we observed only trace or mild residual MR post-operatively [8].

In the MV repair group, we observed a tendency towards higher proportion of concomitant coronary artery bypass grafting (CABG) (51% vs. 33%, p = 0.054) and a nonsignificant difference in tricuspid annuloplasty procedure (26% vs. 17%, p = 0.216).

Short-term mortality

Demographic and echocardiographic data of all studied patients and those who died (group B) are presented in Table 1. Operative and postoperative parameters are shown in Table 2.

Overall short-term (30 days) mortality was 6% (n = 7) in the whole study population, which was a surprisingly low number of deaths. Five patients died in the MV repair group (3 of them due to cardiovascular reasons, one because of mediastinitis, and the last in the course of recurrent bladder bleeding). Two patients died in group B due to refractory heart failure during the early postoperative period. Among non-survivors (group B), 5 patients underwent MV repair (including 2 with concomitant CABG), and 2 patients underwent MV replacement. In our study, there were no significant differences in STS and EuroSCORE II between survivors and non-survivors. Among RV parameters, besides RV diameter and RVSP, the TAPSE/RVSP ratio was significantly lower in group B.

Based on ROC curve analysis, RVSP > 55 mmHg was associated with 30-day mortality with sensitivity of 85.7% and specificity of 78.9% (area under curve [AUC] 0.810, 95% confidence interval [CI] 0.690–0.929, p < 0.001; Fig. 1A).

Table 1. Baseline characteristics of the study groups

Parameter	Total (n = 112)	Group A (n = 105)	Group B (n = 7)	P
Age [years]	66.5 (60.0–72.0)	68.0 (61.0–72.0)	66.0 (51.0–68.0)	0.312
Male	80 (71.4%)	75 (71.4%)	5 (71.4%)	1.000
BSA [m^2]	1.9 (1.8–2.0)	1.9 (1.8–2.0)	1.8 (1.7–2.0)	0.366
BMI [kg/m^2]	28.0 (25.5–30.0)	28.0 (25.4–30.4)	26.0 (25.7–28.0)	0.222
NYHA I/II	63 (56.3%)	62 (59.1%)	1 (14.3%)	**0.042**
NYHA III/IV	49 (43.8%)	43 (41.0%)	6 (85.7%)	**0.042**
DCM	42 (37.5%)	39 (37.1%)	3 (42.9%)	1.000
Previous PCI	29 (25.9%)	27 (25.7%)	2 (28.6%)	1.000
Previous MI	29 (25.9%)	26 (24.8%)	3 (42.9%)	0.372
