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Impact of Tricuspid Regurgitation Severity and Repair on Aortic Valve Replacement

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ABSTRACT

BACKGROUND Aortic stenosis is one of the most prevalent valve diseases but is rarely accompanied by tricuspid regurgitation. Our objective was to analyze the impact of tricuspid regurgitation severity and its surgical treatment on prognosis of patients undergoing aortic valve replacement.

METHODS This was a retrospective cohort study including all patients presenting with aortic stenosis with some degree of tricuspid regurgitation between 2001 and 2018. Patients were grouped according to the degree of tricuspid regurgitation.

RESULTS From a sample of 8080 patients with aortic stenosis, 143 (1.8%) presented with more than trace tricuspid regurgitation. Among patients with mild, moderate, or severe tricuspid regurgitation, we observed no differences in 30-day (15.1% vs 14.8% vs 8.7%; $P = .727$), 12-month (51.2% vs 56% vs 55%; $P = .892$), or 5-year (64% vs 73.3% vs 66.7%; $P = .798$) survival. Aortic valve replacement plus tricuspid annuloplasty, when compared with aortic valve replacement only was associated with longer intensive care unit stay (9 vs 3 days; $P = .043$) but not higher 30-day (0% vs 15.5%; $P = .112$), 12-month (38.5% vs 54.3%; $P = .278$), or 5-year mortality (57.1% vs 67.1%; $P = .594$). Only history of liver disease and postoperative major morbidity were independent predictors of survival 30 days, 12 months and 5 years after surgery.

CONCLUSIONS Severity of tricuspid regurgitation in patients with aortic stenosis was not associated with increased mortality. Tricuspid annuloplasty did not improve survival in this subset of patients but was associated with increased postoperative morbidity.

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Aortic stenosis is one of the most common valve diseases in the western world.[1] Although the development of transcatheter aortic valve implantation made it possible to treat a greater number of patients, those who require cardiac surgery for aortic stenosis have more severe comorbidities, which increase surgical risk.[2] Tricuspid regurgitation, which may be accompanied by mitral regurgitation, is a rare finding, with prevalence rates that vary between 5.6% and 15.7%.[3,4]

Tricuspid pathology develops owing to aortic stenosis increasing left ventricle filling pressure, which is transmitted to the pulmonary vascular bed and right ventricle. Increased left ventricle pressure increments atrial and capillary wedge pressures. Pulmonary vascular compliance declines and adds to the augmenting resistance against the right ventricle, causing a rise of right ventricle end-diastolic pressure. Because of these hemodynamic changes, dilation of the tricuspid ring and of the right ventricle develops progressively.[5-9]

The impact of tricuspid regurgitation, pulmonary hypertension, and right ventricle dysfunction on prognosis after aortic valve replacement began to become

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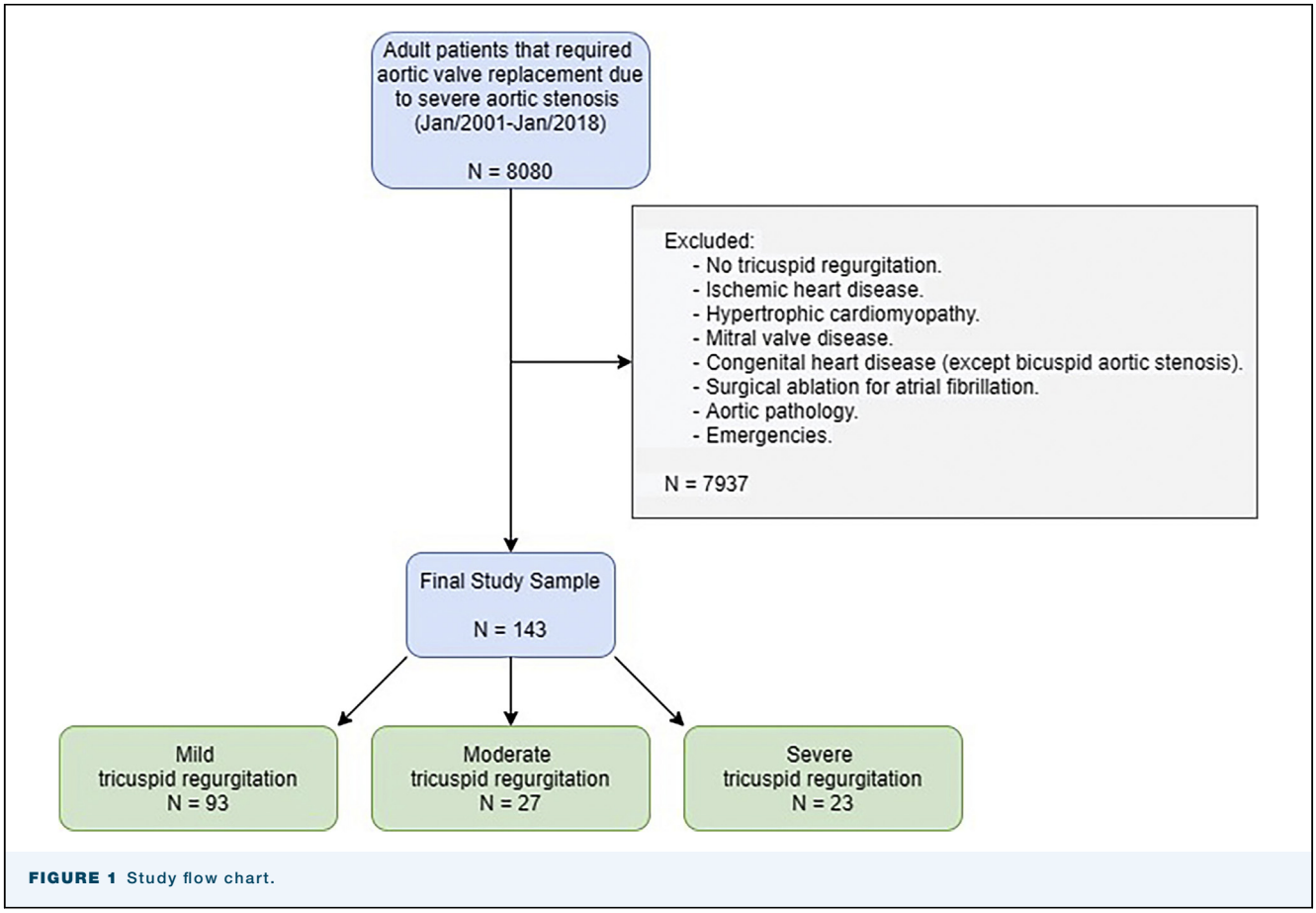

