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ORIGINAL RESEARCH

STRUCTURAL

Right Ventricular–Pulmonary Artery Coupling in Tricuspid Regurgitation

Prognostic Value and Impact of Treatment Strategy

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ABSTRACT

BACKGROUND Right ventricular–pulmonary artery coupling (RVPAC) predicts outcomes after transcatheter tricuspid valve edge-to-edge repair (T-TEER), but its role in patient selection remains unclear.

OBJECTIVES The aim of this study was to evaluate the prognostic implications of RVPAC in a European registry of patients with tricuspid regurgitation undergoing either T-TEER or medical management.

METHODS Among 1,885 patients with tricuspid regurgitation (n = 585 medical, n = 1,300 T-TEER), 946 were propensity matched (1:1). RVPAC, assessed as the ratio of tricuspid annular plane systolic excursion to systolic pulmonary artery pressure was analyzed for its association with 1-year mortality.

RESULTS RVPAC was significantly associated with mortality (HR: 0.11; 95% CI: 0.04-0.29; $P < 0.01$), with an optimized cutoff of 0.41 mm/mm Hg. Mortality differed significantly by RVPAC in both treatment groups (log-rank $P < 0.01$). Across RVPAC tertiles (<0.32, 0.32-0.46, and >0.46 mm/mm Hg), tricuspid annular plane systolic excursion increased (14 mm [Q1-Q3: 12-17 mm] vs 18 mm [Q1-Q3: 15-20 mm] vs 21 mm [Q1-Q3: 18-24 mm]; $P < 0.01$), while systolic pulmonary artery pressure (60 mm Hg [Q1-Q3: 50-70 mm Hg] vs 45 mm Hg [Q1-Q3: 40-52 mm Hg] vs 34 mm Hg [Q1-Q3: 29-41 mm Hg]; $P = 0.30$) and kidney function (43 mL/min/m^2 [Q1-Q3: 30-57 mL/min/m^2] vs 49 mL/min/m^2 [Q1-Q3: 38-67 mL/min/m^2] vs 53 mL/min/m^2 [Q1-Q3: 40-69 mL/min/m^2]; $P = 0.03$) declined. Mortality was highest in the low RVPAC tertile, with no difference between treatment modalities (HR: 1.04; 95% CI: 0.68-1.61; $P = 0.85$). T-TEER was associated with better survival than medical management in the intermediate RVPAC tertile (HR: 0.54; 95% CI: 0.31-0.94; $P = 0.03$). This difference persisted but weakened in the high RVPAC tertile, with the overall most favorable outcomes (HR: 0.69; 95% CI: 0.35-1.36; $P = 0.27$).

CONCLUSIONS Poorer RVPAC reflects higher baseline risk and mortality, regardless of treatment. T-TEER is associated with better survival across a range of RVPAC values, including those less than previously suggested thresholds. (JACC Cardiovasc Interv. 2025;18:1411–1421) © 2025 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

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ABBREVIATIONS AND ACRONYMS

EROA = effective regurgitant orifice area

LVEF = left ventricular ejection fraction

NT-proBNP = N-terminal pro-B-type natriuretic peptide

PA = pulmonary artery

ROC = receiver-operating characteristic

RV = right ventricle/ventricular

RVPAC = right ventricular-to-pulmonary artery coupling

sPAP = systolic pulmonary artery pressure

T-TEER = transcatheter tricuspid valve edge-to-edge repair

TAPSE = tricuspid annular plane systolic excursion

TR = tricuspid regurgitation

Severe tricuspid regurgitation (TR) is now widely recognized as an independent risk factor for a poor prognosis and an adverse clinical course, proportionate to its severity.[1,2] The negative impact of TR on survival is exacerbated by coexistent right ventricular (RV) function alterations and increased pulmonary artery (PA) pressure.[3,4]

The recent advent of transcatheter tricuspid valve edge-to-edge repair (T-TEER) has provided safe and effective means to reduce TR.[5] Notably, patients considered for this intervention are those at prohibitive surgical risk, in whom increased PA pressure and RV dysfunction frequently coexist, leaving them at high residual risk even after successful TR reduction.[3,6] Efforts have thus focused on identifying predictors of procedural success and a favorable prognosis to enhance patient selection.[7,8]

Assessment of RV-to-PA coupling (RVPAC) evaluates RV function in the context of its adaptation to afterload. This can clinically be estimated from the echocardiographically derived tricuspid annular plane systolic excursion (TAPSE) over systolic PA pressure (sPAP) ratio and has been associated with mortality in various types of heart failure.[9]

Similarly, RV-PA uncoupling serves as a potent predictor of mortality in patients after T-TEER and has been suggested for use in patient selection.[3,10,11] However, the utility of TAPSE/sPAP ratio for patient selection is limited, as prior studies have proposed different binary cutoffs, compared patients with different baseline risks, and lacked medically treated control groups, precluding conclusions regarding the potential therapeutic benefit of the intervention.

We therefore aimed to evaluate the prognostic impact of RVPAC in a large cohort of patients with TR undergoing medical or interventional management and scrutinize the prognostic impact of T-TEER across the range of RVPAC after matching medically and interventionally treated patients.

METHODS

PATIENT COHORT. Patients in the interventional group were enrolled from the Euro-TR (European Registry of Transcatheter Repair for Tricuspid Regurgitation) registry, which focused on individuals who underwent T-TEER for symptomatic TR between 2016 and 2022 at 12 European study sites. Inclusion criteria comprised a diagnosis of severe TR and an interventional therapeutic approach based on a local heart team decision. Clinical and echocardiographic baseline and follow-up data were retrospectively collected.