Previous stroke	10 (8.9%)	9 (8.6%)	1 (14.3%)	0.490
Diabetes mellitus	29 (25.9%)	27 (25.7%)	2 (28.6%)	1.000
Hypertension	99 (88.4%)	93 (88.6%)	6 (85.7%)	0.589
Preoperative AF	57 (50.9%)	54 (51.4%)	3 (42.9%)	0.714
Preoperative pacemaker	10 (8.9%)	9 (8.6%)	1 (14.3%)	0.490
COPD	9 (8.0%)	9 (8.6%)	0 (0.0%)	1.000
Creatinine [µmol/L]	92.0 (80.0–110.5)	91.0 (80.0–110.0)	103.0 (98.0–114.0)	0.153
eGFR [mL/min/1.73 m^2]	67.0 (54.5–74.5)	67.0 (56.0–75.0)	56.0 (40.0–74.0)	0.271
EuroSCORE II [points]	2.4 (1.6–3.7)	2.3 (1.5–3.7)	4.9 (2.0–7.3)	0.116
STS score [points]	1.9 (1.1–2.8)	1.8 (1.1–2.7)	2.4 (1.5–3.8)	0.272
Pharmacotherapy				
ASA	74 (66.1%)	69 (65.7%)	5 (71.4%)	1.000
Beta-blocker	76 (67.9%)	69 (65.7%)	7 (100.0%)	0.094
ACEi/ARB	107 (95.5%)	101 (96.2%)	6 (85.7%)	0.280
MRA	53 (47.3%)	47 (44.8%)	6 (85.7%)	0.051
Loop diuretic	95 (84.8%)	88 (83.8%)	7 (100.0%)	0.251
Statin	50 (44.6%)	46 (43.8%)	4 (57.1%)	0.496
Echocardiographic parameters				
LVEF [%]	50.0 (30.0–55.0)	50.0 (35.0–60.0)	30.0 (25.0–45.0)	**0.044**
LVEDD [mm]	57.0 (50.0–66.0)	57.0 (50.0–65.0)	68.0 (65.0–73.0)	**0.015**
LVESD [mm]	40.0 (34.0–48.5)	40.0 (34.0–46.0)	49.0 (42.0–50.0)	0.071
LVEDDi [mm/m^2]	30.8 (27.1–33.8)	30.4 (26.8–33.5)	36.5 (33.6–37.8)	**0.002**
LVESDi [mm/m^2]	21.0 (17.7–25.0)	20.7 (17.6–24.1)	25.0 (22.4–29.5)	**0.043**
LA area [cm^2]	30.5 (27.0–36.5)	31.0 (27.0–36.0)	28.0 (28.0–46.0)	0.652
Tenting area [cm^2]	1.9 (1.6–2.1)	1.8 (1.5–2.0)	2.2 (1.8–2.5)	0.282
Coaptation high [mm]	8.2 (7.0–10.0)	8.0 (7.0–10.0)	9.5 (7.8–10.5)	0.407
Annulus diameter [AP] [mm]	39.5 (37.0–44.0)	40.0 (36.0–44.0)	38.5 (38.0–44.0)	0.852
Annulus diameter [CC] [mm]	41.5 (39.5–46.5)	42.5 (39.5–46.5)	40.5 (39.5–50.0)	0.909
RVD [mm]	39.5 (36.0–42.0)	39.0 (36.0–42.0)	41.0 (36.0–43.0)	0.467
FAC [%]	40.0 (32.0–44.0)	40.0 (32.0–44.0)	34.0 (28.0–42.0)	0.151
FAC < 35%	41 (36.6%)	36 (34.3%)	5 (71.4%)	0.098
TAPSE [mm]	20.0 (18.0–23.0)	20.0 (18.0–23.0)	18.0 (16.0–20.0)	**0.041**
RVSP [mmHg]	40.0 (33.0–55.0)	40.0 (33.0–47.0)	60.0 (55.0–65.0)	**0.007**
TAPSE/RVSP [mm/mm Hg]	0.54 (0.33–0.66)	0.54 (0.35–0.66)	0.30 (0.28–0.36)	**0.009**