FIGURE 1 Study flow chart.

recognized after publication of results of subjects that underwent transcatheter aortic valve implantation. These risk factors were associated with considerably worse prognosis.[10,11] However, currently available clinical practice guidelines do not specify when tricuspid regurgitation should be corrected in the context of aortic stenosis without mitral disease.[1] Indications for surgery are insufficiently documented, with aortic valve replacement being recommended over transcatheter aortic valve implantation in patients with aortic stenosis and tricuspid regurgitation. However, these recommendations are based on limited published data on postsurgical outcomes that are mainly focused on patients with mitral pathology. As a consequence, it is not possible to adequately address the real impact of tricuspid regurgitation in patients with isolated aortic stenosis.[12] Pagnesi and colleagues[10] analyzed in a meta-analysis 15 studies in which aortic stenosis was associated with left valve disease. However, the mitral valve was affected in all included cases, which means that the effect of tricuspid regurgitation on isolated aortic valve disease prognosis remains unknown.[10] In addition, it is unclear how tricuspid regurgitation correction can affect already established pulmonary vascular bed damage.[13]

The aim of our study was to analyze the impact of tricuspid regurgitation severity on mortality of patients undergoing aortic valve replacement surgery due to aortic stenosis with tricuspid regurgitation and without mitral valve disease, and to study how surgical treatment of tricuspid regurgitation affected patient prognosis.

MATERIAL AND METHODS

PATIENTS, STUDY DESIGN, AND DEFINITIONS. A retrospective cohort study was carried out that included all adult patients (aged 18 years or more) who underwent aortic valve replacement due to severe aortic stenosis and with some degree of tricuspid regurgitation between January 2001 and January 2018 in one tertiary referral hospital. Patients without tricuspid regurgitation, or with ischemic heart disease, hypertrophic cardiomyopathy, mitral valve disease, congenital heart disease (except bicuspid aortic stenosis), surgical ablation for atrial fibrillation, aortic pathology, and urgencies were excluded from this analysis (Figure 1). The final study sample was divided according to the degree of tricuspid regurgitation (mild, moderate, or severe).[1] The research

TABLE 1 Patient Characteristics, Preoperative Echocardiographic Variables, Surgery-Associated Variables, and Outcomes According to Tricuspid Regurgitation Severity