The conservative group consisted of patients with severe TR assessed at Charité Medical University, specifically at Campus Charité Mitte and Benjamin

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Franklin, from 2010 to 2017. All patients in this cohort received treatment following established medical guidelines. Data were gathered retrospectively. Follow-up information was obtained by contacting the relevant local registration offices. The analysis was approved by the local ethics committees of each center, and all patients gave written informed consent. The study cohort and the investigation conform to the principles outlined in the Declaration of Helsinki.

ECHOCARDIOGRAPHIC ASSESSMENT. Preprocedural assessment included site-reported echocardiography in accordance with current guideline recommendations, as previously outlined.[12] In brief, grading of TR severity was based on the assessment of vena contracta, effective regurgitant orifice area (EROA), and estimated regurgitant volume according to proximal isovelocity surface area. TR severity grades of mild, moderate, and severe were extended to include grades IV and V TR (massive and torrential, respectively).[13] RV systolic function was estimated on the basis of TAPSE measurements. Echocardiographic sPAP levels were approximated from the TR regurgitant jet and estimated right atrial pressures.[14] RVPAC was assessed as TAPSE/sPAP ratio, as previously suggested.[3,10,15]

PROCEDURAL OUTCOMES. T-TEER was conducted using either the PASCAL device (Edwards Lifesciences) or the TriClip system (Abbott Vascular). Procedural success was defined as the successful implantation of the device and retrieval of the delivery system with residual TR grade ≤2/5, as assessed by transthoracic echocardiography before discharge (ie, 2-5 days postprocedure).[16,17]

CLINICAL OUTCOMES. The primary clinical outcome was 1-year all-cause mortality. Survival data were obtained by reviewing the German civil registry or hospital documentation or by contacting the general practitioner.

STATISTICAL ANALYSES. Patients in the T-TEER cohort were matched with conservatively managed patients using propensity scores, which were estimated using logistic regression. The following variables were used for the calculation of propensity scores: age, the presence of an RV lead, a history of atrial fibrillation or flutter, the presence of coronary artery disease, left ventricular ejection fraction (LVEF), TR EROA, echocardiographically determined sPAP, and N-terminal pro-B-type natriuretic peptide (NT-proBNP). On the basis of the propensity scores, T-TEER-treated patients were matched 1:1 with conservatively managed patients using the nearest neighbor method without replacement and a caliper width of ±0.2 SDs. Balance between the T-TEER and control groups was assessed using standardized mean differences (Cohen's *d*), with differences <0.15 considered negligible. Love plots were used to visualize balance before and after matching.

Continuous variables are presented as median (Q1-Q3), and between-group differences were tested using Mann-Whitney *U* tests or Kruskal-Wallis tests as appropriate. Paired data were analyzed using Wilcoxon rank tests. Categorical variables are presented as frequencies and percentages and were compared using chi-square or McNemar tests as appropriate. Receiver-operating characteristic (ROC) curve statistics were calculated to identify optimal cutoff values for mortality prediction according to the Youden index.

Univariable Cox regression analyses were performed to investigate the prognostic value of RVPAC. Results are presented as HRs and 95% CIs. Restricted cubic spline regression was used to assess nonlinear associations between RVPAC and 1-year mortality, with knot locations selected at the 10th, 50th, and 90th percentiles. Kaplan-Meier survival estimates with 95% CIs were used to compare the time of the first occurrence of the clinical endpoints between groups. The proportional hazards assumption was tested using time-dependent covariates, with no significant violations detected. Outcomes were compared between high and low RVPAC, stratified by treatment groups, and between treatment groups, stratified by RVPAC tertiles.

A 2-sided significance level of $\alpha = 0.05$ was defined as appropriate to indicate statistical significance. Statistical analyses were performed using SPSS version 29.0.0.0 (SPSS).

RESULTS

OVERALL PATIENT COHORT. The present analysis comprised 1,885 patients, with a median age of 79 years and a female predominance (n = 1,005 [53%]), displaying preserved biventricular function on average alongside severe TR (EROA 0.6 cm^2). Among them, 585 received conservative treatment, while 1,300 underwent T-TEER. Baseline characteristics of the entire cohort are displayed in Supplemental Table 1, with separate data for included and excluded patients in Supplemental Table 2. Patients in the T-TEER group tended to be older, with a higher prevalence of RV leads, atrial fibrillation, and coronary artery disease. Furthermore, they manifested greater RV dilatation and poorer renal function. However, they exhibited lower NYHA functional