Data are given as number (percentage) for categorical variables and median (interquartile range) for continuous variables; ACEi — angiotensin-converting enzyme inhibitor; AF — atrial fibrillation; AP — anterior-posterior mitral annulus diameter; ARB — angiotensin II receptor blocker; ASA — acetylsalicylic acid; BMI — body mass index; BSA — body surface area; CC — intercommissural distance; COPD — chronic obstructive pulmonary disease; DCM — dilated cardiomyopathy; eGFR — estimated glomerular filtration rate; FAC — fractional area change; LA — left atrium; LVEF — left ventricular ejection fraction; LVEDD — left ventricular end-diastolic diameter; LVEDDi — indexed left ventricular end-diastolic diameter; LVESD — left ventricular end-systolic diameter; LVESDi — indexed left ventricular end-systolic diameter; MI — myocardial infarction; MRA — mineralocorticoid receptor antagonist; NYHA — New York Heart Association; PCI — percutaneous coronary intervention; RVD — right ventricular diameter; RVSP — right ventricular systolic pressure; STS score — Society of Thoracic Surgery score; TAPSE — tricuspid annular plane systolic excursion

Table 2. Operative and postoperative characteristics of the study patients

Parameter	Group A (n = 105)	Group B (n = 7)	P
Aortic cross-clamp time [min]	76.0 (63.0–97.0)	75.0 (68.0–83.0)	0.988
Cardiopulmonary bypass time [min]	119.0 (99.0–158.0)	149.0 (113.0–228.0)	0.211
Type of procedure:			
MV annuloplasty	59 (56.2%)	5 (71.4%)	0.697
MV replacement	46 (43.8%)	2 (28.6%)	0.697
Concomitant TV annuloplasty	25 (23.8%)	0 (0.0%)	0.346
Concomitant CABG	47 (44.8%)	2 (28.6%)	0.465
Transfusion (red cells) [units]	0.0 (0.0–2.0)	4.0 (2.0–6.0)	**0.006**
Transfusion (plasma) [units]	0.0 (0.0–3.0)	3.0 (2.0–4.0)	**0.049**
Transfusion (platelets) [units]	0.0 (0.0–1.0)	0.0 (0.0–1.0)	0.652
Postoperative drainage > 800 mL	26 (24.8%)	0 (0.0%)	0.198
Rethoracotomy	6 (5.7%)	0 (0.0%)	1.000
Low cardiac output	23 (21.9%)	3 (42.9%)	0.350
Postoperative myocardial infarction	3 (2.9%)	0 (0.0%)	1.000
Intubation time > 24 h	2 (1.9%)	0 (0.0%)	1.000
New postoperative AF	3 (2.9%)	0 (0.0%)	1.000
Permanent pacemaker following surgery	2 (1.9%)	1 (14.3%)	0.178
Wound infection	2 (1.9%)	1 (14.3%)	0.178
Length of hospital stay [days]	10.0 (8.0–14.0)	14 (7.0–28.0)	0.552
Length of ICU stay [days]	2.0 (1.0–4.0)	7.0 (1.0–12.0)	0.092

Data are given as number (percentage) for categorical variables and median (interquartile range) for continuous variables; AF — atrial fibrillation; CABG — coronary artery bypass graft; ICU — intensive care unit; MV — mitral valve; TV — tricuspid valve

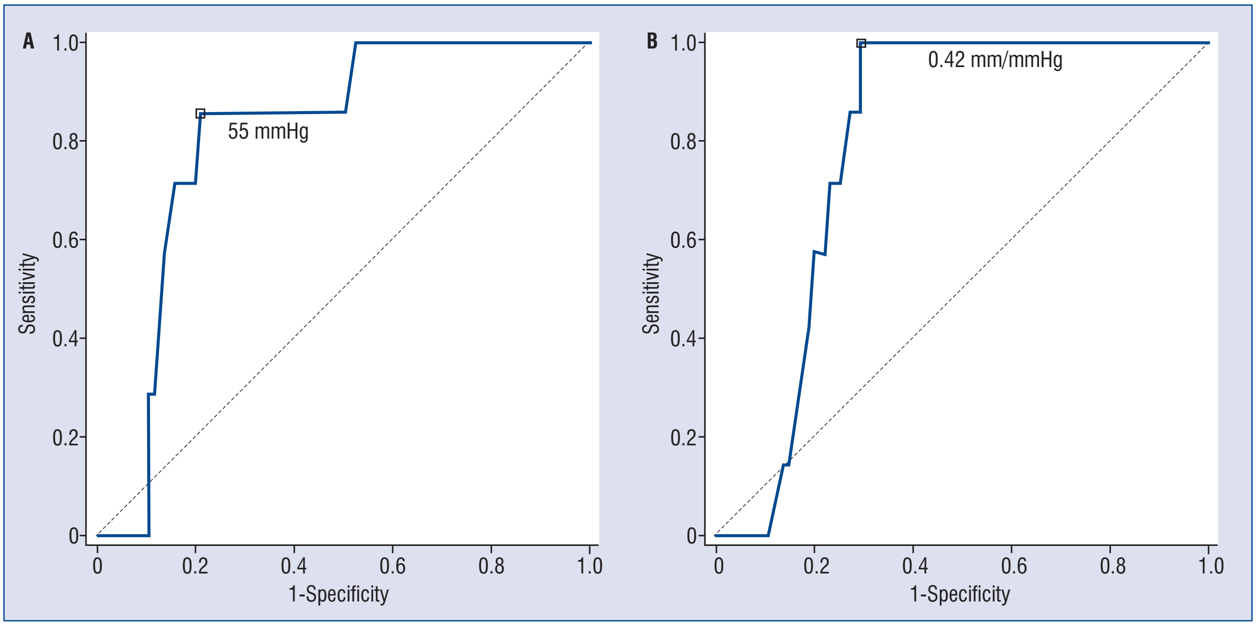

Figure 1. Receiver operating characteristic (ROC) curves for right ventricular systolic pressure (RVSP) (**A**) and tricuspid annular plane systolic excursion (TAPSE) to RVSP ratio (**B**). The outcome investigated in the ROC analysis was 30-day mortality. Optimal cut-offs are presented

