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Role of Right Ventricular-Pulmonary Arterial Coupling Measured by Echocardiography in Predicting Right Ventricular Dysfunction after Cardiac Surgery

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Abstract

Background: The tricuspid annular plane systolic excursion (TAPSE) and pulmonary artery systolic pressure (PASP) is an indirect estimate of right ventricular-pulmonary arterial (RV-PA) coupling that has been shown to correlate with invasive measures. We aimed to assess the ability of the tricuspid annular plane systolic excursion/pulmonary systolic pressure ratio (TAPSE/PASP) as a measure for RV-PA coupling to predict the development of RV dysfunction after cardiac surgery. **Methods:** This prospective study was conducted on 100 patients with ischemic heart disease and undergoing cardiac surgery (coronary artery bypass graft (CABG)) with normal preoperative right ventricular function, classified according to RV function outcomes into 2 groups: Normal RV group (65 patients) and RV dysfunction group (35 patients). All cases underwent per and postoperative transthoracic echocardiography. **Results:** By using receiver operating characteristic curve analysis, preoperative TAPSE/PASP ratio could significantly predict the RV dysfunction ($P < 0.001$), at cutoff point of >0.58, with AUC of 94%, 88.6% sensitivity, and 89.2% specificity. Post-operative TAPSE/PASP Ratio could significantly predict the RV dysfunction ($P < 0.001$), at cutoff point of >0.39, with AUC of 84%, 100% sensitivity, and 76.9% specificity. Pre-operative TAPSE/PASP ratio could significantly predict mortality ($P < 0.001$), at cutoff point of ≤0.52, with AUC of 84%, 56.1% sensitivity, and 100% specificity. Post-operative

TAPSE/PASP ratio could significantly predict mortality ($P < 0.001$), at cutoff point of ≤0.36, with AUC of 71%, 100% sensitivity, and 76.9% specificity. **Conclusion:** The TAPSE/PASP ratio is an excellent tool for CABG patients for its ability to detect and predict the development of RV dysfunction after cardiac surgery, along with the prediction of mortality in post-operative CABG patients.

Keywords

Right Ventricular, Pulmonary Arterial Coupling, Echocardiography, Cardiac Surgery

1. Introduction

Cardiac surgery relieves symptoms and increases life expectancy in cardiac patients, with and without congenital heart disease (CHD). However, patients undergoing surgery are at risk of complications, including right ventricular (RV) failure [1].

RV dysfunction pathology includes high RV preload or afterload, impaired right coronary artery perfusion, and decreased contractility. In contrast to the left coronary artery, perfusion of the right coronary artery occurs during the whole heart cycle. Moreover, high RV pressure due to pathological causes such as pulmonary hypertension leads to lower coronary artery perfusion, highlighting the importance of preserving the normal pressure inside the two ventricles [2].

Classically, RV exploration may be achieved by right cardiac catheterization, X-ray computed tomography, cardiac magnetic resonance imaging, and echocardiography. Echocardiography is widely available, less expensive than other techniques, noninvasive, and is not associated with radiation or contrast injection. Moreover, echocardiography is a well-validated tool for a comprehensive evaluation of RVD and RVF.

Recently, some studies suggested that combining measures of PH severity and RV function might better capture the RV-pulmonary artery (RV-PA) coupling than the isolated measures [3].

The echocardiography-derived ratio between tricuspid annular plane systolic excursion (TAPSE) and pulmonary artery systolic pressure (PASP), or TAPSE/PASP, is an indirect estimate of RV-PA coupling that has been shown to correlate with invasive measures [4].

The researchers found an association between baseline TAPSE/PASP ratio and all-cause mortality after TAVR. A higher TAPSE/PASP ratio (implying better RV-PA coupling) was associated with a favorable survival even after a meticulous adjustment for relevant baseline clinical and echocardiographic characteristics and was found to be a better predictor than other individual prognostic factors such as TAPSE, PASP or the STS-PROM risk assessment tool [5].