TABLE 1 Patient Characteristics According to TAPSE/sPAP Ratio

	Overall (N = 946)	Low TAPSE/sPAP Ratio (n = 317)	Intermediate TAPSE/sPAP Ratio (n = 315)	High TAPSE/sPAP Ratio (n = 314)	*P* Value
Age, y	78 (73-82)	78 (73-82)	79 (73-83)	78 (72-82)	0.15
Male	432 (46)	165 (52)	148 (47)	119 (38)	0.08
BMI, kg/m^2	25 (23-28)	26 (23-29)	25 (23-28)	25 (23-28)	0.74
RV lead	165 (17)	55 (17)	53 (17)	57 (18)	0.18
AF/atrial flutter	787 (83)	258 (81)	270 (86)	259 (83)	**0.01**
Coronary artery disease	212 (22)	85 (27)	66 (21)	61 (19)	0.07
NYHA functional class					<0.01
I/II	108 (11)	24 (8)	39 (13)	45 (14)	
III	600 (64)	192 (60)	199 (63)	209 (67)	
IV	237 (25)	101 (32)	76 (24)	60 (19)	
EuroSCORE II, %	3.9 (2.3-7.2)	5.2 (2.9-10.0)	3.7 (2.1-6.2)	3.4 (2.1-5.8)	**<0.01**
LVEF, %	55 (45-60)	53 (39-60)	55 (45-60)	58 (50-63)	0.70
LVEDD, mm	48 (43-55)	51 (44-56)	49 (44-55)	46 (41-51)	0.11
LA volume, mL	98 (71-130)	100 (75-132)	100 (73-130)	95 (62-126)	**0.04**
TR EROA, cm^2	0.62 (0.47-0.83)	0.55 (0.43-0.67)	0.64 (0.49-0.85)	0.70 (0.53-1.04)	0.88
TR vena contracta, mm	9 (8-12)	9 (8-11)	10 (8-12)	9 (8-13)	**<0.01**
TR grade ≥4	522 (55)	132 (42)	174 (55)	216 (69)	0.62
RV base diameter, mm	43 (36-50)	42 (36-48)	44 (36-51)	44 (36-51)	**<0.01**
TAPSE, mm	17 (14-21)	14 (12-17)	18 (15-20)	21 (18-24)	0.09
sPAP, mm Hg	45 (35-56)	60 (50-70)	45 (40-52)	34 (29-41)	0.30
TAPSE/sPAP ratio	0.39 (0.29-0.52)	0.25 (0.20-0.29)	0.39 (0.35-0.43)	0.58 (0.51-0.71)	0.52
eGFR, mL/min/m^2	48 (35-66)	43 (30-57)	49 (38-67)	53 (40-69)	0.34
AST, U/L	29 (23-37)	28 (23-38)	29 (24-37)	29 (23-37)	**0.03**
NT-proBNP, pg/mL	2,386 (1,150-5,782)	4,141 (1,765-9,589)	2,351 (1,055-4,898)	1,715 (875-3,921)	**0.03**

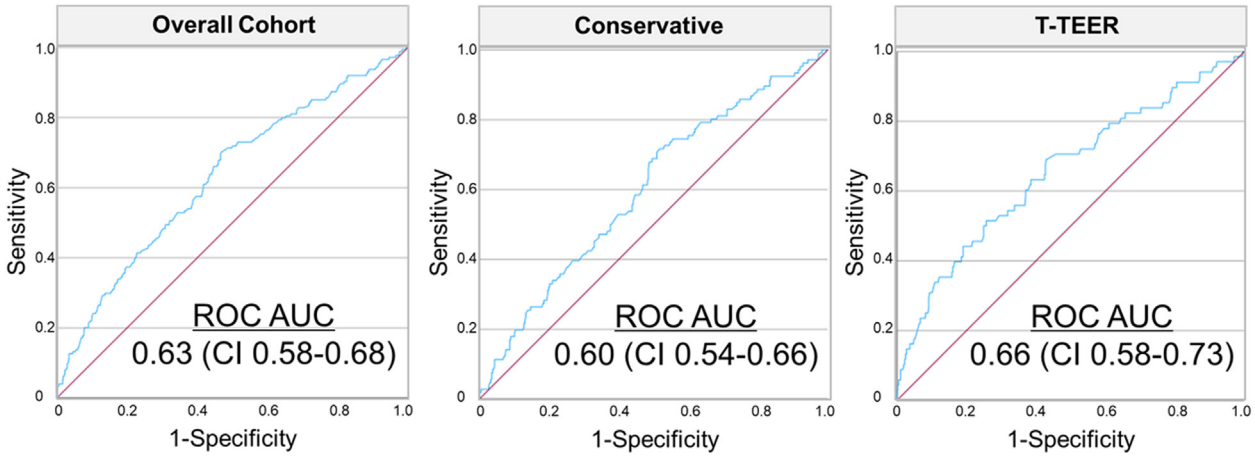
Values are median (Q1-Q3) or n (%). *P* values in **bold** denote statistical significance.

AF = atrial fibrillation; AST = aspartate transaminase; BMI = body mass index; eGFR = estimated glomerular filtration rate; EROA = effective regurgitant office area; EuroSCORE = European System for Cardiac Operative Risk Evaluation; LA = left atrial; LVEDD = left ventricular end-diastolic diameter; LVEF = left ventricular ejection fraction; NT-proBNP = N-terminal pro-B-type natriuretic peptide; RV = right ventricular; sPAP = systolic pulmonary artery pressure; TAPSE = tricuspid annular plane systolic excursion; TR = tricuspid regurgitation; T-TEER = transcatheter tricuspid valve edge-to-edge repair.

classes, higher LVEF, lower sPAP levels, lower aspartate aminotransferase levels, and lower NT-proBNP levels.