Table 3. Univariate and multivariate Cox proportional hazard regression analysis for prediction of 30-day mortality in the study patients

Variable	Univariate Cox regression analysis			Multivariate Cox regression analysis		
	HR	95% CI	P	HR	95% CI	P
Clinical characteristics and laboratory investigations						
Heart failure NYHA class III–IV	8.09	0.97–67.21	0.053			
Red cells transfusion	10.20	1.97–52.77	0.006	6.13	1.16–32.26	0.033
Number of RBC units transfused, n	1.19	1.03–1.39	0.023			
Postoperative sternal dehiscence	8.92	1.07–74.04	0.043			
Hospitalization in ICU [days]	1.20	1.06–1.37	0.004			
Serum lactate concentration > 2 mM	4.35	0.97–19.45	0.054			
Echocardiographic parameters						
RVD [mm]	1.11	1.01–1.22	0.040			
RV systolic area [cm^2]	1.15	1.02–1.30	0.027			
RV diastolic area [cm^2]	1.13	1.01–1.28	0.042			
RVSP [mmHg]	1.05	1.01–1.09	0.018			
RVSP > 50 mmHg	19.78	2.38–164.26	0.006			
TAPSE/RVSP [mm/mmHg]	0.001	0.001–0.21	0.012			
TAPSE/RVSP < 0.35 mm/mmHg	8.40	1.55–45.39	0.014			
TAPSE/RVSP < 0.42 mm/mmHg	15.86	1.75–143.70	0.014	13.54	1.44–127.58	0.023
LVEDD [mm]	1.09	1.02–1.18	0.019			
LVEDDi [mm/m^2]	1.17	1.05–1.30	0.004			
LVEF [%]	0.94	0.88–1.00	0.052			

CI — confidence interval; HR — hazard ratio; ICU — intensive care unit; LVEDD — left ventricular end-diastolic diameter; LVEDDi — indexed left ventricular end-diastolic diameter; LVEF — left ventricular ejection fraction; NYHA — New York Heart Association; RBC — red blood cell; RV — right ventricular; RVD — right ventricular diameter; RVSP — right ventricular systolic pressure; TAPSE — tricuspid annular plane systolic excursion

In turn, the cut-off value of the TAPSE/RVSP ratio that was indicative of 30-day mortality was 0.42 mm/mmHg (sensitivity 100.0%, specificity 70.5%, AUC 0.795, 95% CI 0.710–0.880, p < 0.001; Fig. 1B).

Cox analysis showed that TAPSE/RVSP < 0.42 mm/mmHg was a predictor of 30-day mortality in the study patients (Table 3).

In univariate analysis, TAPSE/RVSP was a significant predictor of 30-day mortality and remained so after adjusting for age and sex (**Suppl. Table 1**).

The Kaplan-Meier survival analysis showed that patients with RVSP > 55 mmHg and those with TAPSE/RVSP ratio < 0.42 mm/mmHg had a lower survival probability compared with those with RVSP ≤ 55 mmHg (p = 0.002) and TAPSE/RVSP ratio ≥ 0.42 mm/mmHg (p = 0.003), respectively (Fig. 2).

Discussion

The importance of the present study was evaluation of the RV function parameters, such as the TAPSE to RVSP ratio, as a predictor of perioperative mortality among patients operated due to secondary mitral valve regurgitation.