	Severity of Tricuspid Regurgitation			
Variable	**Mild**	**Moderate**	**Severe**	***P* Value**
Number of patients	93	27	23	
Preoperative factors				
Age, y	73 (67-78)	79 (73-81)	74 (64-79)	.006
Male	56 (60.2)	10 (37)	10 (43.5)	.063
Body mass index >30 kg/m^2	28 (30.1)	7 (25.9)	11 (47.8)	.197
Hypertension	67 (79.8)	21 (80.8)	18 (81.8)	.975
Diabetes mellitus	29 (36.3)	10 (38.5)	9 (42.9)	.854
Dyslipidemia	43 (53.8)	16 (61.5)	11 (55)	.785
Peripheral artery disease	9 (11.8)	4 (16)	2 (9.5)	.786
COPD	24 (30.8)	6 (24)	5 (23.8)	.715
Stroke	8 (10.5)	1 (4)	2 (9.5)	.611
Liver disease	3 (3.2)	0 (0)	5 (21.7)	.001
Chronic kidney disease	50 (53.8)	10 (37)	12 (52.2)	.304
Current smoker	7 (7.5)	1 (3.7)	3 (13)	.464
NYHA class				.158
I	4 (4.3)	0 (0)	0 (0)	
II	16 (17.2)	3 (11.1)	5 (21,7)	
III	39 (41.9)	18 (66.7)	14 (60.9)	
IV	34 (36.6)	6 (22.2)	4 (17.4)	
Logistic EuroSCORE I	19.2 (10.3-29.5)	18 (15-24)	17 (11-24)	.569
Preoperative echocardiography				
Ejection fraction, %	52 (26-62)	58 (33-66)	45 (22-60)	.228
PSP, mm Hg	60 (56-67)	64 (60-74)	60 (43-64)	.032
TAPSE, mm	13 (11-14)	10 (7-13)	11 (10-13)	.02
TAPSE/PSP ratio	0.29 ± 0.08	0.23 ± 0.13	0.24 ± 0.09	.126
Maximum velocity, m/s	2.4 (2.1-2.8)	2.8 (2.1-3.1)	2.5 (2-2.9)	.413
Mass index	163 (140-188)	111 (105-162)	142 (119-157)	.023
Surgical factors				
Biological valve	68 (73.9)	24 (88.9)	18 (81.8)	.229
Type of surgery				<.001
IAVR	90 (96.8)	27 (100)	12 (52.2)	
IAVR + TA	3 (3.2)	0 (0)	11 (47.8)	
ECC time, min	81 (66-104)	74 (64-84)	99 (75-128)	.006
Aortic cross-clamp time, min	56 (46-75)	52 (43-63)	72 (53-93)	.004
Outcomes				
ICU length of stay, d	2 (1-5)	3 (1-13)	7 (2-17)	.006
Inhospital length of stay, d	70 (40-139)	88 (38-329)	185 (64-428)	.007
Major morbidity[a]	34 (54)	13 (72.2)	15 (78.9)	.089
Early mortality	14 (15.1)	4 (14.8)	2 (8.7)	.727
Twelve-month mortality[b]	43 (51.2)	14 (56)	11 (55)	.892
Five-year mortality[c]	32 (64)	11 (73.3)	8 (66.7)	.798
Overall cardiovascular mortality	16 (17.2)	4 (14.8)	6 (26.1)	.54

[a]Major morbidity includes prolonged ventilation, reoperation, deep sternal wound infection, stage 3 acute kidney injury, or permanent stroke; [b]Valid sample size at 12 months = 129; [c]Valid sample size at 5 years = 77. Values are median (interquartile range), n (%), or mean ± SD. AVR, aortic valve replacement; COPD, chronic obstructive pulmonary disease; ECC, extracorporeal circulation; EuroSCORE, European System for Cardiac Operative Risk Evaluation; ICU, intensive care unit; NYHA, New York Heart Association; PSP, pulmonary systolic pressure; TA, tricuspid annuloplasty; TAPSE, tricuspid annular plane systolic excursion.

protocol was approved by the local Institutional Review Board and was compliant with the ethical guidelines of the 1975 Declaration of Helsinki. Patients gave their written consent to store their data anonymously in the hospital database.

Cardiovascular mortality was defined as death due to acute myocardial infarction, sudden cardiac death, heart failure, stroke, cardiovascular procedures, or hemorrhage. Chronic hepatic disease was defined as a Child-Pugh score class B or C at the time of surgery.[14] Chronic kidney disease was defined as a baseline estimated glomerular filtration rate less than 60 mL · min^{-1} · 1.73 m^{-2} maintained for more than 3 months.[15] The European System for Cardiac Operative Risk Evaluation

TABLE 2 Patient Characteristics, Preoperative Echocardiographic Variables, Surgery-Associated Variables, and Outcomes According to Type of Valve Surgery