PROGNOSTIC IMPLICATIONS OF RVPAC IN THE MATCHED COHORT. Propensity score matching identified 946 patients undergoing either conservative or interventional treatment in a 1:1 fashion, with a median age of 78 years and 54% (n = 514) women (Table 1). Matching resulted in acceptable standardized mean differences, except for LVEF, which showed an absolute mean between-group difference of 3%. This difference was deemed acceptable given its questionable clinical relevance (Supplemental Figure 1). The median RVPAC overall was 0.39 mm/mm Hg (Q1-Q3: 0.29-0.52 mm/mm Hg). In the overall cohort, RVPAC was significantly associated with mortality (HR: 0.11; 95% CI: 0.04-0.29; $P < 0.01$) and exhibited moderate prognostic performance on ROC analysis with an area under the curve of 0.63 (95% CI: 0.58-0.68; $P < 0.01$), with slightly better performance in patients undergoing T-TEER compared with the conservative cohort (area under the curve, 0.66 [95% CI: 0.58-0.73; $P < 0.01$] vs 0.60 [95% CI: 0.54-0.66; $P < 0.01$]) (Figure 1). The Youden index-optimized cutoff for 1-year mortality prediction by RVPAC was 0.41 mm/mm Hg (sensitivity, 74.7%; specificity, 43.1%). The specificity-optimized cutoff was 0.29 mm/mm Hg (sensitivity, 44.6%; specificity, 72.6%). These findings align closely with the log-rank maximization values (0.40 and 0.30), as shown in Supplemental Table 3. On cubic spline analysis, a steady hazard increase was observed for TAPSE/sPAP ratio between 0.80 and 0.30 mm/mm Hg, with an exponential increase <0.30 mm/mm Hg in the overall cohort (Figure 2). In patients in the conservative arm, the hazard increased linearly across the spectrum of TAPSE/sPAP values. In the T-TEER cohort, a slow increase in hazard was noted starting from 0.70 mm/mm Hg, with a much steeper, linear

FIGURE 1 Predictive Value of Right Ventricular–Pulmonary Artery Coupling for Mortality by Treatment Strategy



Receiver-operating characteristic (ROC) curves for mortality prediction by right ventricular–to–pulmonary artery coupling show moderate predictive value in the overall cohort (left) as determined by the area under the curve (AUC), which was similar in patients treated with medical therapy (conservative) (middle) and those treated with transcatheter tricuspid valve edge-to-edge repair (T-TEER) (right).

increase in hazard <0.40 mm/mm Hg (Figure 2). Patients with RVPAC ≥0.41 mm/mm Hg demonstrated better 1-year survival in both medically treated (85% [95% CI: 80%-90%] vs 71% [95% CI: 65%-76%]; log-rank $P < 0.01$) and T-TEER (88% [95% CI: 84%-94%] vs 75% [95% CI: 69%-81%]; log-rank $P < 0.01$) cohorts (Figure 3).

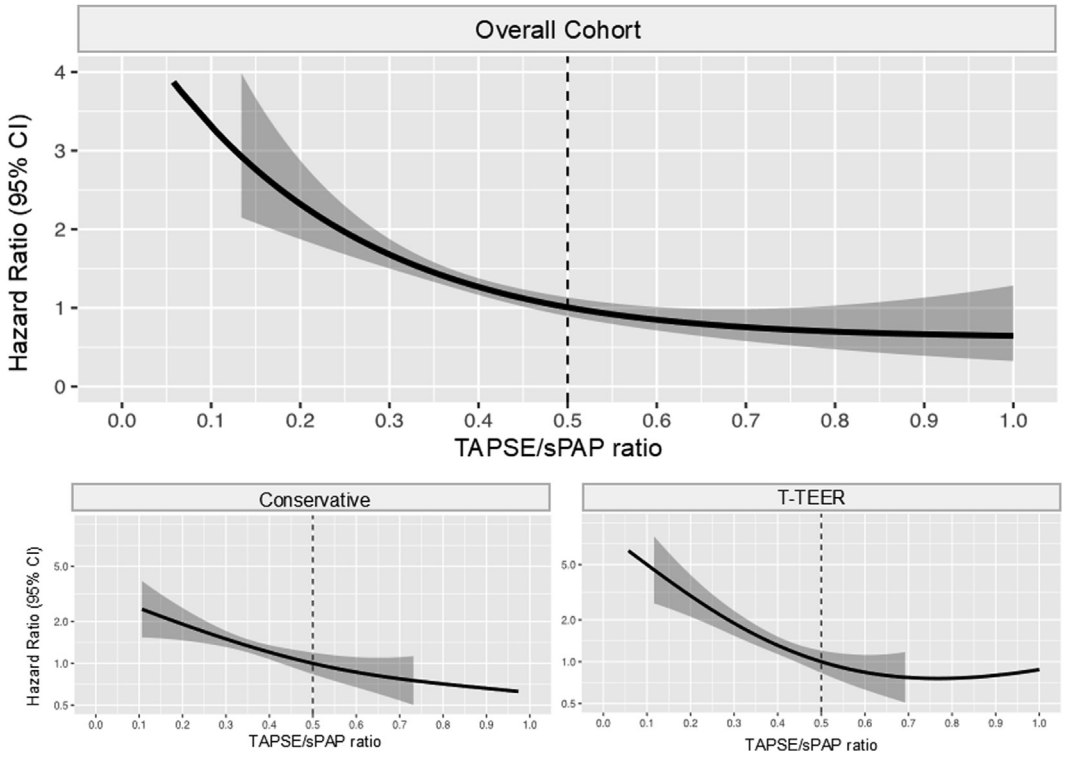
RVPAC TERTILES AND PROGNOSTIC IMPLICATIONS OF T-TEER. When stratifying patients into a low RVPAC tertile (TAPSE/sPAP ratio <0.32 mm/mm Hg), an intermediate RVPAC tertile group (TAPSE/sPAP ratio 0.32-0.46 mm/mm Hg), and a high RVPAC tertile group (TAPSE/sPAP ratio >0.46 mm/mm Hg), the median RVPAC ratios were 0.25, 0.39, and 0.58 mm/mm Hg, respectively. Patients with lower RVPAC demonstrated higher baseline risk, as indicated by higher European System for Cardiac Operative Risk Evaluation scores, lower LVEFs, more dilated left ventricles, worse RV function, higher PA pressures, worse renal function, and higher NT-proBNP levels. Conversely, TR grades and EROA were lower in patients with worse RVPAC (Table 1). Patient characteristics according to RVPAC tertile and treatment modality are summarized in Table 2. Age, sex, and comorbidity burden were balanced between patients treated conservatively or with T-TEER within each RVPAC tertile. However, conservatively treated patients remained more symptomatic and exhibited higher NT-proBNP levels across RVPAC tertiles, along with lower LVEF in the low and intermediate RVPAC groups, while T-TEER patients demonstrated larger RV volumes across the tertiles. Procedural success was achieved in 375 T-TEER patients (81%) and was not different between tertiles ($P = 0.20$). One-year survival estimates were lowest in the low RVPAC tertile (70%; 95% CI: 65%-76%), with no significant difference in survival time between medically treated patients and the T-TEER cohort (HR: 1.04; 95% CI: 0.68-1.61; $P = 0.85$). Patients in the intermediate RVPAC tertile showed a 1-year survival estimate of 81% (95% CI: 76%-85%), with T-TEER being associated with significantly better survival time compared with conservative management (HR: 0.54; 95% CI: 0.31-0.94; $P = 0.03$). The high RVPAC tertile group exhibited the best estimated 1-year survival (87%; 95% CI: 82%-91%). Although a numerical prognostic benefit of M-TEER over conservative management was suggested in this group, it did not reach statistical significance (HR: 0.69; 95% CI: 0.35-1.36; $P = 0.27$) (Central Illustration).

