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Influence of Tricuspid Regurgitation After Heart Transplantation: A Single-center Experience

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Background. Tricuspid valve regurgitation (TVR) is often observed after orthotopic heart transplantation. However, there is a scarcity of data regarding long-term outcomes of patients with TVR. **Methods.** Between January 2008 and December 2015, 169 patients underwent orthotopic heart transplantation at our center and were included in this study. TVR trends and associated clinical parameters were retrospectively analyzed. TVR was assessed after 30 d, 1 y, 3 y, and 5 y, and groups were defined according to changes in TVR grade: constant (group 1; n = 100), improvement (group 2; n = 26), and deterioration (group 3; n = 43). Survival, outcome with regard to operative technique, and long-term kidney and liver function during follow-up were assessed. **Results.** Mean follow-up time was 7.67 ± 4.17 y (median 8.62, Q1 5.06, Q3 11.16). Overall mortality was 42.0%, with differences between the groups ($P < 0.01$). Cox regression analysis revealed improvement of TVR as a significant predictor for survival (hazard ratio 0.23; 95% confidence interval, 0.08-0.63, $P < 0.01$). After 1 y 2.7%, after 3 y 3.7%, and after 5 y 3.9% of the patients showed persistent severe TVR. Creatinine levels after 30 d and 1, 3, and 5 y showed significant differences between the groups ($P = 0.02$, $P < 0.01$, $P < 0.01$, and $P = 0.01$), deterioration of TVR being associated with higher creatinine levels during follow-up. **Conclusions.** Deterioration of TVR is associated with higher mortality and renal dysfunction. Improvement of TVR may function as a positive predictor for long-term survival after heart transplantation. Improvement of TVR should be a therapeutic goal offering a prognostic value for long-term survival.

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Outcomes after orthotopic heart transplantation, the gold-standard therapy for end-stage heart failure, have significantly improved since the first transplantation in 1967.[1,2] Median survival of patients who received heart transplantation during the last 2 decades has reached 12.5 y. Besides allograft vasculopathy and infectious complications, tricuspid valve regurgitation (TVR) in the allograft has been associated with decreased long-term survival.[3,4] TVR is the most common valvular complication in patients after cardiac transplantation, with a reported incidence of up to 84%.[5] Approximately 34% of these patients experience a decreased quality of life because of symptoms like fatigue, dyspnea, arrhythmias, peripheral edemas, or cirrhosis cardiaque as a result of moderate or severe regurgitation.[3,6] The cause of TVR after heart transplantation remains to be the subject of discussion: number of biopsies, disturbances in the geometry of the tricuspid valve or the right ventricle because of anastomotic technique, preoperative recipient pulmonary vascular resistance, ischemic time of the donor heart, sex of donor and recipient, donor–recipient size mismatch, or the presence of TVR in the donor heart have all been argued to influence TVR after cardiac transplantation.[7,8] There is no consensus on whether prophylactic simultaneous or 2-staged management of the tricuspid valve during heart transplantation is beneficial.[3,9] Surgical management options include Carpentier's ring annuloplasty, De Vega technique, and valve replacement.[10-12] Other publications postulate that, in most cases, significant TVR improves within the first postoperative year after transplantation without intervention.[2]

The aim of this study was to compare alterations in TVR, with and without surgical correction, and its influence on long-term mortality and morbidity after 1, 3, and 5 y of close monitoring.

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MATERIALS AND METHODS

Out of 200 patients who underwent orthotopic heart transplantation at our institution between January 2008 and December 2015, 169 patients were included in the analysis. Thirty-one patients were excluded because of missing or incomplete follow-up information (n = 13) or death within 30 d after transplantation (n = 18). This study was performed in accordance with the ethical standards of the Declaration of Helsinki. Approval was granted by the institutional review board of Heidelberg University (ethics approval number: S-286/2015, version 1.2, July 28, 2020). We obtained written informed consent from patients for their inclusion in the Heidelberg HTX Registry and the clinical and scientific use of their data. The ethics approval does not require additional consent for this observational study because only routine clinical data were used. Clinical data from preoperative workups, operative notes, intensive care notes, and follow-up assessments were retrospectively recorded in the clinical database and analyzed.

As per protocol, all patients received a predischarge transthoracic echocardiogram and regular clinical and echocardiographic assessments during outpatient visits. TVR was assessed with transthoracic echocardiography according to the German Society of Cardiology Echocardiography criteria after 30 d, 1 y, 3 y, and 5 y.[13] Groups were defined according to changes in TVR grade in transthoracic echocardiography over the course of the first 5 y after heart transplantation: constant (group 1; n = 100), improvement (group 2; n = 26), and deterioration (group 3; n = 43). Of the included patients, no patient was lost to follow-up.

The primary end points of this study were survival at 1, 3, and 5 y after transplantation. Secondary end points were influence of changes in TVR grade postoperatively on need for posttransplant tricuspid valve intervention, incidence of kidney and liver dysfunction, and right and left heart function.

