

The factors associated with progression of tricuspid regurgitation after left-sided double valve replacement in propensity score matched analysis

Propensity skor ile eşleştirilmiş analizlerde sol taraf çift kapak replasmanı sonrası ilerlemiş triküspit yetmezliği ile ilişkili faktörler

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ABSTRACT

Background: This study aims to investigate the association of progression of tricuspid regurgitation following double-valve replacement by comparing the tricuspid valve repair and no repair groups, and to analyze outcomes of patients with non-repaired mild-to-moderate tricuspid regurgitation.

Methods: Between January 2014 and September 2017, a total of 157 patients (74 males, 83 females; mean age: 51.7±13.7 years; range, 18 to 78 years) who underwent aortic and mitral valve replacements with/without concomitant tricuspid valve repair were retrospectively analyzed. The patients were divided into two groups: no-repair (n=78) and repair groups (n=79). The primary outcome measure was development of more than moderate tricuspid regurgitation during follow-up.

Results: The data were evaluated according to propensity score matched analysis. The progression of tricuspid regurgitation was significantly increased in the no-repair group (p=0.006). Rheumatic etiology was independently associated with the presence of postoperative moderate-to-severe tricuspid regurgitation (p=0.004, odds ratio: 3.40). There was no statistically significant difference between the groups in terms of the potential complications and mortality and survival rates. A multivariable subgroup analysis for the baseline mild-to-moderate tricuspid regurgitation without repair showed that rheumatic etiology was an independent factor for the progression of postoperative tricuspid regurgitation (p=0.01).

Conclusion: Our study results demonstrated that rheumatic etiology was an independent marker for increased tricuspid regurgitation and it was also independently associated with increased tricuspid regurgitation in patients with mild-to-moderate non-repaired patients. The degree of tricuspid regurgitation was improved in the repair group during follow-up.

Keywords: Aortic valve, mitral valve, tricuspid valve regurgitation, tricuspid valve.

ÖZ

Amaç: Bu çalışmada triküspit kapak tamiri yapılan ve yapılmayan gruplar karşılaştırılarak çift kapak replasmanı sonrasında triküspit yetersizliğinin ilişkisi incelendi ve tamir yapılmayan hafif ila orta dereceli triküspit yetersizliği olan hastaların sonuçları karşılaştırıldı.

Çalışma planı: Ocak 2014 - Eylül 2017 tarihleri arasında, aort ve mitral kapak replasmanı ile birlikte eş zamanlı triküspit kapak tamiri yapılan veya yapılmayan toplam 157 hasta (74 erkek, 83 kadın; ort. yaş: 51.7±13.7 yıl; dağılım, 18-78 yıl) retrospektif olarak incelendi. Hastalar tamir edilmeyen (n=78) ve tamir edilenler (n=79) olmak üzere iki gruba ayrıldı. Birincil sonuç ölçümü, takip süresinde orta dereceden daha fazla triküspit yetersizliği gelişmesiydi.

Bulgular: Veriler propensity skor ile uyumlu analize göre değerlendirildi. Kapak tamiri yapılmayan grupta, ilerlemiş triküspit yetersizliği anlamlı olarak yüksekti (p=0.006). Romatizmal etyoloji, ameliyat sonrası orta ila ilerlemiş triküspit yetersizliği varlığı ile bağımsız ilişkili idi (p=0.004; olasılık oranı: 3.40). Olası komplikasyonlar, mortalite ve sağkalım oranları açısından gruplar arasında istatistiksel olarak anlamlı bir fark yoktu. Kapak tamiri yapılmayan başlangıçta hafif ila orta dereceli triküspit yetersizliği olan hastalar için yapılan çok değişkenli alt grup analizinde, romatizmal etyoloji, ilerlemiş ameliyat sonrası triküspit yetersizliği için bağımsız risk faktörüydü (p=0.01).

Sonuç: Çalışma sonuçlarımız romatizmal etyolojinin artmış triküspit yetersizliği için bağımsız bir belirteç olduğunu ve ayrıca hafif ila orta derecede triküspit yetersizliği olan tamir yapılmayan hastalarda da artmış triküspit yetersizliği ile bağımsız olarak ilişkili olduğunu göstermiştir. İzlemlerde triküspit yetersizliğinin derecesi tamir yapılan grupta düzelmiştir.