The overall mortality in our study was 6%, which is similar to the mortality rates observed in previous studies in comparable populations [9–13]. According to Magne et al. [11], age, recent heart failure, and lower ejection fraction are independent predictors of short-term mortality in patients with SMR, regardless of the type of interventions (MV repair or replacement). Similarly, Noack et al. [12] reported that reduced preoperative LVEF correlates with reduced postoperative survival after isolated MV repair in patients with SMR. Atrial fibrillation increases the risk of death in patients undergoing MV surgery [13]. In the Reisman et al. [14] study, preoperative hematocrit was a significant predictor of short-term mortality after MR repair. Heikinnen et al. [15] observed that the New York Heart Association (NYHA) classification, patient age, and history of prior cardiac surgery on multivariate analysis were significantly associated with short-

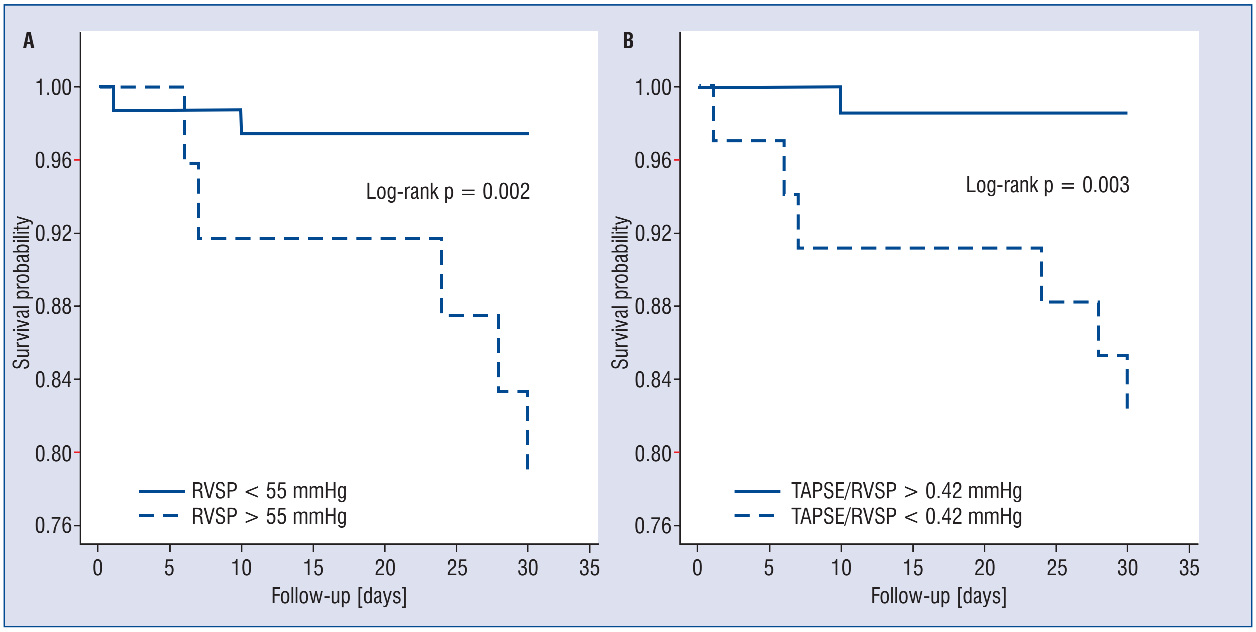

Figure 2. Kaplan-Meier survival curves for 30-day mortality in patients with right ventricular systolic pressure (RVSP) > 55 mmHg and those with RVSP < 55 mmHg (**A**), and individuals with tricuspid annular plane systolic excursion (TAPSE) to RVSP ratio < 0.42 mm/mmHg and those with TAPSE to RVSP ratio > 0.42 mm/mmHg (**B**)

term mortality in patients after MV repair. Likewise, in our study the survival rate was lower in patients with higher NYHA functional class, and univariable analysis showed that among others red cell transfusion and TAPSE/RVSP ratio were significant predictors of 30-day mortality.

Although a recent meta-analysis showed reduced perioperative mortality following MV repair [16, 17], in our study short-term mortality was non-significantly lower in patients undergoing MV replacement. This may result from a lower LVEF in the MV repair group.

In our study we observed that LV dimensions, as well as LVEF, were lower in non-survivors, similarly to other research [10].