Percentages are reported for categorical variables. Continuous measures are summarized with median and interquartile ranges or mean with SD. The Pearson χ^2 was used when appropriate to test for differences in categorical variables. One-way ANOVA was used to assess differences in continuous variables. Kaplan-Meier analysis of survival with log-rank testing for statistical significance was conducted. Cox proportional hazards regression models were used to establish predictors for survival. A P value of <0.05 was considered statistically significant. Statistical analysis was performed using SPSS, version 28.0 (IBM Statistics, Armonk, NY), and GraphPad Prism, version 9.0 (GraphPad Software, San Diego, CA).

RESULTS

Patient Characteristics

Patient preoperative characteristics are shown in Table 1. Median age was 54 (47–59) y. No statistical differences in age, height, or weight ($P = 0.35$, $P = 0.26$, and $P = 0.67$) were detectable between groups. The cohort comprises predominantly male patients (78.7%). Underlying diseases included dilated cardiomyopathy (DCMP) (n = 99; 58.6%), ischemic cardiomyopathy (n = 40; 23.7%), congenital heart disease (n = 5; 3.0%), cardiomyopathy after myocarditis (n = 2; 1.2%), restrictive cardiomyopathy (n = 4; 2.4%), amyloidosis (n = 11; 6.9%), and arrhythmogenic right ventricular (RV) dysplasia (n = 2; 1.2%). Most patients who later showed an improved TVR had DCMP (69.2%), and no improvements were observed in patients with a congenital cause or amyloidosis. Most patients with congenital heart disease or amyloidosis showed constant or deteriorating TVR. However, no statistical significance was detectable ($P = 0.19$). Kidney and liver functions were similar in the entire cohort, with no differences between groups. Mean pulmonary artery pressure (PAP_{mean}) in pretransplantation right heart catheter was 31.53 ± 8.49 mm Hg in patients with constant TVR, 33.40 ± 8.07 mm Hg in patients with improving TVR, and 31.44 ± 8.80 mm Hg in patients with deterioration of TVR. No statistical difference was found ($P = 0.59$). Pulmonary vascular resistance in pretransplantation right heart catheter was 2.67 ± 1.52 Wood Units (group 1), 2.63 ± 1.30 Wood Units (group 2), and 2.86 ± 1.36 (group 3) with no differences between groups ($P = 0.73$). Mean follow-up time was 7.67 ± 4.17 y (median 8.62 y, Q1 5.06 y, Q3 11.16 y).

Surgical Procedure

All patients received orthotopic heart transplantation through a median sternotomy. The Shumway technique (biatrial) was used in 29 patients (17.3%.), and 139 patients (82.7%) were transplanted using the bicaval technique. Ischemic time was 263.3 ± 54.5 min. Overall mortality was similar after both surgical techniques (log-rank $P = 0.09$). Furthermore, logistic regression analysis showed no statistically significant impact of surgical techniques on long-term survival ($P = 0.10$). The surgical technique showed no statistical influence on the development of TVR in our cohort ($P = 0.47$). Ischemic time was similar ($P = 0.93$).

Survival After Heart Transplantation

At the end of the follow-up, 98 of 169 patients (58%) were still alive. Overall mortality over the entire study period was 42.0%, with significant differences between the groups ($P < 0.01$). Mortality in group 1 was 43.0%, in group 2 was 15.4%, and in group 3 was 55.8%. The 1-, 3-, and 5-y survival was 88.16%, 82.24%, and 76.92%, respectively. Survival differed significantly between groups, showing patients with improvement of TVR having a superior outcome ($P < 0.01$, Figure 1). Five years after transplantation, 88.46% of patients with improvement of TVR were alive, whereas 76.0% of patients with constant TVR and 65.12% of patients with deterioration were alive. Cox regression analysis revealed improvement of TVR as a significant predictor for survival (hazard ratio 0.23; 95% confidence interval, 0.08-0.63; $P < 0.01$).

Postoperative Transthoracic Echocardiography

In their predischarge transthoracic echocardiogram after 30 d, significant differences in mean TVR grade between the 3 groups were observed ($P < 0.01$, Table 2). After 30 d, 7.1% of the patients (12/169) showed severe TVR. In the regular clinical and echocardiographic assessments, after 1 y 2.7%, after 3 y 3.7%, and after 5 y 3.9% of the patients still showed severe TVR. TVR was constant in 100 patients (59.1%), improved in 26 cases (15.4%), and deteriorated in 43 patients (25.4%) during long-term follow-up (Figure 2). In Figure 3, left ventricular (LV) and RV function in transthoracic echocardiography is depicted. LV function did not differ between groups in the early follow-up period (after 30 d $P = 0.45$; 1 y $P = 0.95$; 3 y $P = 0.09$). After 5 y of follow-up, a significant difference in LV function was observed between the groups ($P = 0.01$).

TABLE 1.