Anahtar sözcükler: Aort kapak, mitral kapak, triküspit kapak yetersizliği, triküspit kapak.

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Double-valve replacement (DVR) is more complex than an isolated aortic or mitral valve replacement (MVR).^[1] Following left-sided valve surgery, left-sided valve dysfunction with tricuspid regurgitation (TR) may occur owing to progression of rheumatic disease in native heart valves or to prosthetic valve dysfunction.^[2] Recently, several studies have shown that DVR is more strongly related to the late severe TR.^[2,3] It is of clinical significance to prevent late TR, since it has negative impacts on long-term morbidity and mortality.

Surgical intervention of TR following mitral valve (MV) surgery results in substantially increased morbidity and mortality.^[4] As correction of the left-sided valve disease may decrease the right ventricular pressure or lower volume overload, TR can regress following left-sided surgery.^[3] It remains challenging whether or not to repair the tricuspid valve (TV) depending on TR severity, tricuspid annular diameter and the disease etiology while performing left-sided DVR.^[5] At left-sided surgery, intervention to the TV is still controversial among patients with mild-to-moderate TR.^[6] Surgical management of moderate-to-severe TR is widely recommended by current guidelines.^[7] The progression of TR is associated with dysfunction of the right ventricle, which is known to be linked to poor quality of life.^[8,9]

In the present study, we, therefore, aimed to investigate the factors affecting the progression of TR following DVR in a propensity score (PS) matched analysis by comparing TV repair TV and no-TV repair groups and to analyze outcomes of patients with unrepaired mild-to-moderate TR.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at University of Health Sciences, Kosuyolu Higher Specialized Educational and Research Hospital, Department of Cardiovascular Surgery between January 2014 and September 2017. Records of all patients undergoing concomitant aortic and MVR with or without concomitant TV repair were reviewed. A total of 179 patients who underwent DVR with/without TV repair were assessed. Of these patients, 22 who had mild-to-moderate TR with a dilated annulus (>40 mm) but did not undergo TV repair, which was not consistent with the current guidelines, were excluded.^[10,11] Finally, a total of 157 consecutive patients (74 males, 83 females; mean age: 51.7±13.7 years; range, 18 to 78 years) were included in the study. Baseline transthoracic echocardiography (TTE) showed 87 (55.4%) patients had mild TR,

44 (28%) moderate TR, 26 (16.6%) severe TR. Exclusion criteria were as follows: having emergency procedure, mitral or aortic valve repair, simultaneous coronary artery bypass grafting or thoracic aortic surgery, adult congenital cardiac disease except for a patent foramen ovale, intensive care unit (ICU) admission before surgery, infective endocarditis, concomitant surgical arrhythmia ablation, e.g., maze procedures, and low left ventricular ejection fraction (LVEF) (<30%). All patients were divided into two groups based on the TV repair as the no-TV repair group (n=78) and the TV repair group (n=79).

Surgical procedure

All surgeries were performed with the same standard surgical approach. Cardiopulmonary bypass (CBP) was performed via aortic arterial and bi-caval venous cannulations. The myocardium was protected by intermittent antegrade cardioplegia and/or retrograde cardioplegia, as well as mild hypothermia. While the mechanical prosthetic valve was the most commonly used material as the artificial valve, biological prosthetic valve replacement was performed for the elderly or women considering pregnancy. After performing aortic and MVR, the TV was assessed and TV repair was performed. The technique for repair was left to the discretion of the operating surgeon. For De-Vega TV annuloplasty, double row-pledged stitching through right atriotomy was used. When the ring annuloplasty was scheduled for TV repair, we used a three-dimensional (3D) rigid tricuspid ring (Medtronic Contour 3D; Medtronic, Minneapolis, The United States of America) or all patients. After the operation, all patients were transferred to the cardiac ICU for postoperative management.

Echocardiographic evaluation

All patients were evaluated by a single team of expert cardiologists. The valves were evaluated based on the etiology of valve diseases by echocardiography: rheumatic disease and degenerative MV disease.