DISCUSSION

This large multicenter study represents the first comprehensive investigation into the prognostic role of RVPAC in patients with severe TR undergoing T-TEER compared with a matched cohort receiving medical therapy.

The main findings are as follows: 1) The TAPSE/sPAP ratio was associated with 1-year mortality in both overall and individual treatment groups;

FIGURE 2 Mortality Hazard Across the Spectrum of TAPSE/sPAP Ratio



Cubic spline analyses of the association between the ratio of tricuspid annular plane systolic excursion (TAPSE) to systolic pulmonary artery pressure (sPAP) and hazard of mortality. The top panel represents the overall cohort, showing a steady hazard increase between 0.80 and 0.30 mm/mm Hg, with an exponential rise below 0.30 mm/mm Hg. The bottom left panel illustrates the medical therapy cohort (conservative), in which hazard increased linearly across the TAPSE/sPAP spectrum. The bottom right panel depicts the transcatheter tricuspid edge-to-edge repair (T-TEER) cohort, demonstrating a gradual hazard increase from 0.70 mm/mm Hg, with a steeper linear rise below 0.40 mm/mm Hg. HRs are referenced to a value of 0.50.

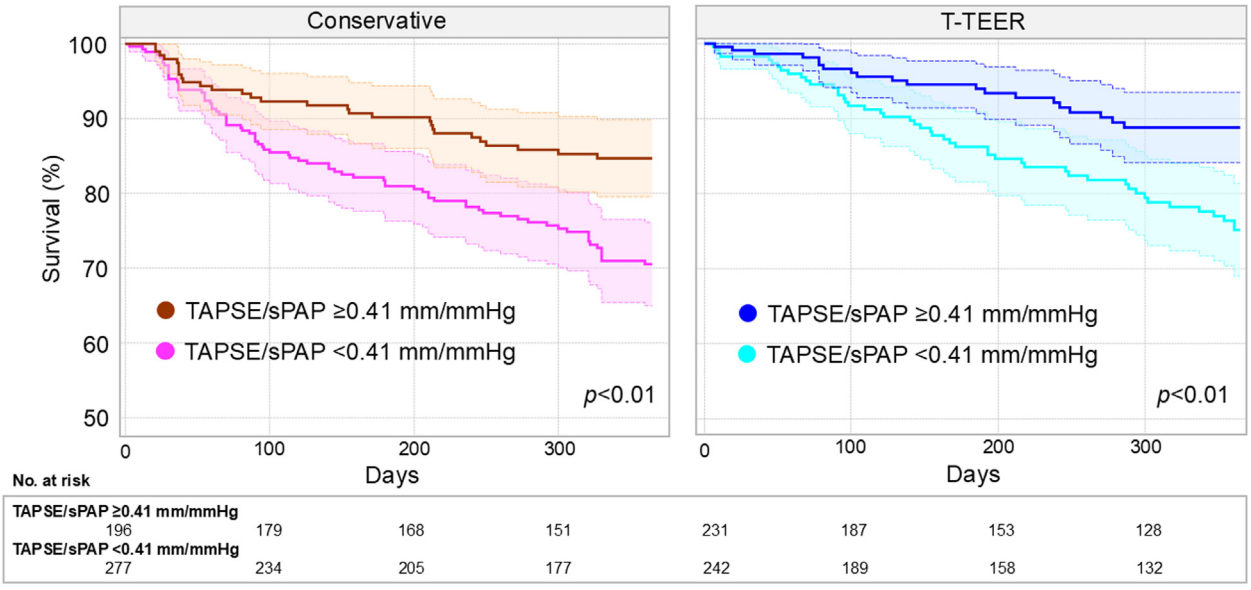
2) baseline risk and mortality rates increased with lower RVPAC tertiles; 3) the prognostically optimized RVPAC cutoff, at 0.41 mm/mm Hg, mirrored previous findings but lacked specificity; and 4) in matched analysis, T-TEER exhibited a survival benefit over medical therapy in the intermediate TAPSE/sPAP range, extending to RVPAC values less than previously postulated cutoffs.