Demographics and operative technique

	Constant (n = 100)	Improvement (n = 26)	Deterioration (n = 43)	Total (n = 169)	*P*
Age (y), median (IQR)	54.5 (47–59)	54.5 (50–58)	53 (47–59)	54 (47–59)	0.35
Height (cm), median (IQR)	175 (169-180)	172 (167-180)	175 (168-180)	175 (168-180)	0.26
Weight (kg), median (IQR)	75 (65.5-84.5)	78 (70-87)	76 (67-86)	75 (66-86)	0.67
Sex recipient, n (%)					
Male	**79 (79.0)**	**22 (84.6)**	**32 (74.4)**	**133 (78.7)**	0.60
Female	21 (21.0)	4 (15.4)	11 (25.6)	36 (21.3)	
Diagnosis, n (%)					
DCMP	**60 (60.0)**	**18 (69.2)**	**21 (48.8)**	**99 (58.6)**	0.19
ICMP	**24 (24.0)**	**7 (26.9)**	**9 (20.9)**	**40 (23.7)**	
Congenital	1 (1.0)	0 (0)	4 (9.3)	5 (3.0)	
CMP (myocarditis)	1 (1.0)	0 (0)	1 (2.3)	2 (1.2)	
CMP (restrictive)	1 (1.0)	1 (3.8)	2 (4.7)	4 (2.4)	
Amyloidosis	12 (12.0)	0 (0)	5 (11.6)	17 (10.1)	
ARVC	1 (1.0)	0 (0)	1 (2.3)	2 (1.2)	
Creatinine preop (mg/dL), mean ± SD	1.35 ± 0.60	1.43 ± 0.70	1.50 ± 0.72	1.40 ± 0.64	0.76
Bilirubin preop (mg/dL), median (IQR)	1.1 ± 0.7	1.6 ± 2.0	1.00 ± 0.6	1.2 ± 1.0	0.09
PAP_{mean} preop (mm Hg), mean ± SD	31.53 ± 8.49	33.40 ± 8.07	31.44 ± 8.80	31.79 ± 8.48	0.59
PVR preop (Wood Units), mean ± SD	2.67 ± 1.52	2.63 ± 1.30	2.86 ± 1.36	2.71 ± 1.45	0.73
Operative technique, n (%)					0.47
Shumway technique	18 (18.0)	6 (23.1)	5 (11.9)	29 (17.3)	
Bicaval	**82 (82.0)**	**20 (76.9)**	**37 (88.1)**	**139 (82.7)**	
Ischemic time (min), mean ± SD	265.4 ± 52.50	261.1 ± 54.60	265.9 ± 61.30	263.3 ± 54.50	0.93

Bold numbers to emphasize majorities.

ARVC, arrythmogenic right ventricular dysplasia; CMP, cardiomyopathy; DCMP, dilated cardiomyopathy; ICMP, ischemic cardiomyopathy; IQR, interquartile range; PAPmean, mean pulmonary artery pressure; preop, prrreoperative; PVR, pulmonary vascular resistance.

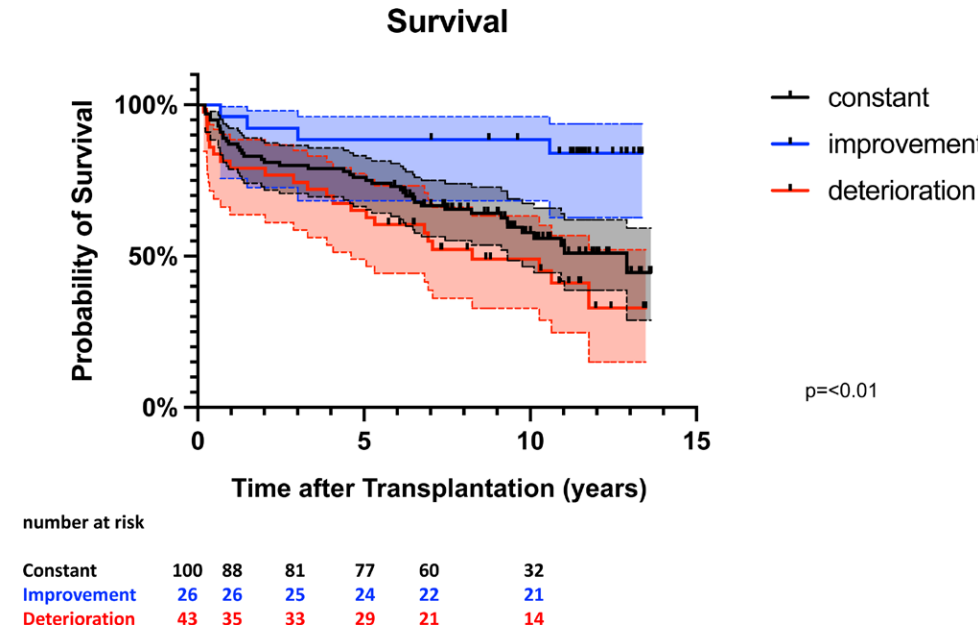

FIGURE 1. Kaplan-Maier survival for patients with constant vs improving vs deteriorating TVR after heart transplantation ($P < 0.01$). TVR, tricuspid valve regurgitation.