Tricuspid regurgitation was evaluated with color Doppler imaging to assess jet area using the parasternal short-axis view, the right ventricular inflow view, and the apical four-chamber view. Tricuspid regurgitation was evaluated as mild, moderate, or severe using a collective approach.^[12] The diameter of the tricuspid annulus was calculated by echocardiography at end-diastole on the apical four-chamber view. Tricuspid annular dilation was described as an annular dimension of ≥40 mm.^[13] Surgeons made decisions whether to perform TV repair according to the guidelines in patients with moderate-to-severe or severe TR and

patients who had dilated TV annulus (≥ 40 mm) with mild TR (Class IIa).^[10,11]

Follow-up

All data were obtained from the hospital registration system, and physical and echocardiographic examinations were performed in the postoperative period. During the postoperative period, warfarin was prescribed as a life-long oral anticoagulant treatment to patients with a mechanical prosthetic valve and patients with a bio-prosthetic valve and tricuspid ring annuloplasty received it for three months as an oral anticoagulant treatment. The valve functions and the presence of TR regurgitation were evaluated by echocardiography. The two groups were compared in terms of postoperative outcomes and long-term survival rates. We included postoperative echocardiographic results at three years or those beyond three years. The patients were followed for a mean of 3.2 ± 1.6 years ($n=82$), while 45.81% of the patients were followed for more than three years. The primary outcome measure was the progression of more than moderate TR in mid-term follow-up.

Statistical analysis

Statistical analysis was performed using the R 4.02 software (R Foundation for Statistical Computing, Vienna, Austria) with “Hmisc”, “rms”, “ggplot”, “matchit”, and “survival” package. Continuous data were expressed in mean \pm standard deviation (SD) or median and interquartile range (IQR), while the categorical data were expressed in number and frequency. For the continuous independent data and the group comparisons, we used the Mann-Whitney U test, while the Wilcoxon test was used for continuous data before-after data and the Pearson chi-square or Fisher exact test was used for categorical data. To determine independent predictors for dependent (postoperative TR) variable, univariate (Crude) and multivariable (adjusted) logistic regression analyses were used. Candidate predictors (confounders) of multivariable were selected according to the literature and consensus opinion by an expert group of physicians as follows: sex, baseline, and persistent atrial fibrillation (AF), baseline ejection fraction % (EF%), baseline diameter of tricuspid annulus, no-TV repair (reference TV repair), and rheumatic etiology.^[9]

The PS adjusted by mixed logistic regression model after PS matching was used. To obtain the PS, we fitted the multivariable logistic regression analysis with the preoperative moderate-to-severe TR as the outcome conditional on the following covariates: body surface area (BSA), age, CPB, neurological

complications, ventilation time (h), the length of ICU (day), and hospital stay (day), in-hospital mortality, and late mortality. The nearest-neighbor 1:1 matching algorithm was used with callipers of 0.25 SDs of the logit of the PS. To find predictors of postoperative TR, a mixed (conditional) logistic regression model was performed (double robust).^[9,14] A *p* value of <0.05 was considered statistically significant with 95% confidence interval (CI).

RESULTS

Of the patients, 78 comprised the no-TV repair group and 79 comprised the TV repair group. Comparison of baseline clinical and echocardiographic parameters between the TV repair and no-TV repair groups are shown in Table 1. Demographic data were mostly similar between the groups. However, AF was significantly lower in the no-TV repair group ($p<0.001$). The TV repair group had a significantly longer duration of CBP ($p=0.003$). There were no significant differences in valvular etiology between the groups ($p=0.81$).

The no-TV repair group had significantly decreased pulmonary artery pressure (PAP) and decreased TR degree ($p<0.001$). Additionally, the no-TV repair group had a significantly smaller tricuspid annulus diameter (TAD), and a smaller left atrial diameter (LAD) ($p<0.001$ and $p=0.002$, respectively). The baseline echocardiography characteristics are shown in Table 1.

No significant differences were noted between the groups concerning potential complications and mortality. Neurological complications (postoperative delirium, trans-ischemic attack, cerebrovascular event) did not significantly differ between the groups ($p=0.48$). On the other hand, the duration of mechanical ventilation and ICU stay was significantly shorter in the no-TV repair group ($p=0.005$ and $p<0.001$, respectively). The TV repair group had a lesser degree of TR ($p=0.004$). Comparison of postoperative clinical and echocardiographic parameters between the TV repair and no-TV repair groups are shown in Table 2.

The 3D Ring repair and De-Vega repair were analyzed, and the patients who had 3D Ring repair showed significantly decreased postoperative TR ($p=0.01$).