Variable	Type of Surgery		*P* Value
	AVR	AVR+TA	
Number of patients	129	14	
Preoperative factors			
Age, y	75 (68-78)	66 (58-75)	.05
Male	69 (53.5)	7 (50)	.804
Body mass index >30 kg/m^2	40 (31)	6 (42.9)	.367
Hypertension	96 (81.4)	10 (71.4)	.377
Diabetes mellitus	43 (37.7)	5 (38.5)	.958
Dyslipidemia	63 (56.3)	7 (50)	.657
Peripheral artery disease	15 (13.8)	0 (0)	.153
COPD	30 (27)	5 (38.5)	.386
Stroke	11 (10.1)	0 (0)	.23
Liver disease	6 (4.7)	2 (14.3)	.136
Chronic kidney disease	62 (48.1)	10 (71.4)	.097
Current smoker	9 (7)	2 (14.3)	.33
TR severity			<.001
Mild	90 (69.8)	3 (21.4)	
Moderate	27 (20.9)	0 (0)	
Severe	12 (9.3)	11 (78.6)	
NYHA class			.632
I	3 (2.3)	1 (7.1)	
II	22 (17.1)	2 (14.3)	
III	63 (48.8)	8 (57.1)	
IV	41 (31.8)	3 (21.4)	
Logistic EuroSCORE 1	17.5 (11.4-28.6)	19.6 (13.9-24.1)	.897
Preoperative echocardiography			
Ejection fraction	53 (29-64)	41 (21-61)	.303
PSP, mm Hg	61 (57-67)	56 (36-65)	.125
TAPSE, mm	13 (11-14)	11 (10-13)	.178
TAPSE/PSP ratio	0.27 ± 0.09	0.23 ± 0.06	.219
Maximum velocity, m/s	2.5 (2.1-2.9)	2.5 (2.1-3.5)	.468
Mass index	153 (133-183)	149 (119-161)	.512
Surgical factors			
ECC time, min	77 (66-102)	127 (97-149)	<.001
Aortic cross-clamp time, min	54 (45-73)	83 (69-107)	<.001
Outcomes			
ICU length of stay, d	3 (1-6)	9 (2-16)	.043
Inhospital length of stay, d	77 (42-156)	236 (48-106)	.054
Major morbidity[a]	51 (39.5)	11 (78.6)	.011
Early mortality	20 (15.5)	0 (0)	.112
Twelve-month mortality[b]	63 (54.3)	5 (38.5)	.278
Five-year mortality[c]	47 (67.1)	4 (57.1)	.594
Overall cardiovascular mortality	23 (17.8)	3 (21.4)	.74

[a]Major morbidity includes prolonged ventilation, reoperation, deep sternal wound infection, stage 3 acute kidney injury, or permanent stroke; [b]Valid sample size at 12 months = 129; [c]Valid sample size at 5 years = 77. Values are median (interquartile range), n (%), or mean ± SD. AVR, aortic valve replacement; COPD, chronic obstructive pulmonary disease; ECC, extracorporeal circulation; EuroSCORE, European System for Cardiac Operative Risk Evaluation; ICU, intensive care unit; NYHA, New York Heart Association; PSP, pulmonary systolic pressure; TA, tricuspid annuloplasty; TAPSE, tricuspid annular plane systolic excursion; TR, tricuspid regurgitation.

(EuroSCORE) was calculated in all cases.[16] The EuroSCORE II, an updated version of the original EuroSCORE, was calculated in all subjects since 2012 (n = 74).[17]

Major morbidity included prolonged ventilation, reoperation, deep sternal wound infection, stage 3 acute kidney injury according to the 2012 Kidney Disease: Improving Global Outcomes classification,[18] and permanent stroke. Early mortality was defined as death from any cause within the first 30 days after surgery. Any death occurring after that period was defined as late mortality. Patients were followed up on an outpatient basis.

ECHOCARDIOGRAPHY. Baseline tricuspid regurgitation severity was evaluated using echocardiography. Continuous-wave Doppler was used to record flow and regurgitant jet signals in the apical four-chamber and right ventricle inflow views. Tricuspid regurgitation grade was assessed following the European and American guidelines on echocardiography. Tricuspid regurgitation was graded according to current guideline-recommended standard methods as none, mild, moderate, or severe.[19,20] Right ventricle function was assessed according to information on size, visual assessment of contractility, and tricuspid annular plane systolic excursion (TAPSE).[21] Right ventricle dysfunction was defined as TAPSE less than 16 mm. Pulmonary hypertension was considered if a peak tricuspid regurgitation velocity greater than 3.4 m/s (estimated systolic pulmonary artery pressure greater than 50 mm Hg) was present.

STATISTICAL ANALYSIS. Mean ± SD or median (interquartile range [IQR]) were used for continuous variables according to data distribution. Counts with percentages were used for binary variables. Continuous data were assessed using Student's *t* test, Mann-Whitney *U* test, or Kruskal-Wallis test. Binary data were analyzed using the χ^2 test.

Cumulative survival curves of 30-day, 12-month, and 5-year follow-up were estimated with the Kaplan-Meier method. The effect of tricuspid regurgitation severity and type of surgery were compared between groups using the log rank test. Regarding 12-month and 5-year survival analyses, only subjects with complete potential follow-up were considered. Therefore, the valid sample used for each analysis was as follows: early mortality, 143 patients; 12-month mortality, 129 patients; and 5-year mortality, 77 patients. Cox proportional hazards models with hazard ratio and 95% confidence interval were used to evaluate potential risk factors of mortality at each different timepoint. The proportional hazards assumption was tested using Schoenfeld's residual plots. Variables with P values less sthan .1 in unadjusted analysis were chosen to be included in the adjusted models. Statistical analysis was carried out using IBM SPSS Statistics 20.0 (IBM Corp, Armonk, NY).