LV dysfunction was detected more often in patients with deterioration of TVR. RV function also worsened in patients with deterioration of TVR, showing significant differences between groups at 30 d, 3 y, and 5 y after heart transplantation ($P = 0.03$, $P < 0.01$, and $P < 0.01$).

Postoperative Characteristics

Postoperative kidney and liver functions were indirectly monitored through laboratory results of creatinine and bilirubin levels at 30 d, 1 y, 3 y, and 5 y after heart transplantation (Table 2; Figures 4 and 5). In the entire cohort, creatinine levels remained constant on slightly elevated levels of between 1.52 ± 0.80 and 1.66 ± 1.17 mg/dL (normal creatinine level, 0.6–1.4 mg/dL). Creatinine levels did not improve visibly in the group of patients with improvement in TVR. Groups differed in creatinine levels during monitoring. After 1 y, creatinine levels after 30 d and 1, 3, and 5 y showed significant differences ($P = 0.02$,

TABLE 2.

Outcomes

	Constant (n = 100)	Improvement (n = 26)	Deterioration (n = 43)	*P*
TVR grade 30 d postoperative, mean ± SD	0.23 ± 0.63	1.38 ± 1.10	0.67 ± 115	**<0.01**
Creatinine 30 d (mg/dL), mean ± SD	1.41 ± 0.67	1.48 ± 0.76	1.81 ± 1.03	**0.02**
Creatinine 1 y (mg/dL), mean ± SD	1.42 ± 0.53	1.54 ± 0.54	2.35 ± 2.08	**<0.01**
Creatinine 3 ye (mg/dL), mean ± SD	1.37 ± 0.50	1.47 ± 0.42	2.39 ± 2.21	**<0.01**
Creatinine 5 y (mg/dL), mean ± SD	1.42 ± 0.75	1.64 ± 0.89	2.25 ± 2.26	**0.01**
Bilirubin 30 d (mg/dL), mean ± SD	0.68 ± 0.33	1.04 ± 1.61	1.34 ± 3.32	0.15
Bilirubin 1 y (mg/dL), mean ± SD	0.72 ± 0.87	0.53 ± 0.21	0.52 ± 0.21	0.27
Bilirubin 3 y (mg/dL), mean ± SD	0.72 ± 0.77	0.57 ± 0.25	0.75 ± 0.50	0.57
Bilirubin 5 y (mg/dL), mean ± SD	0.68 ± 0.35	0.55 ± 0.18	0.64 ± 0.31	0.26
Dialysis after 1 y, n/N (%)	3/85 (3.5)	2/26 (7.7)	6/34 (17.6)	**0.03**
Dialysis after 3 y, n/N (%)	1/79 (1.3)	2/23 (8.7)	5/30 (21.9)	**<0.01**
Dialysis after 5 y, n/N (%)	2/75 (2.7)	2/23 (8.7)	5/29 (16.7)	**0.04**
ECMO after transplantation, n/N (%)	3/100 (3.0)	1/26 (3.8)	2/43 (4.7)	0.88
IABP after transplantation, n/N (%)	2/100 (2.0)	3726 (11.5)	3/43 (7.0)	0.09
Biopsy-proven cellular rejection, n/N (%)	35/100 (35.0)	12/36 (33.3)	13/43 (30.2)	0.43
CAV after 1 y, n/N (%)	17/86 (19.8)	5/25 (20.0)	9/33 (27.3)	0.66
CAV after 3 y, n/N (%)	24/79 (30.4)	6/23 (26.1)	17/32 (53.1)	**0.05**
CAV after 5 y, n/N (%)	28/76 (36.8)	7/22 (31.8)	14/28 (50.0)	0.36
Number of right heart biopsies, mean ± SD	7.59 ± 3.11	8.38 ± 3.53	7.14 ± 3.45	0.31
Posttransplant tricuspid valve reoperation, n/N (%)	1/100 (1.0)	0/26 (0)	5/38 (11.6)	**0.04**
Maintenance immunosuppression				
Tacrolimus, n/N (%)	66/100 (66.0)	16/26 (61.5)	31/43 (72.1)	0.65
Everolimus, n/N (%)	35/100 (35.0)	5/26 (19.2)	15/43 (34.9)	0.33
Mycophenolic acid, n/N (%)	74/100 (74.0)	24/26 (92.3)	32/43 (74.4)	0.14
Cyclosporin, n/N (%)	17/100 (17.0)	7/26 (26.9)	5/43 (11.6)	0.26
Azathioprine, n/N (%)	4/100 (4.0)	0/26 (0.0)	1/43 (2.3)	0.54

Bold numbers highlight statistical significance.
CAV, cardiac allograft vasculopathy; ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon pump; TVR, tricuspid valve regurgitation.