Both groups were analyzed in the PS analyses, after the PS matched analysis of the no-TV repair group ($n=76$) and the TV repair group ($n=76$). The baseline characteristics, the length of postoperative ICU and hospital stay, ventilation time and mortality are shown in Table 3. A total of 76 patients had

Table 1. Comparison of baseline clinical and echocardiographic parameters between the TV repair and no-TV repair groups

Variables	All-patients (n=157)			No-TV repair group (n=78)			TV repair group (n=79)			p			
	n	%	Median	25 th -75 th percentiles	n	%	Median	25 th -75 th percentiles	n		%	Median	25 th -75 th percentiles
Age (year)	83	52.9	52	43-63	41	52.6	51	43.3-62	42	53.2	54	43-64	0.48
Sex													0.94
Female													
BMI (kg/m ²)	16	10.2	26	23-29	9	11.5	26	23-30	7	8.9	26	23.5-29	0.93
BSA (m ²)	33	21	1.79	1.66-1.93	17	21.8	1.77	1.65-1.93	16	20.3	1.82	1.66-1.93	0.27
DM	25	12.1			13	16.7			32	43			0.58
HT													0.81
AF													<0.001
Dominant diagnosis													0.13
AS-MS	21	13.4			10	12.8			11	13.9			
AR-MR	46	29.3			17	21.8			29	36.7			
AS-MR	48	30.6			25	32.1			23	29.1			
AR-MS	42	26.8			26	33.3			16	20.3			
CPB (min)	82	52.2	182	152-226	40	51.3	175	136-211	42	53.2	194	167-233	0.003
Rheumatic aetiology													0.81
Echocardiographic characteristics													
EF%													
Degree of MR			60	50-65			60	55-65			58	50-65	0.17
Mitral mean gradient (mmHg)			3	2-4			3	2-3.5			3	2-4	0.14
Mitral max gradient (mmHg)			9	6-14			7.5	5.25-11			10	8-17.8	0.008
Aortic mean gradient (mmHg)			19	14-27			15.5	12-23			21.5	16.3-27.8	0.02
Aortic max gradient (mmHg)			40	25-50			38	27-50			41	25-49	0.81
Aortic max gradient (mmHg)			61	44-78			60	44-75			64	43-80	0.62
MVA (cm ² , in MS)			1.3	1.1-1.6			1.39	1.10-1.66			1.36	1.1-1.51	0.63
Diameter of tricuspid annulus (cm)			3.9	3.8-4			3.9	3.4-3.9			4	4-4.2	<0.001
Degree of TR (median)			2	2-3			1	1-1			2	1-3	<0.001
Aortic regurgitation			3	2-4			3	3-4			3	2-3.5	0.03
Mild TR	87	55.4			66	84.6			22	27.8			<0.001
Moderate	44	28			12	15.4			32	40.5			
Severe	26	16.6			0	0			25	31.6			
LVEDD (cm)			5.2	4.7-6			5.2	4.6-6.1			5.2	4.7-5.9	0.36
LVESD (cm)			3.5	3-4.3			3.5	3-4.3			3.5	3-4.3	0.80
IVSD (cm)			1.1	1-1.3			1.1	1-1.4			1.1	1-1.3	0.42
LAD (cm)			4.6	4.2-5.1			4.35	4.2-4.8			4.7	4.4-5.2	0.002
PAP (mmHg)			48	35-60			40	35-50			55	45-65	<0.001
AVA (cm ² , in AS)			0.8	0.75-1.1			0.78	0.75-1.1			0.80	0.72-1.10	0.68

TV: Tricuspid valve; BMI: Body mass index; BSA: Body surface area; DM: Diabetes mellitus; HT: Hypertension; AF: Atrial fibrillation; AS: Aortic stenosis; MS: Mitral stenosis; AR: Aortic regurgitation; MR: Mitral regurgitation; CPB: Cardiopulmonary bypass; EF: Ejection fraction; MVA: Mitral valve area; TR: Tricuspid regurgitation; LVEDD: Left ventricular end-diastolic diameter; LVESD: Left ventricular end-systolic diameter; LAD: Left-atrial diameter; PAP: Pulmonary artery pressure; AVA: Aortic valve area; IVSD: Interventricular septum diameter; Mann-Whitney-U: Categorical variables comparison with chi-square test.