RV function is a major determinant of symptoms and prognosis in many cardiovascular conditions, thought to be highly sensitive to afterload.[18] Indexing RV systolic function to PA pressures helps capture the intricate relationship between the RV and its afterload and assessing the efficiency of energy transfer from the RV to the PA. This concept, known as RVPAC, can be clinically estimated by the TAPSE/sPAP ratio, alterations of which have been associated with outcomes in numerous conditions, including heart failure with reduced and preserved ejection fraction,[9] pulmonary hypertension,[19] and non-tricuspid valvular heart disease.[20-22]

We were the first to demonstrate the prognostic relevance of the RVPAC index in patients with isolated severe TR undergoing T-TEER.[3] This finding was subsequently confirmed in a cohort of patients undergoing various transcatheter interventions for TR[15] and in patients with TR under medical management.[23] However, data regarding the clinical utility of this index in selecting patients for TR therapies are limited, as the association of RVPAC with outcomes after interventional compared with medical management has not been established.

Our present data suggest, for the first time, that RVPAC might aid in identifying patients who derive a survival benefit from T-TEER compared with medical therapy. This finding appears provocative, as a

FIGURE 3 Prognostic Impact of RVPAC According to Treatment Modality



Kaplan-Meier survival curves (solid lines) and their corresponding 95% CIs (dashed lines) stratified by a right ventricular-to-pulmonary artery coupling (RVPAC) ratio threshold of 0.41 mm/mm Hg. Patients with higher RVPAC exhibited significantly longer survival in both the medically treated (conservative; left) and T-TEER (right) cohorts. Abbreviations as in Figure 2.

prognostic benefit of T-TEER over medical therapy could not be established in the randomized controlled TRILUMIATE and Tri-FR trials.[24,25] However, compared with these trial cohorts, our patients were more symptomatic, had lower LVEFs, and had higher 1-year mortality, indicating more advanced disease. Notably, the impact of T-TEER on prognosis was observed in the intermediate RVPAC range, which overall demonstrated characteristics of an intermediate disease stage. This aligns with previous reports suggesting maximized benefit with T-TEER in patients with midstage disease.[17,26,27]

In this regard, the TAPSE/sPAP ratio could serve as a valuable indicator for disease staging in TR, as it reflects functional ventricular compensation when the RV is increasingly strained by volume and pressure overload as the disease progresses. As in prior studies, lower RVPAC ratios were associated with higher baseline risk factors and ultimately increased mortality, highlighting the importance of evaluating interventional benefit against the backdrop of a medically treated control cohort when considering the RVPAC ratio for patient selection. Our prognostically optimized cutoff of 0.41 mm/mm Hg mirrored findings from previous studies on interventional TR therapy,[10,15] although lacking specificity. Optimized specificity was observed at 0.29 mm/mm Hg, nearly coinciding with the low margin of the intermediate TAPSE/sPAP tertile and the exponential rise in hazard on the spline curve, potentially serving as a more suitable cutoff for patient selection. Importantly, multiple cutoff values for prognostication have been proposed, with lower values when using invasive sPAP measurements.[3,10,15] Nevertheless, we believe that the noninvasive TAPSE/sPAP ratio will continue to play a crucial role in assessing TR patients because of its feasibility and ease of assessment. Although our study and others suggest that prognostic benefit is optimized in patients with intermediate disease stages, we cannot explicitly extrapolate futility in those with higher or lower RVPAC ratios, as symptomatic alleviation may still be achievable with interventional TR treatment.[17,26,27]

Of interest are the distinct trajectories of mortality hazards associated with continuous RVPAC ratios on spline curves. In the medical group, the hazard appeared to increase linearly, whereas in the T-TEER group, a more pronounced risk increase might be deduced in the lower RVPAC ranges. This suggests that the prognostic implications of RVPAC are

TABLE 2 Patient Characteristics According to TAPSE/sPAP ratio and Treatment Modality