We aimed to assess the ability of the tricuspid annular plane systolic excursion/pulmonary systolic pressure ratio (TAPSE/PASP) as a measure for right ventricle pulmonary artery coupling to predict the development of right ventricular dysfunction after cardiac surgery.

2. Methods

This prospective study was performed at Al Azhar University Hospital for 6 months that enrolled a total of 100 patients aged ≥20 years old with ischemic heart disease and undergoing cardiac surgery (CABG) with normal preoperative right ventricular function.

It is not a clinical trial, so "Clinical trial number: not applicable".

Exclusion criteria were severe pulmonary hypertension, chronic obstructive pulmonary disease and chronic bronchitis, morbid obesity, recurrent thromboembolism, any known pre-operative right ventricle dysfunction which is defined by presence of echocardiographic evidence of RV dysfunction in form of (TAPSE less than 16 mm, 2D RV FAC less than 35%, DTI annular systolic velocity Less than 10 cm/s, RV wall thickness more than 5 mm), and preoperative moderate or severe tricuspid valve disease.

This study was conducted after the approval of the institutional ethical committee. An informed written consent was obtained from all participants.

3. Methods

All patients were subjected to the following:

a-Full medical history: Age, Gender, Current medications, History of current illness, and Presence of any comorbidities (ex. Hypertension and diabetes mellitus, smoking, substance abuse, & dyslipidemia), **b-Full clinical examination:** Vital signs at time of arrival: blood pressure, heart rate, respiratory rate, temperature, oxygen saturation, and Complete physical examination: general, chest, and cardiac examination, **c-Laboratory investigations:** Complete blood count, Creatinine, Urea, Na, K, and Coagulation profile, and **d-ECG:** 12-lead surface ECG obtained from all subjects in the supine position to assess any abnormality or arrhythmias.

e-Transthoracic echocardiography: The following parameters were assessed in each patient:

All patients had a baseline 2-dimensional (2-D) echocardiogram and tissue Doppler (DTI) before surgery (within 48 hours) and after surgery (within 72 hours). Two-dimensional grey scale harmonic images obtained in the left lateral decubitus position using Vivid 7 machine equipped with a transthoracic 2.5 MHz transducer. Left ventricular (LV) end diastolic, end systolic dimensions, ejection fraction (EF), right atrial (RA) and right ventricular (RV) size all assessed by 2-D echocardiography through parasternal and apical views. Pulsed wave and color doppler were also used to assess LV-diastolic function and valvular incompetence successively. RV systolic function evaluated by tricuspid annular plane systolic excursion (TAPSE), estimated PASP, 2D RV FAC and tissue Doppler imaging (RV S') from the apical four-chamber view. The difference in the displacement of the right ventricular base from end-diastole to end-systole at the junction of the tricuspid valvular plane was used to determine TAPSE. Tissue Doppler imaging S (RV S') measured using a pulsed wave Doppler sampling gate is placed about 1cm apical to the tricuspid annulus. In the apical four-chamber view, the end-diastolic and end-systolic RV areas are traced to calculate fractional area change. A value of TAPSE < 16 mm, RV S' < 10 cm, 2D RV FAC < 35% considered abnormal and defined as RV dysfunction [6].

Follow up echocardiography obtained post-operatively to measure the same modalities to assess RV function.

Primary outcomes:

The value of right ventricular-pulmonary arterial coupling in predicting post-operative RV dysfunction, and the value of ventricular-arterial coupling in predicting short term outcome and morbidity after cardiac surgery.

Secondary outcome parameters:

The prognostic value of right ventricular-pulmonary arterial coupling measuring as the ratio between TAPSE/PASP and the value of other modalities used for assessment of the right ventricle as 2D RV FAC, DTI S'.

Statistical Analysis:

Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) V20 (Armonk, NY: IBM Corp). The qualitative data were presented as number and percentages while quantitative data were presented as mean, standard deviations and ranges when their distribution found parametric. The comparison qualitative data were done by using ***Chi-square test*** and/or ***Fisher exact test*** was used instead of Chi-square test when the expected count in any cell was found less than 5. The comparison between two independent groups with quantitative data and parametric distribution was done by using ***independent t-test.*** The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following: P > 0.05 = non-significant (NS), P < 0.05 = significant (S), P < 0.001 = highly significant (HS).