Table 2. Comparison of postoperative clinical and echocardiographic parameters between the TV repair and no-TV repair groups

Variables	All patients				No-TV repair group			TV repair group			p		
	n	%	Median	25 th -75 th percentiles	n	%	Median	25 th -75 th percentiles	n	%		Median	25 th -75 th percentiles
Baseline AF-continue AF	11	7			2	2.6			9	11.4			0.03
Baseline AF-free AF	25	15.9			9	11.5			16	20.3			0.13
PVL aortic	3	1.9			2	2.6			1	1.3			0.62
PVL mitral	3	1.9			1	1.3			2	2.5			0.99
PVL combined	1	0.6			0	0			1	1.3			0.99
Valvular thrombosis aortic	1	0.6			1	1.3			0	0			0.50
Valvular thrombosis mitral	2	1.3			0	0			2	2.5			0.49
IE	1	0.6			0	0			1	1.3			0.99
In-hospital mortality	5	3.2			3	3.8			2	2.5			0.68
Late mortality	20	12.7			7	9			13	16.5			0.16
Ventilation time (h)			13	9-18			11	8-14			15	10-19	0.005
Duration of ICU (day)			2	2-4			2	1-4			3	2-5	<0.001
Duration of hospital stay (day)			11	8-16			10	8-15			12	8.5-16	0.25
Follow-up duration (year)			3.3	2.3-4.45			4.03	3.1-4.54			2.73	2-3.98	<0.001
Neurological complication (delirium-TIA-CVO)	19	12.1			8	10.3			11	13.9			0.48
Echocardiographic characteristics													
EF%			55	50-65			60	50-64			55	50-65	0.62
Mitral mean gradient (mmHg)			6	4-7			5	5.5-7			6	4-7	0.85
Mitral max gradient (mmHg)			12	10-14			12	10-13			13	10-15	0.26
Aortic mean gradient (mmHg)			14	11-17			14	11-18			13.5	10.8-17	0.96
Aortic max gradient (mmHg)			25	20-31			25	20-30.5			25	20-31	0.86
MVA (cm ²)			2.5	2.3-2.6			2.5	2.3-2.6			2.5	2.3-2.6	0.47
Mild TR	115	73.2			50	64.1			65	82.3			0.004
Moderate TR	16	10.2			14	17.9			2	2.5			
Severe TR	26	16.6			14	17.9			12	15.2			
LVESD (cm)			5	4.6-5.4			4.85	4.60-5.40			5	4.6-5.4	0.26
LVESD (cm)			3.3	3-4			3.2	3-3.7			3.4	3-4	0.24
IVSD (cm)			1.1	1-1.2			1.1	1-1.2			1.1	1-1.2	0.43
LAD (cm)			4.5	4.2-4.8			4.5	4.2-4.8			4.5	4-4.9	0.63

TV: Tricuspid valve; AF: Atrial fibrillation; PVL: Paravalvular leak; IE: Infective endocarditis; ICU: Intensive care unit; TIA: Transient ischemic attack; CVO: Cerebro-vascular event; EF: Ejection fraction; MVA: Mitral valve area; TR: Tricuspid regurgitation; LVESD: Left ventricular end-diastolic diameter; LVESD: Left ventricular end-systolic diameter; IVSD: Interventricular septum diameter; LAD: Left-atrial diameter; Mann-Whitney-U: Categorical variables comparison with Chi-Square Test.

Table 3. Baseline characteristics, postoperative ICU duration and hospital stay, ventilation time and mortality

Variables	Unmatched						Matched						
	No-TV repair group (n=78)			TV repair group (n=79)			No-TV repair group (n=76)			TV repair group (n=76)			
	n	%	Median	25 th -75 th percentiles	n	%	Median	25 th -75 th percentiles	n	%	Median	25 th -75 th percentiles	p
Age (year)	51		51	43-64	51		51	44-62	53		53	43-62	0.76
CBP (min)	175		175	167-233	175		175	134-214	194		194	170-233	0.16
BSA	1.77		1.77	1.65-1.93	1.81		1.79	1.65-1.92	1.81		1.81	1.66-1.93	0.14
Neurological complication (delirium-TIA-CVO)	8	10.3			11	13.9			8	10.5			0.48
Ventilation time (h)	11		11	8-14	15		12	8-15	15		15	10-18	0.08
Duration of ICU (day)	2		2	1-4	3		2	1-3	3		3	2-5	0.02
Duration of hospital stay (day)	10		10	8-15	12		11	8-15	12		12	9-16	0.29
In-hospital mortality	3	3.8			2	2.5			3	3.9			0.68
Late mortality	7	9			13	16.5			7	9.2			0.16