	Low TAPSE/sPAP Ratio			Intermediate TAPSE/sPAP Ratio			High TAPSE/sPAP Ratio		
	Conservative (n = 182)	T-TEER (n = 135)	*P* Value	Conservative (n = 150)	T-TEER (n = 165)	*P* Value	Conservative (n = 141)	T-TEER (n = 173)	*P* Value
Age, y	78 (73-83)	78 (73-82)	0.83	77 (72-82)	80 (75-83)	0.06	77 (71-82)	78 (75-82)	0.15
Male, %	98 (54)	67 (50)	0.46	68 (45)	80 (49)	0.58	46 (33)	73 (42)	0.08
BMI, kg/m^2	25 (22-28)	26 (23-30)	0.19	25 (23-28)	25 (23-28)	0.66	25 (23-28)	25 (22-28)	0.74
RV lead	37 (20)	18 (13)	0.10	23 (15)	30 (18)	0.50	21 (15)	36 (21)	0.18
AF/atrial flutter	148 (81)	110 (82)	0.97	132 (88)	138 (84)	0.27	**108 (77)**	**151 (87)**	**0.01**
Coronary artery disease	52 (29)	33 (24)	0.41	37 (25)	29 (18)	0.12	21 (15)	40 (23)	0.07
NYHA functional class			**<0.01**			<0.01			<0.01
I/II	9 (5)	15 (11)		9 (6)	9 (6)		15 (11)	30 (17)	
III	98 (54)	94 (70)		91 (61)	91 (61)		84 (60)	125 (72)	
IV	75 (41)	26 (19)		50 (33)	50 (33)		42 (30)	18 (10)	
EuroSCORE II, %		5.2 (2.9-10.0)			3.7 (2.1-6.2)			3.4 (2.1-5.8)	
LVEF, %	**50 (35-60)**	**55 (43-60)**	**0.04**	**53 (40-60)**	**55 (49-61)**	**0.04**	60 (50-61)	57 (52-64)	0.70
LVEDD, mm	51 (42-56)	51 (45-57)	0.73	49 (43-55)	49 (45-55)	0.47	45 (41-50)	47 (42-52)	0.11
LA volume, mL	101 (81-130)	97 (64-144)	0.44	95 (74-123)	108 (72-145)	0.11	**86 (62-112)**	**102 (61-151)**	**0.04**
TR EROA, cm^2	0.57 (0.46-0.68)	0.50 (0.40-0.65)	**<0.01**	0.61 (0.48-0.78)	0.70 (0.50-0.94)	0.13	0.69 (0.56-1.03)	0.72 (0.50-1.10)	0.88
TR vena contracta, mm	**9 (8-10)**	**10 (8-13)**	**<0.01**	**9 (7-10)**	**11 (8-14)**	**<0.01**	**9 (8-10)**	**11 (8-16)**	**<0.01**
TR grade ≥4, %	75 (41)	57 (42)	0.86	78 (52)	96 (58)	0.27	99 (70)	117 (67)	0.62
RV base diameter, mm	**39 (35-45)**	**48 (43-55)**	**<0.01**	**40 (33-47)**	**50 (42-58)**	**<0.01**	**36 (31-46)**	**49 (44-56)**	**<0.01**
TAPSE, mm	14 (12-17)	14 (12-17)	0.98	18 (15-21)	18 (15-20)	0.32	22 (18-25)	20 (18-24)	0.09
sPAP, mm Hg	58 (50-68)	62 (51-70)	0.14	48 (39-53)	45 (40-50)	0.16	35 (28-42)	34 (29-39)	0.30
TAPSE/sPAP ratio	0.26 (0.20-0.29)	0.24 (0.20-0.29)	0.31	0.39 (0.35-0.43)	0.39 (0.36-0.43)	0.72	0.59 (0.51-0.72)	0.58 (0.51-0.71)	0.52
eGFR, mL/min/m^2	43 (29-60)	43 (31-55)	0.48	46 (36-64)	52 (41-72)	0.01	55 (41-72)	52 (39-67)	0.34
AST, U/L	**32 (24-40)**	**26 (22-36)**	**<0.01**	31 (23-41)	29 (24-34)	0.10	**31 (23-42)**	**28 (22-35)**	**0.03**
NT-proBNP, pg/mL	**4,750 (1,981-11,608)**	**3,024 (1,385-6,615)**	**<0.01**	3,537 (1,529-7,168)	1,541 (870-2,663)	**<0.01**	**2,007 (988-5,370)**	**1,519 (855-2,768)**	**0.03**

Values are median (Q1-Q3) or n (%). Values in **bold** denote statistical significance.
Abbreviations as in Table 1.

influenced by T-TEER, as it acutely reduces flow to the low-pressure atrium, forcing a vulnerable RV to eject blood into a high-resistance pulmonary circuit. Patients with low RVPAC and, therefore, relative functional ventricular decompensation might struggle to overcome this hemodynamic challenge, indirectly supporting the concept of decreased afterload reserve.[15] However, considering that acute RV failure after T-TEER is extremely rare, these effects seem to manifest as either subacute RV functional deterioration or an additional interaction with increased baseline risk.[28]

In previous studies, we observed that RV preload also influences the prognostic implications of TAPSE/sPAP ratio.[29,30] Interestingly, we observed higher TR grades and, consequently, more RV preload in patients with high PVPAC ratios. However, outcomes were favorable in this group, suggesting that, in light of similar procedural success as in the other RVPAC tertiles, the lack of significantly elevated PA pressures seems to be the primary reason for this observation.

STUDY LIMITATIONS. This study is the first to assess RVPAC in patients treated with T-TEER compared with medical therapy. However, it relied on a propensity-matched analysis with a limited sample size and a historic TR cohort, introducing inherent biases and making the results hypothesis generating. Besides prognostic benefits, T-TEER might have significant implications for quality of life, which were not addressed in this study. TAPSE/sPAP is just one of many surrogates for RVPAC, might have limitations in situations with reduced longitudinal RV functions and might exhibit variability across different disease stages, particularly in patients with low RV function. Additionally, the absence of invasive hemodynamic data prevents a more detailed assessment of the specific contributions of central venous pressure and venous properties. However, this ratio has been

CENTRAL ILLUSTRATION **Echocardiographic Evaluation of Patients With Tricuspid Regurgitation**

Right Ventricular–Pulmonary Artery Coupling and Outcomes in Tricuspid Regurgitation