RESULTS

PATIENT CHARACTERISTICS. From January 2001 to January 2018, 8080 patients with severe aortic stenosis underwent operation. 143 patients (1.8%) also had some grade of tricuspid regurgitation without mitral valve disease and were included in the final analysis. Median age was 74 years (IQR, 67 to 78) and 76 (53.1%) were male (Table 1).

TABLE 3 Unadjusted and Adjusted Cox Regression Models for Early Mortality

	Unadjusted Analysis			Adjusted Analysis		
Variables	HR	(95% CI)	*P* Value	HR	(95% CI)	*P* Value
Age, per year	1.001	(0.963-1.04)	.959	…	…	
Male	0.912	(0.378-2.202)	.838	…	…	
Liver disease	5.477	(1.821-16.47)	.002	9.249	(2.824-30.292)	<.001
CKD stage G3 or worse	1.849	(0.738-4.634)	.19	…	…	
NYHA class III or IV	28.979	(0.285-2944.851)	.153	…	…	
PSP >50 mm Hg	0.415	(0.096-1.791)	.239	…	…	
Moderate or severe TR	1.287	(0.495-3.349)	.605	…	…	
Tricuspid annuloplasty	0.042	(0-22.365)	.322	…	…	
Postop. major morbidity	4.32	(1.57-11.891)	.005	5.666	(1.966-16.332)	.001

Valid sample size = 143. CI, confidence interval; CKD, chronic kidney disease; HR, hazard ratio; NYHA, New York Heart Association; Postop., postoperative; PSP, pulmonary systolic pressure; TR, tricuspid regurgitation.

Most of the participants included in this analysis were high-risk patients, with median logistic EuroSCORE I of 17.8 (IQR, 11.4 to 25.9; n = 143) and median EuroSCORE II of 6.6 (IQR, 2.9 to 13.1; n = 74). Of the 143 patients, 50 (34.9%) presented with moderate-severe tricuspid regurgitation. We observed no differences in the New York Heart Association (NYHA) functional class between groups. However, patients with more severe tricuspid regurgitation needed longer extracorporeal circulation and aortic cross-clamp times during surgery and lengthier intensive care unit (ICU) and hospital stays. There were no differences in early, 12-month, and 5-year mortality between groups, although patients with more severe tricuspid regurgitation more commonly tended to have major morbidities. Compared with patients with mild tricuspid regurgitation, patients with moderate or severe tricuspid regurgitation presented with lower right ventricle function, TAPSE, and mass index, and slightly higher pulmonary systolic pressure (Table 1).

TABLE 4 Unadjusted and Adjusted Cox Regression Models for 12-Month Mortality

	Unadjusted Analysis			Adjusted Analysis		
Variables	HR	(95% CI)	*P* Value	HR	(95% CI)	*P* Value
Age, per year	1	(0.97-1.031)	.995	…	…	
Male	0.781	(0.382-1.598)	.498	…	…	
Liver disease	4.475	(1.707-11.729)	.002	7.034	(2.38-20.788)	<.001
CKD stage G3 or worse	1.413	(0.681-2.935)	.354	…	…	
NYHA class III or IV	3.693	(0.88-15.508)	.074	2.209	(0.511-9.548)	.288
PSP >50 mm Hg	0.956	(0.391-2.339)	.922	…	…	
Moderate or severe TR	0.919	(0.43-1.964)	.828	…	…	
Tricuspid annuloplasty	0.592	(0.141-2.485)	.474	…	…	
Postop. major morbidity	2.954	(1.381-6.315)	.005	3.672	(1.583-8.519)	.002

Valid sample size = 129. CI, confidence interval; CKD, chronic kidney disease; HR, hazard ratio; NYHA, New York Heart Association; Postop., postoperative; PSP, pulmonary systolic pressure; TR, tricuspid regurgitation.

TABLE 5 Unadjusted and Adjusted Cox Regression Models for 5-Year Mortality

	Unadjusted Analysis			Adjusted Analysis		
Variables	HR	(95% CI)	*P* Value	HR	(95% CI)	*P* Value
Age, per year	1.012	(0.982-1.042)	0.432	…	…	…
Male	0.719	(0.363-1.424)	0.344	…	…	…
Liver disease	2.966	(0.9-9.775)	0.074	5.107	(1.441-18.1)	.012
CKD stage G3 or worse	1.24	(0.626-2.456)	0.537	…	…	…
NYHA class III or IV	1.685	(0.592-4.798)	0.328	…	…	…
PSP >50 mm Hg	1.993	(0.897-4.427)	0.09	2.217	(0.984-4.993)	.055
Moderate or severe TR	1.163	(0.578-2.338)	0.673	…	…	…
Tricuspid annuloplasty	1.379	(0.484-3.924)	0.547	…	…	…
Postop. major morbidity	2.562	(1.258-5.216)	0.01	2.901	(1.391-6.046)	.004

Valid sample size = 77. CI, confidence interval; CKD, chronic kidney disease; HR, hazard ratio; NYHA, New York Heart Association; Postop., postoperative; PSP, pulmonary systolic pressure; TR, tricuspid regurgitation.