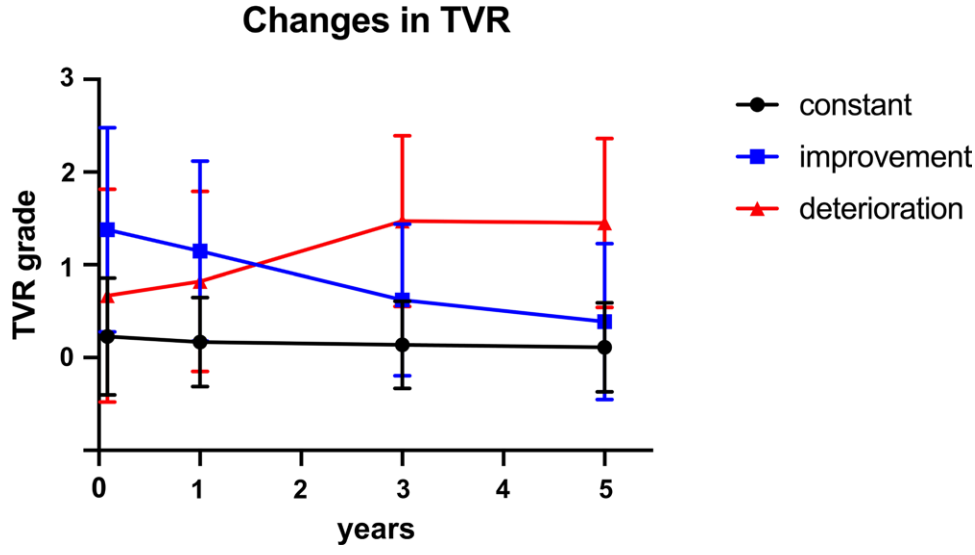

FIGURE 2. Changes in TVR assessed in transthoracic echocardiography in patients with constant, improvement, or deterioration of TVR during monitoring ($P = 0.01$). TVR, tricuspid valve regurgitation.

$P < 0.01$, $P < 0.01$, and $P = 0.01$) and deterioration of TVR being associated with higher creatinine levels in long-term follow-up. In addition, the need for dialysis after 1, 3, and 5 y was significantly higher in group 3 ($P = 0.03$, $P < 0.01$, $P = 0.04$). Bilirubin levels were constantly in normal ranges in the entire cohort without showing any tendencies toward worsening in the subgroups. Furthermore, no statistical differences were found between the groups. The need for ECLS/ECMO or IABP implantation after transplantation was comparable ($P = 0.88$ and $P = 0.09$). Biopsy-proven cellular rejection (grade 2R or higher) was assessed in 35.5% of the patients, with no differences between groups ($P = 0.43$). The incidence of cardiac allograft vasculopathy was higher in patients with deterioration of TVR after 1, 3, and 5 y (27.3%, 53.1%, and 50.0%), with statistical significance after 3 y ($P = 0.05$). During the entire