4. Results

RV dysfunction group had a significantly higher MAP compared to the Normal RV group (P = 0.004). Prevalence of DM was significantly higher in RV dysfunction group compared to the Normal RV group (P < 0.001). Age, Gender, BMI, HR, RR, smoking, HTN and Family history were insignificantly different between the two studied groups.

RV dysfunction group had a highly significant elevation in TLC, TC, and TG compared to the Normal RV group (P < 0.001). Other laboratory data (Hb, PLT, Creatinine, Urea, Na, K, INR, HbA1c, HDL, and LDL) were insignificantly different between the two studied groups.

Table 1. Comparison between normal RV group (no. = 65) and RV dysfunction group (no. = 35) regarding post-operative echocardiographic data.

		Total	Normal RV group	RV dysfunction group	Test value•	P-value	Sig.
		No. = 200	No. = 130	No. = 70			
LVEDD (mm)	Mean ± SD	5.58 ± 0.86	5.60 ± 0.98	5.80 ± 1.09	1.323	0.187	NS
	Range	5 - 6	5 - 5.7	5.3 - 6			
LVESD (mm)	Mean ± SD	5.96 ± 1.05	5.70 ± 0.99	5.93 ± 1.08	1.518	0.130	NS
	Range	5.1 - 6	5.1 - 5.7	5.4 - 6			
EF (%)	Mean ± SD	57.00 ± 8.25	60.00 ± 9.68	58.00 ± 9.12	−1.422	0.156	NS
	Range	50 - 60	50 - 58	53 - 60			
RA size (cm)	Mean ± SD	3.45 ± 0.15	3.10 ± 0.12	3.80 ± 0.19	31.862	<0.001	HS
	Range	3 - 4	3 - 3.6	3.2 - 4			
RV 1 size (cm)	Mean ± SD	3.41 ± 0.21	2.90 ± 0.25	3.90 ± 0.19	29.217	<0.001	HS
	Range	2.8 - 3.8	2.8 - 3.4	3.3 - 3.8			
RV 2 size (cm)	Mean ± SD	3.45 ± 0.19	3.40 ± 0.17	3.70 ± 0.21	10.943	<0.001	HS
	Range	3.3 - 3.9	3.3 - 3.6	3.4 - 3.9			
RV 3 size (cm)	Mean ± SD	6.39 ± 0.65	5.90 ± 0.56	6.90 ± 0.78	10.454	<0.001	HS
	Range	5.5 - 6.5	5.5 - 6.1	5.8 - 6.5			
RV-FAC (%)	Mean ± SD	0.42 ± 0.04	0.49 ± 0.06	0.35 ± 0.02	−18.945	<0.001	HS
	Range	0.25 - 0.53	0.42 - 0.53	0.25 - 0.32			
RV wall thickness (mm)	Mean ± SD	0.56 ± 0.14	0.40 ± 0.12	0.70 ± 0.17	14.509	<0.001	HS
	Range	0.5 - 0.65	0.5 - 0.56	0.59 - 0.65			
IVC diameter (cm)	Mean ± SD	2.16 ± 0.34	1.70 ± 0.12	2.60 ± 0.42	22.807	<0.001	HS
	Range	1.5 - 2.8	1.5 - 2.1	2.2 - 2.8			
DTI S’ (mm/s)	Mean ± SD	10.60 ± 1.15	14.00 ± 1.21	7.00 ± 0.96	−41.816	<0.001	HS
	Range	5 - 15	10 - 15	5 - 9			
TAPSE (mm)	Mean ± SD	15.00 ± 1.24	19.00 ± 1.32	11.00 ± 1.02	−44.093	<0.001	HS
	Range	10 - 20	15 - 20	10 - 16			
PASP (mmHg)	Mean ± SD	40.00 ± 2.98	35.00 ± 2.36	52.00 ± 3.54	40.553	<0.001	HS
	Range	30 - 55	30 - 42	43 - 55			
TAPSE/PASP Ratio	Mean ± SD	0.35 ± 0.03	0.48 ± 0.02	0.21 ± 0.01	−105.959	<0.001	HS
	Range	0.2 - 0.58	0.42 - 0.58	0.2 - 0.28			