ICU: Intensive care unit; TV: Tricuspid valve; CBP: Cardiopulmonary bypass; TIA: Transient ischemic attack; CVO: Cerebrovascular event.

baseline mild-to-moderate TR with no-TV repair, 27 of whom (35.5%) had postoperative elevated TR (>2+). In a PS matched subgroup analysis, the patients who had baseline mild-to-moderate TR with no-TV repair were analyzed in the logistic regression model. Instead of univariable screening, we used the clinically significant parameters in the current literature.^[12] Table 4 shows the predictors of postoperative progression of TR in the subgroups (the patients who had preoperative mild/moderate TR in the no-TV repair group). The relationship between eight predictors and moderate and severe TR was also examined in the adjusted model. Among variables, rheumatic etiology was significantly different for progression of TR on univariable analyses (p=0.007, odds ratio [OR]: 4.14, 95% CI: 1.47-11.63). In the multivariable analyses, rheumatic etiology was an independent factor for postoperative progression of TR (p=0.01, OR: 4.14, 95% CI: 1.34-12.76).

Table 5 shows all groups' conditional multivariable logistic regression analyses (PS data). The logistic regression model was used to seek the relationship across six candidate predictors for the presence of progression of TR. No-TV repair (p=0.006, OR: 3.72, 95% CI: 1.45-9.56) and rheumatic etiology (p=0.004, OR: 3.40, 95% CI: 1.49-7.81) were independently associated with the presence of progression TR in all groups. Figure 1 shows common support of the PS matched data distributions.

The TV repair and no-TV repair groups had similar survival rates (p=0.32) (Figure 2).

DISCUSSION

Tricuspid valve repair in mild-to-moderate TR patients with concomitant left-sided valve surgery is still challenging.^[6] In the present study, we investigated the factors affecting functional TR outcomes, compared TV repair and no-TV repair groups following DVR, and analyzed patients with no-TV repair mild-to-moderate TR as a subgroup. The two groups had similar potential complications and mortality rates. No-TV repair was associated with the progression of TR in the multivariable analysis. The main finding of the current study was the rheumatic valvular disease, being an independent marker for the progression of TR, which remains to be an important problem for healthcare professionals in Türkiye.^[15] In the subgroup analysis for the baseline mild-to-moderate TR in the no-TV repair group, rheumatic etiology was an independent factor for progression of TR.

Tricuspid valve interventions carried out simultaneously with left-sided valve surgery have been recommended for patients with severe TR; however,

Table 4. Logistic regression analyses (propensity matched data); Predictive of postoperative progression of (moderate-to-severe) TR in the subgroup (the patients who had preoperative mild-to-moderate TR in the no-TV repair group)

Variables	Univariable			Multivariable		
	OR	IQR	<i>p</i>	OR	IQR	<i>p</i>
Age (from 42-62)	1.02	0.98-1.06	0.27			
Sex (male reference)	2.45	0.92-6.53	0.07	1.70	0.59-4.95	0.32
Baseline/continue AF	1.84	0.11-30.74	0.67	1.30	0.06-27.25	0.86
Baseline EF% (from 51 to 65%)	1.02	0.96-1.07	0.58			
Baseline diameter of tricuspid annulus (from 3.4-3.9)	1.60	0.38-6.65	0.52	2.66	0.59-11.95	0.20
Rheumatic etiology	4.14	1.47-11.63	0.007	4.14	1.34-12.76	0.01
Baseline LVEDD (from 4.7 to 6 cm)	0.65	0.37-1.13	0.12			
Baseline LVESD (from 3 to 4.3)	0.72	0.43-1.22	0.23			

OR: Odds ratio; IQR: Interquartile range; TR: Tricuspid regurgitation; TV: Tricuspid valve; AF: Atrial fibrillation; EF: Ejection fraction; LVEDD: Left ventricular end-diastolic diameter; LVESD: Left ventricular end-systolic diameter.