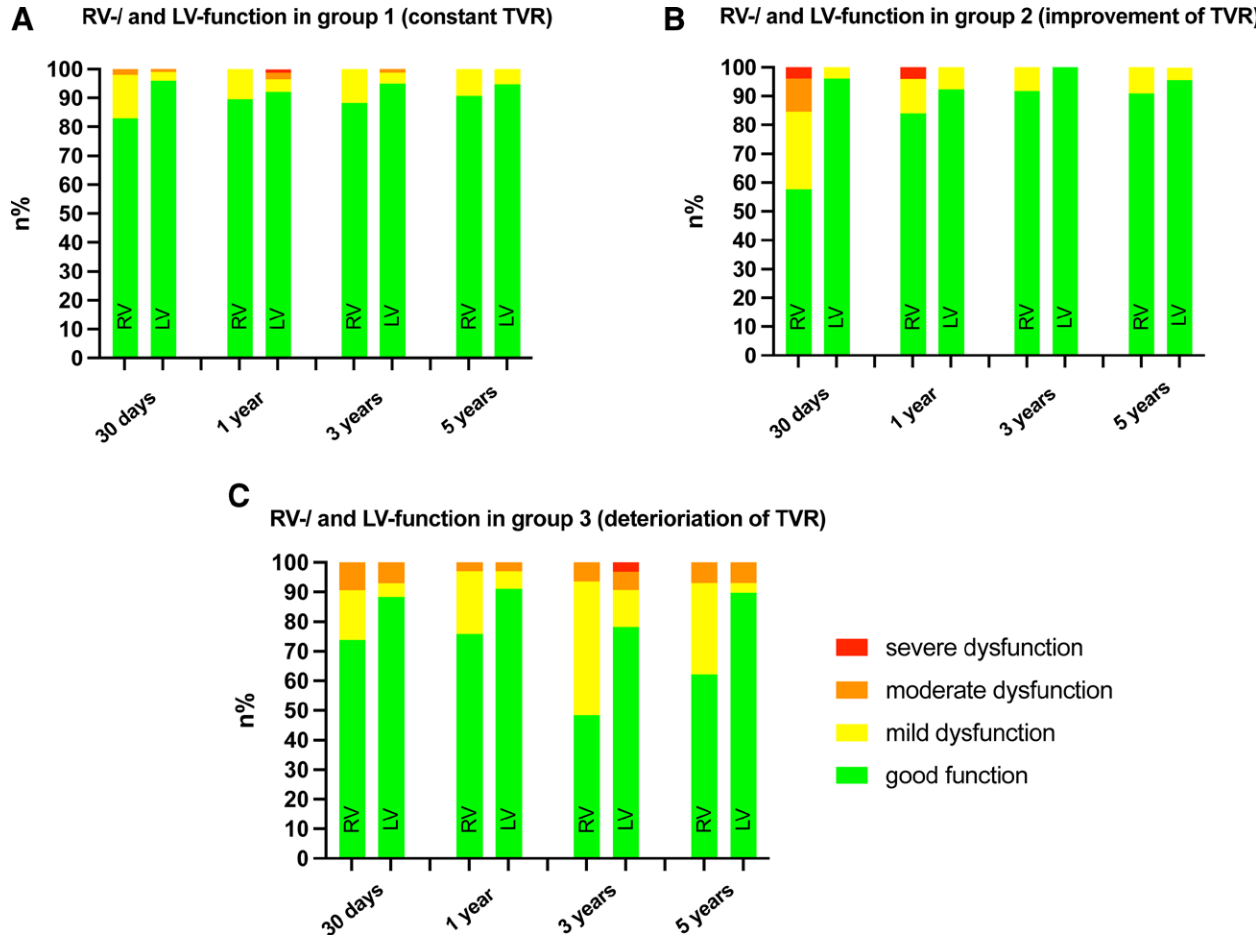

FIGURE 3. RV/LV function at 30 d, 1 y, 3 y, and 5 y assessed in transthoracic echocardiography for (A) group 1 (constant TVR), (B) group 2 (improvement of TVR), and (C) group 3 (deterioration of TVR). (LV function 30 d $P=0.45$, 1 y $P=0.95$, 3 y $P=0.09$, and 5 y $P=0.01$); (RV function 30 d $P=0.03$, 1 y $P=0.10$, 3 y $P<0.01$, and 5 y $P<0.01$). RV/LV, right and left ventricular; TVR, tricuspid valve regurgitation.

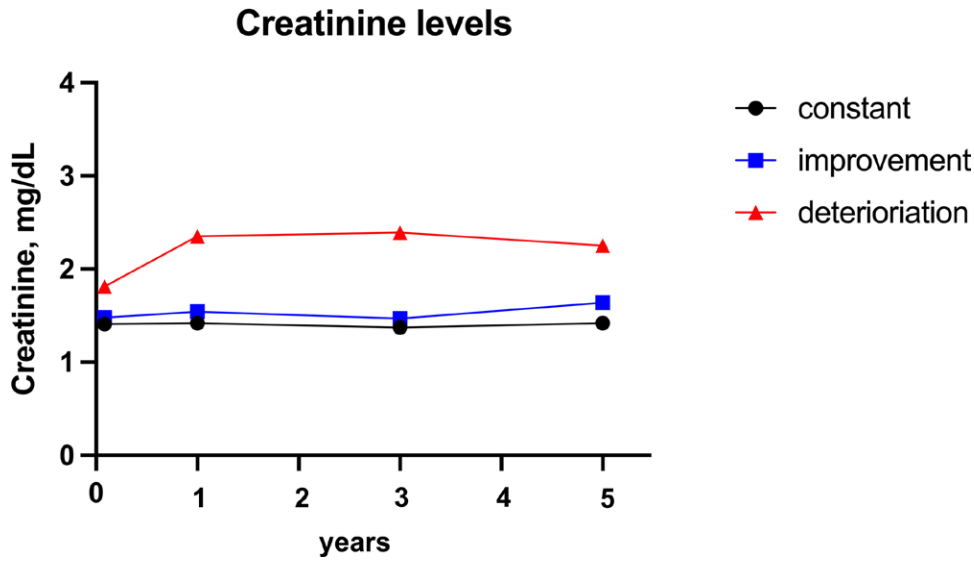

FIGURE 4. Development of creatinine levels in patients with constant, improvement, or deterioration of TVR during monitoring (30 d $P=0.02$, 1 y $P<0.01$, 3 y $P<0.01$, and 5 y $P=0.01$). TVR, tricuspid valve regurgitation.

follow-up period, 7.60 ± 3.27 endomyocardial biopsies per patient were performed, finding no significant relationship between TVR grade and number of right heart biopsies ($P=0.31$). In addition, no biopsy-related valvular injury was recorded. Overall, 6 patients (3.6%) underwent posttransplant tricuspid valve reoperation with significant differences between the 3 groups ($P=0.04$; Table 2). Five of these patients presented with deterioration of TVR (group 3), of whom all died during follow-up. All patients had similar immunosuppressive regimens.