The presence of RV dysfunction increases morbidity and mortality in patients with MR. In our study a simple and easily achievable TAPSE/ /RVSP ratio was associated with mortality after MV surgery.

However, data regarding assessment of RV dysfunction in patients undergoing MV surgery due to SMR are inconclusive. Widely used cardiac surgical risk score systems — STS and EuroSCORE II — do not include parameters of RV geometry or function.

Di Mauro et al. [10] showed that TAPSE was found to be a risk factor for poorer early and mid-term outcomes: ROC analysis in that study identified TAPSE ≤ 12 mm as a predictive cut-off in patients with dilated cardiomyopathy after MV annuloplasty.

In the study of Towheed et al. [3], preoperative RV dysfunction, assessed by a composite of echocardiographic variables, was independently associated with a 3- to 5-fold (95% CI 1.1–11.1) increased risk of 30-day mortality after left-sided heart valve surgery.

Longitudinal markers of RV function like TAPSE and peak systolic RV lateral velocity by tissue Doppler imaging are more accurate than RV FAC to predict cardiac outcomes [18, 19]. The factors that may contribute to RV dysfunction in these patients include pulmonary hypertension, ventricular interdependence, and RV myocardial ischemia [20, 21]. Backward transmission of elevated LV filling pressure into the pulmonary circulation (postcapillary hemodynamic profile) increases RV afterload and may cause some degree of RV dysfunction [22]. Pulmonary hypertension is a well-known mortality risk factor in cardiac surgical patients and is found in 15% to 60% of patients who have valvular heart disease [23–26]. Similarly, in our study, ROC curve analysis showed that an RVSP of 55 mmHg was the best indicator to identify patients with good and poor prognosis. Di Mauro et al. [18] showed that the combination of RV dysfunction and severe pulmonary hypertension may increase mortality even 11.5-fold.

Recently, RV to pulmonary artery (PA) coupling has been identified as an important indicator in patients with heart failure and pulmonary hypertension [27, 28]. In a study by Guazzi et al. [29], the TAPSE to PASP ratio was a strong and independent predictor of mortality (hazard ratio 10.3), with a threshold of 0.36 mm/mmHg that best identified the population with heart failure independently of LV dysfunction severity.

Trejo-Velasco et al. [30] showed that a TAPSE//PASP ratio ≤ 0.35 mm/mmHg was a prognostic predictor of heart failure readmission and all-cause mortality in patients undergoing MitraClip implantation. Similarly, in the study of Sultan et al. [31], baseline TAPSE to PASP ratio was associated with all-cause mortality in transcatheter aortic valve implantation patients. It has, however, not yet been evaluated in patients undergoing MV surgery. RV to PA coupling assesses the adaptation of RV to the afterload and may be useful to detect pending RV failure [32]. In clinical practice, RV to PA coupling can be quantified noninvasively as the ratio of TAPSE and PASP [33]. To the best of our knowledge this is the first study assessing the prognostic value of TAPSE to PASP after MV surgery in patients with SMR. In our study, the ROC curve analysis showed that TAPSE to PASP < 0.42 mm/mmHg, rather than ≤ 0.35 mm/mmHg, predicted mortality. In our study, patients who met the criteria for MitraClip procedure were excluded from the analysis.

Limitations of the study

Our study has several limitations. The study cohort was limited, with a relatively low number of endpoints. The study was retrospective and performed in a single center. Due to the limited number of events (perioperative deaths) that occurred during the 30-day follow-up, it was not possible to perform a reliable multivariable logistic regression analysis with all significant predictors identified during the univariate analysis. Instead, these predictors were adjusted for age and gender. Secondly, we used simple, easily achievable parameters of RV function, such as TAPSE and FAC, with their limitations. Thirdly, at the time of collecting data, we did not have a chance to perform three-dimensional reconstruction and longitudinal strain analysis.

Conclusions

Despite these limitations, echocardiographic assessment of RV function and right ventricular to pulmonary circulation coupling using a simple TAPSE/RVSP ratio may become a useful parameter associated with mortality after MV surgery. Furthermore, large, prospective studies are needed to prove the efficacy of these parameters in future perioperative risk prediction scores in MV surgery.

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