Table 5. Conditional multivariable logistic regression analyses in all groups (propensity matched data)

Variables	OR	%95 CI	<i>p</i>
Sex (male reference)	1.36	0.61-3.06	0.45
Rheumatic etiology	3.40	1.49-7.81	0.004
Baseline/continue AF	1.58	0.34-7.37	0.56
Baseline diameter of tricuspid annulus (from 3.8 to 4.1)	1.46	0.74-2.85	0.27
Baseline EF%	0.99	0.95-1.04	0.77
No-TV repair (reference repair)	3.72	1.45-9.56	0.006

CI: Confidence interval; TV: Tricuspid valve; TR: Tricuspid regurgitation; AF: Atrial fibrillation; EF: Ejection fraction; Prediction of postoperative progression of (moderate-to-severe) TR in all groups.

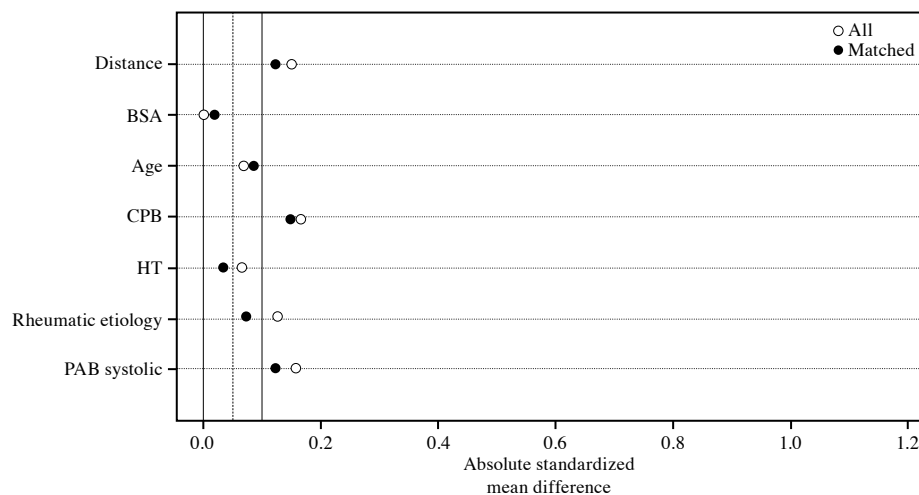


Figure 1. Common support of the PS matched data distributions.

BSA: Body surface area; CPB: Cardiopulmonary bypass; HT: Hypertension; PAB: Pulmonary artery pressure.

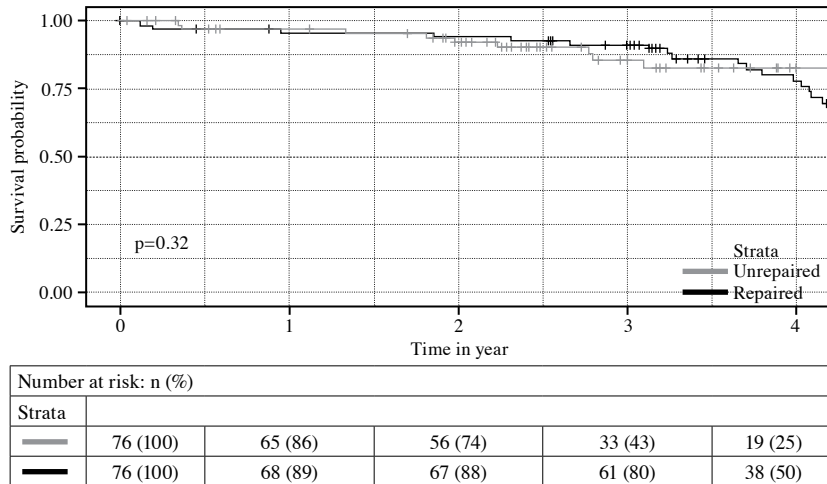


Figure 2. Survival rates of according to the groups.

similar interventions in patients with less than moderate TR are challenging.^[16,17] Mitral valve replacement performed concomitantly with the intervention of mild-to-moderate functional TR may protect from increased TR postoperatively and may improve clinical outcomes.^[17] Late severe TR was more likely to occur following DVR than isolated aortic valve replacement.^[2,3] Survival rates were reported to be similar between TV repair and unrepaired groups.^[18] Our study found no significant difference between the groups concerning mid-term survival, potential complications, and mortality. No-TV repair was associated with the progression of TR. Additionally, we analyzed the baseline mild-to-moderate TR in the no-TV repair subgroup and found that rheumatic etiology was an independent factor for the progression of TR.