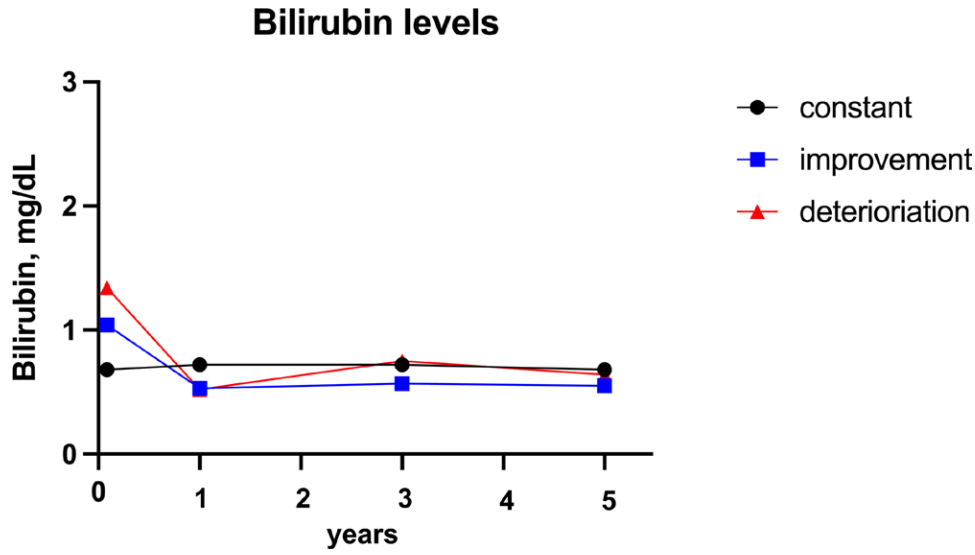

FIGURE 5. Development of bilirubin levels in patients with constant, improvement, or deterioration of TVR during monitoring (30 d $P=0.15$, 1 y $P=0.27$, 3 y $P=0.57$, and 5 y $P=0.26$). TVR, tricuspid valve regurgitation.

DISCUSSION

Long-term survival after orthotopic heart transplantation has continued to improve over the past decades.[2] However, the development of tricuspid regurgitation, as the most common valvular complication after heart transplantation, is associated with increased mortality and morbidity.[4,14] There is an ongoing debate about the management of TVR in heart transplant recipients, timing of repair, and technique used.[5,15] This study presents the influence of changes in TVR (constant, improvement, deterioration) on long-term survival and postoperative outcome. As expected, improvement of TVR was identified as a positive predictor for long-term survival after orthotopic heart transplantation, whereas deterioration led to impaired morbidity and higher mortality.

Despite the fact that other studies describe a relationship between the number of biopsies and TVR, in this cohort, an endomyocardial biopsy has no impact on worsening TVR because no differences between the groups were detected.[16] A study from Montreal showed a direct correlation between the number of biopsies and the grade of TVR and recommended to develop biopsy protocols with minimal numbers to reduce the risk of severe iatrogenic TVR.[17] In this study, they defined a cutoff of 31 biopsies and showed that no severe TVR was caused by ≤18 biopsies. In our cohort, <10 biopsies were performed per patient, intending to minimize the risk for iatrogenic TVR. Endomyocardial biopsies potentially lead to deterioration of TVR over the postoperative course; however, our data set does not reflect this, which might be because of the small number of biopsies performed. New assays for noninvasive rejection monitoring in solid organ transplantation, like continuous monitoring of donor-derived cell-free DNA, are potentially the future, hopefully decreasing the need for invasive monitoring of allograft rejection and possible damage to valvular structures even further. However, infrastructure and cover of costs for routine use of this method are still nonexistent in most centers.

Interestingly, the largest proportion of patients in our cohort with congenital heart disease showed constant or even deteriorating TVR, whereas patients with DCMP were predominantly in the groups with constant or improving TVR. This might be explained simply by the pathophysiology of these diseases. Our data suggest that patients who later develop deterioration of TVR had slightly higher pulmonary resistance measures before heart transplantation, albeit with no statistical significance. Patients with DCMP do not universally have high pulmonary pressure or RA/RV remodeling before transplant and, therefore, might have better RV function and TV morphology postoperatively, contrary to those in the congenital group.[18-20]

Deterioration of TVR has been associated with higher creatinine levels during long-term follow-up in our cohort. Our data set does not allow further analysis within specific years to differentiate which event occurred first, deterioration of the TVR or renal dysfunction, especially because both mechanisms seem reasonable. However, the need for dialysis after heart transplantation in the deterioration group was also significantly higher than in the other 2 groups, highlighting a relationship between deteriorating TVR and renal dysfunction. This is in accordance with other studies describing the association of severe TVR with renal dysfunction.[2,14] In addition, Jeevanandam et al[21] suggested to preserve renal function by performing concomitant De Vega annuloplasty of the donor heart during transplantation. However, this intervention had no influence on survival compared with standard transplantation without concomitant TR repair in this prospective study.