Data is presented as mean ± SD and Range, P-value > 0.05: Non significant (NS); P-value < 0.05: Significant (S); P-value < 0.01: highly significant (HS), *: Chi-square test, •: Independent t-test, LVEDD: Left ventricular end-diastolic diameter, LVESD: Left ventricular end-systolic diameter, EF: Ejection fraction, RA: Right atrium, RV: Right ventricle, IVC: Inferior vena cava, DTI S’:, TAPSE: Tricuspid annular plane systolic excursion, PASP: Pulmonary arterial systolic pressure.

Regarding preoperative echocardiographic data, RV dysfunction group had a highly significantly reduced RV-FAC, DTI S’, TAPSE, and TAPSE/PASP ratio (P < 0.05), and a highly significant increase in IVC diameter and PASP (P < 0.001) compared to the Normal RV group. Other data (LVEDD, LVESD, EF, RA size, RV 1 size, RV 2 size, RV 3 size, and RV wall thickness) were insignificantly different between the two studied groups.

Regarding operative Data, RV dysfunction group had a significantly higher number of diseased vessels compared to the Normal RV group (P < 0.001). Prevalence of RCA revascularization was significantly higher in RV dysfunction group compared to the Normal RV group (P < 0.001). CCT and BPT were insignificantly different between the two studied groups.

Regarding Postoperative echocardiographic data, RV dysfunction group revealed a highly significant increased RA size, RV 1 size, RV 2 size, RV 3 size, RV wall thickness, IVC diameter, and PASP compared to the Normal RV group (P < 0.001). RV dysfunction group revealed a highly significant reduction in RV-FAC, DTI S', TAPSE, and TAPSE/PASP Ratio compared to the Normal RV group (P < 0.001). LVEDD, LVESD, and EF were insignificantly different between the two studied groups (Table 1).

Table 2. Comparison between normal RV group (no. = 65) and RV dysfunction group (no. = 35) regarding post-operative outcome.

	Total		Normal RV group		RV dysfunction group		Test value*	P-value	Sig.
	No.	%	No.	%	No.	%			
Re-hospitalization rate	22	11.0%	0	0.0%	22	31.4%	45.907	<0.001	HS
Need for IABP	70	35.0%	0	0.0%	70	100.0%	200.000	<0.001	HS
Need for Inotropes	160	80.0%	90	69.2%	70	100.0%	26.923	<0.001	HS
Mortality rate	20	10.0%	0	0.0%	20	28.6%	41.270	<0.001	HS

Data is presented as frequency (Percentage), P-value > 0.05: Non significant (NS); P-value < 0.05: Significant (S); P-value < 0.01: highly significant (HS), *: Chi-square test, •: Independent t-test, IABP: Intra-aortic balloon pump, RV: Right ventricle.

Table 3. Logistic regression model for the factors affecting RV dysfunction occurrence and re-hospitalization occurrence using forward method.

	Predictor Factor	Coefficient	OR	P value
RV dysfunction	(Constant)	−18.2678		
	MAP	0.085299	2.0718	<0.001*
	DM	3.50932	17.5885	<0.001*
	TC	0.069366	3.0506	<0.001*
	TAPSE/PASP ratio	25.08759	2.090	0.014*
Re-hospitalization	(Constant)	−9.62871		
	MAP	0.18845	2.3640	0.031*
	TGs	0.034396	2.0370	0.030*
	TAPSE/PASP Ratio	−22.70604	2.821	0.0019**

*Significant as P < 0.05, Other factors excluded from the model as (P value > 0.1). OR: Odds ratio. RV: Right ventricle, TG: Triglycerides, TC: Total cholesterol, DM: Diabetes mellitus, MAP: Mean arterial pressure, TAPSE: Tricuspid annular plane systolic excursion, PASP: Pulmonary arterial systolic pressure.