Tricuspid annuloplasty in patients with moderate-severe tricuspid regurgitation was performed only in 22% of the cases in which it was indicated following the recommendations of the current clinical practical guidelines.[1,22] Patients who received tricuspid annuloplasty were younger, had more frequently moderate or severe tricuspid regurgitation, and tended to present with chronic kidney disease more commonly. These patients needed, as expected, longer extracorporeal circulation and aortic clamping times (Table 2) and lengthier ICU stay and showed a higher incidence of postoperative major morbidities. Nevertheless, no differences were observed in early, 12-month, or 5-year mortality or overall mortality of cardiovascular cause (Table 2).

PREDICTIVE FACTORS OF EARLY, 12-MONTH, AND 5-YEAR MORTALITY. Median follow-up time was 69 months (IQR, 27 to 130). Cardiovascular disease was the main cause of mortality: early, 60% of all deaths; 12 months, 53.3% of all deaths; and 5 years, 39.4% of all deaths. History of liver disease and postoperative major morbidity were the only independent predictors of mortality, early (Table 3), at 12 months (Table 4), and at 5 years (Table 5). No differences were observed in early survival (Figures 2A, 2B), 12-month survival (Figures 3A, 3B), and 5-year survival (Figures 4A, 4B; Table 6) according to tricuspid regurgitation severity or type of valve surgery.

COMMENT

Our main findings were that (1) patients with isolated aortic stenosis rarely present with tricuspid regurgitation; (2) tricuspid regurgitation severity and surgical treatment modality were not associated with worse early, 12-month, or 5-year mortality; (3) subjects with moderate-severe tricuspid regurgitation were slightly older, more often had liver disease, and had lower ejection fraction, TAPSE, and mass index, as well as

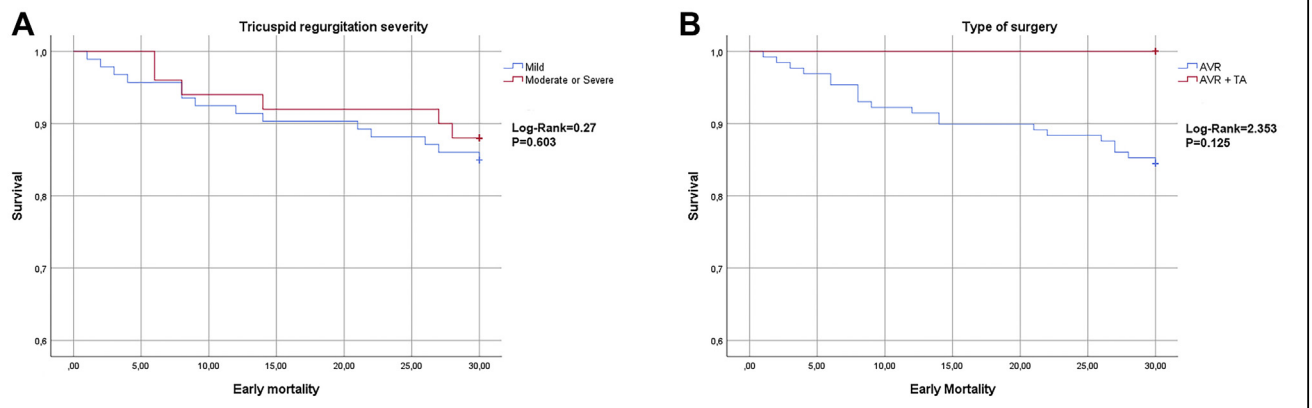

FIGURE 2 Kaplan-Meier plots of early mortality: (A) tricuspid regurgitation severity, mild (blue line) or moderate to severe (red line); and (B) type of surgery, aortic valve replacement (blue line) or aortic valve replacement plus tricuspid annuloplasty (red line). Valid sample size = 143.