The 2020 American College of Cardiology (ACC) and American Heart Association (AHA) guidelines recommend that TV surgery may be of benefit for patients with progressive TR (Stage B) performed left-sided valve surgery: (i) TAD (tricuspid annulus end-diastolic diameter >4.0 cm) or (ii) early findings and symptoms of right-sided heart failure (Class 2a).^[7] The 2021 European Society of Cardiology (ESC)/European Association for Cardio-Thoracic Surgery (EACTS) Guidelines for the management of valvular heart disease recommend that tricuspid surgery should be considered in patients undergoing left-sided valvular surgery who have mild or moderate TR with a dilated TAD (≥ 40 mm or >21 mm/m² by two-dimensional echocardiography) (Class 2a, Level B).^[19] It is still controversial whether to repair the TV for mild-to-moderate functional TR while

performing left-sided valve surgery.^[6] Nonetheless, TR may improve after successful MV surgery, but the TV repair is recommended, even if it is a mild TR.^[2] We performed TV repair in patients with moderate-to-severe and severe TR and patients who had a dilated TV annulus (≥ 40 mm) with mild TR.^[10,11] and found that the no-TV repair was independently associated with progression of TR at the follow-up.

The markers for late TR, including AF, LAD, and impaired right ventricular function, were reported after left-sided valve surgery.^[6] The baseline right atrial diameters were predictive factors, a finding consistent with the current study.^[20] Wang et al.^[21] reported that AF, enlarged left atrium, rheumatic etiology, baseline +2 or +3 TR, rheumatic etiology, low EF, increased right atrial pressure, and isolated MV disease were important risk factors for development of TR. Jeong et al.^[22] found that the female sex was associated with increased TR. We found no significant differences in sex, AF and TAD; however, rheumatic etiology was an independent factor for the progression of TR in the logistic regression analyses. Patients with mild-to-moderate TR with no-TV repair were analyzed, and rheumatic etiology was associated with the progression of TR.

In addition, MV surgery accompanied by tricuspid ring annuloplasty yielded satisfactory early results in rheumatic disease.^[23] Resisting sinus rhythm is the key to preventing late TR progression.^[17] The postoperative TR grade decreases with TV repair. The two groups were found to have similar operative mortality and complications rates. Cardiovascular surgeons often do not consider any intervention to the TV in patients with an annulus diameter of <40 mm and mild-to-moderate TR with the thought that the ensuing reduction in

volume load following the correction of additional valve pathologies would suffice to reduce the degree of TR.^[3] While evaluating the right ventricular volume load, the grade of TR may show differences that mild TR may become trivial or almost none TR. Thus, repair of the mild TR becomes controversial.^[24] Navia *et al.*^[9] investigated left-sided valve surgery in degenerative heart disease and suggested a TV repair for moderate TR to avoid right ventricular dysfunction. They showed the parameters for assessing right ventricular impairment, dilation of the right ventricle and the right atrium, TV tethering distance, AF, hyperbilirubinemia, and female sex. A most recent meta-analysis reported that repair of mild or moderate TR accompanied by left-sided valve surgery might result in favorable long-term clinical outcomes.^[25]

There are many limitations in this study, including its single-center and retrospective design with a relatively small cohort and mid-term follow-up period. Further multi-center, prospective studies are needed to clarify the need for interventions to the TV.

In conclusion, this propensity score matched analysis demonstrated rheumatic etiology was an independent marker for progression of tricuspid regurgitation, and it was also independently associated with progression of tricuspid regurgitation in patients with mild-to-moderate no-tricuspid valve repair tricuspid regurgitation. The postoperative tricuspid regurgitation grade decreased with TV repair. Both groups were found to have a similar operative mortality rate and potential complications. Although the grade of tricuspid regurgitation did not significantly impact the survival of both groups, worsening tricuspid regurgitation is known to adversely affect the patient's quality of life. Considering all these, the authors speculate that tricuspid valve repair may be considered for mild-to-moderate tricuspid regurgitation, particularly in the presence of rheumatic etiology.

Ethics Committee Approval: The study protocol was approved by the University of Health Sciences, Kosuyolu Higher Specialized Educational and Research Hospital Ethics Committee (2021/13/538). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Wrote the paper - R.A., Statistical analyses - A.K., Collected the data - D.Ç., Statistical analyses - M.D., Collected the data - H.H., Design - A.K., M.B.R.

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