Regarding post-operative outcome, prevalence of re-hospitalization rate, need for IABP, need for Inotropes and mortality rate was significantly higher in RV dysfunction group compared to Normal RV group (P < 0.001) (Table 2).

MAP, DM, TC, and TAPSE/PASP ratio were significant predictors of RV dysfunction occurrence (P < 0.05). MAP, TG, and TAPSE/PASP ratio were significant predictors of Re-hospitalization (P < 0.05) (Table 3).

Table 4. Logistic regression model for the factors affecting need for inotropes using forward method.

Predictor Factor	Coefficient	OR	P value
(Constant)	14.62142		
TAPSE	−0.96241	0.2451	<0.001*
PASP	0.17326	1.3269	0.033*

*Significant as P < 0.05, Other factors excluded from the model as (p value > 0.1). OR: Odds ratio. TAPSE: Tricuspid annular plane systolic excursion, PASP: Pulmonary arterial systolic pressure.

TAPSE and PASP were significant predictors for the need for inotropes (P < 0.05) (Table 4).

Table 5. ROC curve of pre- and post-operative TAPSE/PASP ratio (RV dysfunction).

Variable	AUC	Cut off Point	Sensitivity	Specificity	P value
Pre-operative TAPSE/PASP Ratio	94.0%	>0.58	88.6%	89.2%	<0.001*
Post-operative TAPSE/PASP Ratio	84.0%	>0.39	100.0%	76.9%	<0.001*

*Significant as P < 0.05, ROC (Receiver operating characteristic), AUC = Area under curve, SE = Standard Error. TAPSE: Tricuspid annular plane systolic excursion, PASP: Pulmonary arterial systolic pressure, RV: Right ventricle.

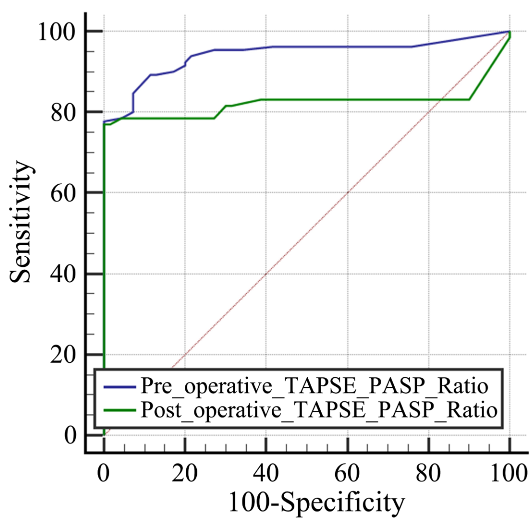

Figure 1. ROC curve of pre and post-operative TAPSE/PASP ratio (RV dysfunction).

By using ROC-curve analysis, pre-operative TAPSE/PASP Ratio could significantly predict the RV dysfunction (P < 0.001), at cutoff point of >0.58, with AUC of 94%, 88.6% sensitivity, and 89.2% specificity. Post-operative TAPSE/PASP Ratio could significantly predict the RV dysfunction (P < 0.001), at cutoff point of >0.39, with AUC of 84%, 100% sensitivity, and 76.9% specificity (Table 5, Figure 1).

Table 6. Roc-curve of echocardiographic parameters to predict Mortality.

Variable	AUC	Cut off Point	Sensitivity	Specificity	P value
Pre-operative TAPSE/PASP Ratio	84.0%	≤0.52	56.1%	100.0%	<0.001*
Post-operative TAPSE/PASP Ratio	71.0%	≤0.36	100.0%	76.9%	<0.001*

*Significant as P < 0.05, ROC (Receiver operating characteristic), AUC = Area under curve, SE = Standard Error. TAPSE: Tricuspid annular plane systolic excursion, PASP: Pulmonary arterial systolic pressure.