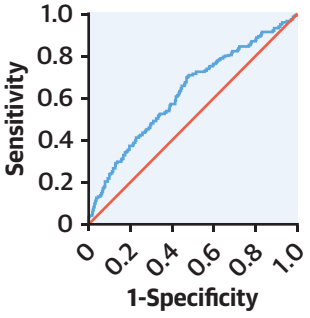
Patients

Treatment: T-TEER
Euro-TR-Registry 2016-2022

Treatment: Conservative
Charité University 2010-2017

Matched Cohort, N = 946

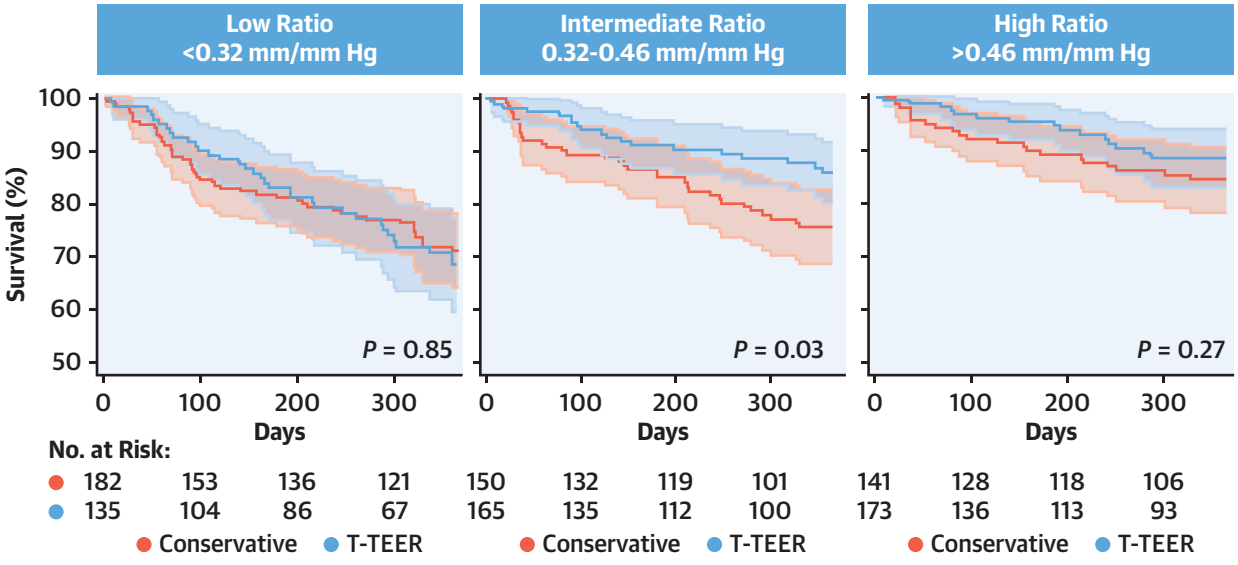
1-Year Mortality Prediction



TAPSE / sPAP

Youden-Index Optimzed Cut-off: 0.41 mm/mm Hg
Specificity Optimized Cut-off: 0.29 mm/mm Hg

1-Year Survival According to TAPSE/sPAP Ratio and Treatment



- Lower TAPSE/sPAP was associated with greater risk and higher mortality.
- In an intermediate TAPSE/sPAP range, T-TEER was associated with better survival than conservatively managed patients.
- No survival difference between treatments groups was observed among patients in a low TAPSE/sPAP range.

Rommel K-P, et al. JACC Cardiovasc Interv. 2025;18(11):1411-1421.

Right ventricular–to-pulmonary artery coupling in tricuspid regurgitation was assessed noninvasively using the ratio of tricuspid annular plane systolic excursion (TAPSE) to systolic PA pressure (sPAP), which was used to predict 1-year mortality. In a matched cohort (N = 946) undergoing tricuspid edge-to-edge repair (T-TEER) or medical therapy, T-TEER conferred a survival benefit in the intermediate range of TAPSE/sPAP ratio, as demonstrated by Kaplan-Meier survival curves (solid lines) and their corresponding 95% CIs (dashed lines). Euro-TR = European Registry of Transcatheter Repair for Tricuspid Regurgitation.

validated invasively and has provided important prognostic information in patients with TR-related right heart failure.[19]

CONCLUSIONS

Abnormalities in RVPAC, as estimated using the TAPSE/sPAP ratio, are associated with elevated baseline risk and increased mortality in patients with TR, regardless of treatment. T-TEER is linked to better survival than medical management in the intermediate range of RVPAC. Whether RVPAC measures or alternative markers of an intermediate disease stage can prospectively identify patients with TR-related right heart failure who benefit prognostically from T-TEER warrants dedicated investigation in future trials.

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PERSPECTIVES

WHAT IS KNOWN? Echocardiographic estimates of RVPAC are attractive in clinical practice to assess afterload-adapted RV function and predict prognosis in patients undergoing interventions for TR, but its role in patient selection is unclear.

WHAT IS NEW? We demonstrate for the first time that RVPAC might be useful in identifying patients with a prognostic benefit from T-TEER compared with medical therapy. Importantly, this benefit was most pronounced in an intermediate RVPAC range, extending below previously suggested cutoffs.

WHAT IS NEXT? Whether RVPAC measures, or alternative markers of an intermediate disease stage, can be used to prospectively identify patients with TR-related right heart failure who benefit prognostically from M-TEER warrants dedicated investigation in future trials.

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KEY WORDS hemodynamics, right heart failure, transcatheter tricuspid valve repair, tricuspid regurgitation

APPENDIX For supplemental tables and a figure, please see the online version of this paper.