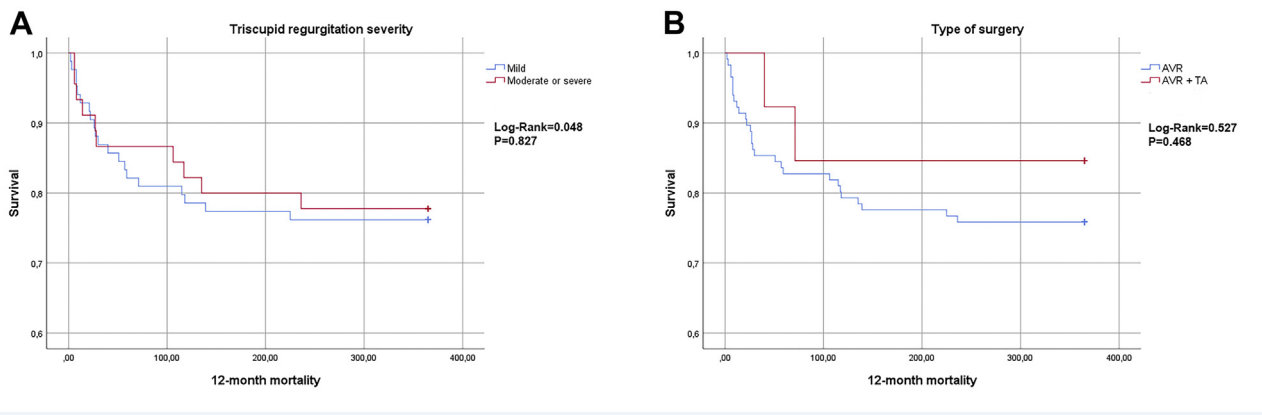

FIGURE 3 Kaplan-Meier plots of 12-month mortality: (A) tricuspid regurgitation severity, mild (blue line) or moderate to severe (red line); and (B) type of surgery, aortic valve replacement (blue line) or aortic valve replacement plus tricuspid annuloplasty (red line). Valid sample size = 129.

higher pulmonary systolic pressure; and (4) patients who received aortic valve replacement plus tricuspid annuloplasty received longer extracorporeal circulation and aortic clamping times, required longer ICU stay, and more commonly had major morbidity.

Patients in our sample had high mortality rates, which may be related to advanced disease according to the development of pulmonary hypertension, right ventricle dysfunction, and NYHA class III-IV. Severe pulmonary hypertension was present in 46.7% of patients with moderate-severe tricuspid regurgitation, 76.7% of them were in NYHA class III-IV, and 88% had right ventricle dysfunction. These risk factors may have determined the high mortality observed during follow-up (Figures 2-4). The observed mortality in our sample was comparable to that estimated by EuroSCORE I. Other researchers, such as Amano and colleagues[23] reported similar results.

We observed an infra indication of tricuspid valve repair based on current clinical practice guidelines.[1,22] However, the basis for such recommendations are studies of patients with mitral valve disease and do not include specific data on subjects with aortic and tricuspid disease without mitral illness. As such, this is not an isolated finding; Amano and associates[23] and Chancellor and colleagues[24] recently reported similar ratios (38% and 31%, respectively) of infra indication of tricuspid valve repair. The performance of tricuspid annuloplasty in our sample was associated with longer extracorporeal circulation and aortic clamping times and lengthier ICU stay, as well as higher incidence of major postoperative morbidity (Table 2). Patients who received tricuspid annuloplasty had more frequently moderate-severe tricuspid regurgitation but showed similar preoperative echocardiographic values, logistic EuroSCORE I, or NYHA functional class. Our data suggest that tricuspid regurgitation severity was the main cause for indication of tricuspid annuloplasty, although it is not possible to exclude other causes of selection bias owing to the retrospective design of the study.

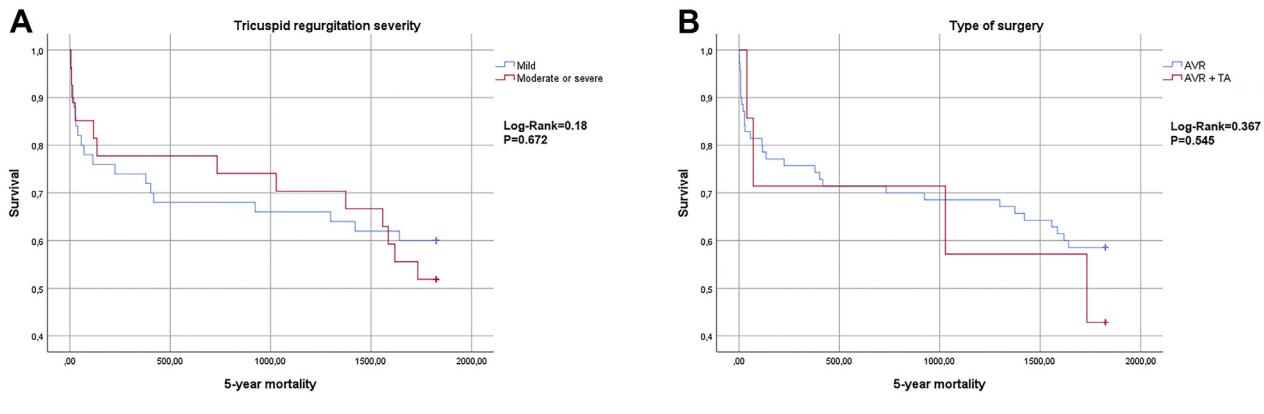

FIGURE 4 Kaplan-Meier plots of 5-year mortality: (A) tricuspid regurgitation severity, mild (blue line) or moderate to severe (red line); and (B) type of surgery, aortic valve replacement (blue line) or aortic valve replacement plus tricuspid annuloplasty (red line). Valid sample size = 77.