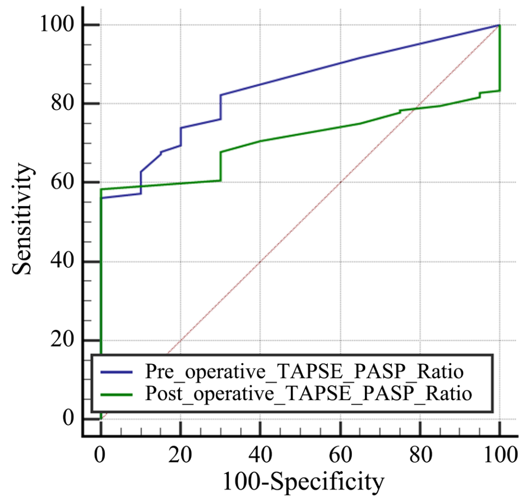

Figure 2. ROC curve of pre and post-operative TAPSE/PASP ratio (mortality).

By using ROC-curve analysis, Pre-operative TAPSE/PASP Ratio could significantly predict mortality (P < 0.001), at cutoff point of ≤0.52, with AUC of 84%, 56.1% sensitivity, and 100% specificity. Post-operative TAPSE/PASP Ratio could significantly predict mortality (P < 0.001), at cutoff point of ≤0.36, with AUC of 71%, 100% sensitivity, and 76.9% specificity (Table 6, Figure 2).

5. Discussion

RV dysfunction pathology includes high RV preload or afterload, impaired right coronary artery perfusion, and decreased contractility. In contrast to the left coronary artery, perfusion of the right coronary artery occurs during the whole heart cycle. Moreover, high RV pressure due to pathological causes such as pulmonary hypertension leads to lower coronary artery perfusion, highlighting the importance of preserving the normal pressure inside the two ventricles [2].

The echocardiography-derived ratio between TAPSE and PASP, or TAPSE/PASP, is an indirect estimate of RV-PA coupling that has been shown to correlate with invasive measures [4].

Similarly, Khaled *et al.* [7] reported that, for the total (164) operated patients at cardiac center-King Abdullah Medical City (KAMC), mean age of (56.1 ± 12.2 years old) and BMI (27.8 ± 5.9) kg/m^2. From the whole cohort, 114 (69.5%) were men, 104 (63%) diabetic, 115 (70%) hypertensive, 70 (43%) obese, only 28 (17%) had chronic kidney disease (CKD), and 97 (59%) had an old history of IHD.

Also, Khaled *et al.* [7] concluded that, the mean cardiopulmonary by-pass time and cross-clamp time for all our patients were (139.41 ± 71.03 and 91.09 ± 37.5 minutes respectively) and regarding to postoperative complications, 27% of the patients were in need for intra-aortic balloon pump (IABP), 72% had inotropic support in early postoperative period and 18% developed atrial fibrillation (AF).

The 100 CABG patients were classified according to RV function outcomes into 2 independent groups: **Normal RV group (65 patients)** and **RV dysfunction group (35 patients).**

Comparative study between the 2 groups revealed RV dysfunction group had a highly significant elevation in TLC, TC, and TG compared to the Normal RV group (P < 0.001). Other laboratory data (Hb, PLT, Creatinine, Urea, Na, K, INR, HbA1c, HDL, and LDL) were insignificantly different between the two studied groups.

Similarly, Khaled *et al.* [7] reported that, they classified their patients into two groups: Group I: 106 patients (64.6%) with RV Dysfunction post operatively and Group II: 58 patients (35.4%) without RV Dysfunction post operatively. Patients of group I showed a higher prevalence of DM and obesity compared to patients of group II (70% and 48%VS 52% and 33%; P = 0.02 and 0.05 respectively). There were also higher prevalence rates of hypertension, chronic kidney disease, smoking, dyslipidemia and history of old IHD among patients of group I compared to group II patients with no significant difference.

Similar to our study, Chinikar *et al.* [8] study reported a significant reduction in the right ventricle function indices (TAPSE, Tei index, Peak systolic movement, IVC size) before CABG and after 1 week (P = 0.001, 0.002, 0.001, and 0.001 respectively).