TABLE 6 Number of Patients at Risk for Figures 2A, 2B, 3A, 3B, 4A, and 4B

Number of Patients at Risk	Number of Days (n)		
Figure 2A[a]			
Mild TR	0 (93)	15 (84)	30 (79)
Moderate or severe TR	0 (50)	15 (46)	30 (44)
Figure 2B[a]			
AVR	0 (129)	15 (116)	30 (109)
AVR+TA	0 (14)	0 (14)	30 (14)
Figure 3A[b]			
Mild TR	0 (84)	200 (65)	365 (64)
Moderate or severe TR	0 (45)	200 (36)	365 (35)
Figure 3B[b]			
AVR	0 (116)	200 (90)	365 (88)
AVR+TA	0 (13)	200 (11)	365 (11)
Figure 4A[c]			
Mild TR	0 (50)	1000 (37)	1825 (34)
Moderate or severe TR	0 (27)	1000 (20)	1825 914)
Figure 4B[c]			
AVR	0 (70)	1000 (48)	1825 (41)
AVR+TA	0 (7)	1000 (5)	1825 (3)

[a]Valid sample size = 143; [b]Valid sample size = 129; [c]Valid sample size = 77. AVR, aortic valve replacement; TA, tricuspid annuloplasty; TR, tricuspid regurgitation.

Many researchers have highlighted the relevance of right ventricle function, pulmonary hypertension, and tricuspid regurgitation severity in left valve surgery, and the role of these factors in the development of postoperative complications and mortality.[25,26] Nevertheless, the majority of these studies are focused on patients whose indication for surgery was due to mitral illness.[24,25] Data published on aortic plus tricuspid valve disease without mitral illness are limited or nonexistent.[12,23,26,27] Therefore, it is not possible to determine the profile of patients with aortic and tricuspid illness who could benefit the most from surgical correction of the tricuspid valve.[10,12,26,28,29]

Moderate-severe tricuspid regurgitation tended to be more frequent among female patients and was associated with pulmonary hypertension and increased left atrial diameter compared with patients having mild tricuspid regurgitation (Table 1). Similar results in the context of mitral and aortic valve disease have been reported.[4,12,22] Although patients with moderate-severe tricuspid regurgitation showed higher pulmonary systolic pressure, severity of valve disease was not associated with increased mortality in adjusted analysis, perhaps owing to the high prevalence of pulmonary hypertension. Previous studies show conflicting data regarding the effect of pulmonary hypertension on mortality in this setting: several authors found no relationship between pulmonary hypertension and patient survival in different samples of patients with moderate-severe tricuspid regurgitation.[4,30,31,32] In contrast, Zuern and colleagues[33] observed a relationship between pulmonary artery pressure greater than 30 mm Hg and worse prognosis. Nath and colleagues[34] also found an association between pulmonary hypertension severity and mortality. It is important to remember that the mechanism through which pulmonary hypertension is produced in patients with aortic stenosis differs from that involved in pulmonary hypertension development due to mitral valve disease. That difference in mechanisms might explain the differences observed in our sample.

This is one of the first studies to analyze tricuspid annuloplasty-associated long-term outcomes in patients with tricuspid regurgitation.[4,12,29] That is of special relevance considering current clinical practice guidelines on tricuspid valve disease are mainly based on data from subjects with mitral valve diseases. In our sample, surgical treatment of tricuspid regurgitation was not associated with short-term or long-term mortality but with longer ICU stay and higher frequency of major morbidity. Surgical correction of tricuspid regurgitation, in addition to not generating a clinical benefit, can be associated with serious postoperative complications.

Several investigators, such as Yajima and associates,[26] have described an improvement in prognosis that was associated with tricuspid annuloplasty just as in mitral valve disease.[28] Similarly, others indicated that annuloplasty might be beneficial.[8,29] However, although in our sample the extracorporeal circulation and aortic clamping times were greater, we observed no differences between groups regarding early, 12-month, or 5-year mortality. Our results are in concordance with those published by other investigators, who found that tricuspid annuloplasty was infra indicated and that it was not associated with improved postoperative outcomes.[23,24]

STUDY LIMITATIONS. This is a single-center retrospective study with a limited number of patients with moderate to severe tricuspid regurgitation and isolated aortic stenosis. As a retrospective study, it is impossible to ascertain why tricuspid annuloplasty was performed in some patients with moderate-severe tricuspid regurgitation and not performed in others. No differences were observed regarding NYHA class, right ventricle function, or pulmonary systolic pressure between patients who received tricuspid annuloplasty and patients who did not.

CONCLUSION. Incidence of tricuspid regurgitation in patients having aortic valve replacement for isolated aortic stenosis was very low in our sample. Patients who received tricuspid annuloplasty required longer ICU stay and more frequently had major morbidities, but we found no correlation between tricuspid regurgitation severity or its surgical correction and patient survival.

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