Bluro *et al.* [6] reported that, a higher PSP (59 mmHg vs. 42 mmHg, P < 0.001) was associated with a higher incidence of post-transplantation RV failure, whereas a lower TAPSE (13.2 mm vs. 15.6 mm, P = 0.057) showed a non-significant trend.

Regarding operative Data, Bluro *et al.* [6] reported that, regarding the hemodynamic variables assessed invasively, the increase in PVR expressed in WU (3.0 vs. 4.7; P = 0.008), PSP (44 mmHg vs. 60 mmHg; P = 0.006) and mPAP (31 mmHg vs. 41 mmHg; OR 1.08 (1.02 - 1.15); P = 0.009) were associated with the development of postoperative RV failure which supports our study.

In agreement with our research, Bluro *et al.* [6] concluded that, of all the variables that were significantly associated with RV failure, the one with the best diagnostic performance was the TAPSE/PSP ratio by Doppler echocardiography. The performance of TAPSE/PSP to predict RV failure was even better than that of a model that integrates the invasive assessment of PVR, mPAP and CO.

Bragança *et al.* [9] also concluded that, TAPSE/PASP ratio is an easily obtained measure that provides a more comprehensive evaluation of the RV length/force relationship and has both pathophysiological and prognostic significance.

Also, Popolo Rubbio *et al.* [10] also reported that, patients with TAPSE/PASP ≤ 0.36 presented higher incidence of 1-year all-cause mortality (32.2% vs. 8.1%; P ≤ 0.001), heart failure hospitalization (24.7% vs. 10.5%; P = 0.007) and of the combined primary endpoint (39.4% vs. 14.8%; P ≤ 0.001), if compared to patients with TAPSE/PASP > 0.36.

By using ROC-curve analysis, Post-operative TAPSE/PASP Ratio could significantly predict the RV dysfunction (P < 0.001), at cutoff point of >0.39, with AUC of 84%, 100% sensitivity, and 76.9% specificity.

Similarly, Bluro *et al.* [6] concluded that, the combination of both variables in a TAPSE/PSP ratio was associated with the occurrence of RV failure (0.24 vs. 0.40 mm/mmHg, P < 0.001), 0.26 mm/mmHg being the cutoff value that best predicted its incidence. A TAPSE/PSP value of 0.26 mm/mmHg showed an area under the ROC curve of 0.84 with very good calibration [6].

Tello *et al.* [11] also concluded that, the TAPSE/PASP cutoff value for prediction of RV-arterial uncoupling was 0.31. On the other hand, Bragança *et al.* [9] reported that, the optimal cut-off points were 17.5 mm for TAPSE, 39 mmHg for PASP and 0.44 mm/mmHg for TAPSE/PASP. Among them, TAPSE/PASP ratio demonstrated the best discriminative ability (AUC of 0.76). The full diagnostic performance of the TAPSE/PASP ratio was the following: sensibility 76%, specificity 71%, positive predictive value 75%, negative predictive value 72%, positive likelihood ratio 2.6 and negative likelihood ratio 0.33.

Sultan *et al.* [12] concluded that, TAPSE/PASP ratio was strongly associated with all-cause mortality even after multivariate adjustment of other prognostically important covariates.

Popolo Rubbio *et al.* [10] also concluded that, TAPSE/PASP ratio ≤ 0.36, as an expression of the RV-PA uncoupling, is strongly associated with an increased risk of composite all-cause mortality and heart failure re-hospitalization.

Limitations: Short follow-up duration and small sample size, we also studied CABG patients only, so further studies with larger sample size and on different operations would strengthen our findings.

6. Conclusion

The tricuspid annular plane systolic excursion/pulmonary systolic pressure ratio (TAPSE/PASP) has proven to be an excellent tool for CABG patients as it revealed the ability to detect and predict the development of right ventricular dysfunction after cardiac surgery, along with prediction of mortality in post-operative CABG patients.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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