Our analysis revealed increased mortality for heart transplant recipients with constant or deterioration of TVR, which is in line with previous findings.[2,7,9] Patients with constant TVR showed intermediate survival relative to those whose TR either got better or deteriorated. Interestingly, TR grades over the course of follow-up remain low in patients with constant TR (all between no TVR and mild TVR), which are similar grades compared with TVR grades in the improvement group after 5 y. Still, mortality in the groups with constant TVR is higher. Furthermore, improvement of TVR proved to be a significant predictor for survival, raising the question of whether TVR needs to be addressed in heart transplant patients. In addition, our data suggest that the improved and deteriorating TVR groups seem to separate around the 3-y mark. This is the same time point in which there is a large difference in the degree of RV/LV dysfunction between the groups. Another finding

pointing in this direction is the difference in incidence of cardiac allograft vasculopathy after 3 y. Patients with deterioration of TVR were affected in >50% of the cases. This suggests that TVR is in part driven by nonspecific graft dysfunction, which is known to be a precursor for poor outcomes.[22]

In most cases, in our cohort, severe TVR was ameliorated with conservative therapy. This observation was also described by Bishawi et al.[2] However, when optimal medical therapy for improvement of LV and RV function hereby reducing RV diameter fails to improve TVR, surgical or transcatheter approaches might be assessed.

Redo cardiac surgery in heart transplant recipients has been proven to be possible with satisfactory short- and long-term results.[15,23] However, timing of surgical tricuspid valve repair or replacement is still the subject of discussions. Jeevanandam et al[21] recommend prophylactic De Vega tricuspid valve annuloplasty of the donor heart to improve renal function but fail to show significant improvement in survival. Concomitant tricuspid valve annuloplasty at the time of transplantation holds the risk of right heart failure directly after operation when pulmonary arterial hypertension is present because an existing TVR no longer serves as a "pop-off" valve.[24] Moderate or severe TVR in combination with pulmonary hypertension, on the other hand, is detrimental to RV function because it eventually leads to volume overload and right heart failure.[14,25] Other authors recommend a cautious and observing strategy for repair/replacement and determine whether surgery is necessary and beneficial for the patient.[26-29] It is imperative to select patients carefully because outcomes are best in patients in whom RV function is still preserved.[3] In this cohort, patients with deterioration of TVR often showed impaired RV function, raising the question as to whether timing for repair had been missed. Most of these patients later additionally showed LV dysfunction.

Studies reviewing the benefits of tricuspid valve repair or replacement in all symptomatic patients with TVR showed lower mortality and better quality of life after operation compared with medical treatment.[30,31] Tricuspid valve repair via annuloplasty is deemed favorable compared with replacement when no structural defect of the valve is present.[32-34] Ring annuloplasty has been shown to be superior to De Vega annuloplasty because the rate of recurrence of TR is significantly higher after De Vega technique as the annulus dilates in long-term follow-up.[10,35] Late after heart transplantation and with considerable structural defects of the leaflets, valve replacement is the therapy of choice.[36] In addition, transcatheter options have been emerging over the last years, offering treatment options for high-risk patients not suited for open heart surgery with satisfactory results in terms of 1-y mortality and rehospitalization rate.[16] Options include MitraClip (Abbott Vascular-Structural Heart, Menlo Park, CA) in tricuspid position, TriClip tricuspid valve repair system (Abbot, Chicago, IL), and Cardioband tricuspid system (Edwards Lifescience, Irvine, CA), each being preferred in different stages of RV function, annular dilation, and valvular structure.[37-39] Having multiple options available, careful selection of therapeutic strategy is mandatory.

This study, as do most similar studies mentioned in this article, shows the limitations of a retrospective analysis. The patient cohort was derived from 1 single center but was operated on by various surgeons with different preferences in technique. Furthermore, the echocardiographic examinations were conducted by different cardiologists and were based on their individual assessments. Therefore, the significance of the results should be regarded with care.

In conclusion, improvement of TVR proved to be a significant predictor for survival. Furthermore, deterioration of TVR has been associated with renal dysfunction. Improvement of TVR should be a therapeutic goal post–heart transplantation, offering a prognostic value for long-term survival. When the best medical therapy is insufficient to improve TVR and right heart function, surgical or transcatheter approaches may offer therapeutic alternatives. This study highlights the importance of early intervention, as in native tricuspid valvular disease, before the onset of severe RV dysfunction and pulmonary hypertension. Therefore, the current practice of monitoring and treating patients after heart transplantation should include early directed therapy of existing or developing regurgitation, avoiding higher grade regurgitation before its development. A thorough selection of therapeutic strategy, surgical or interventional, is mandatory regarding the patient´s characteristics, disease stage, and anatomical considerations. Transcatheter techniques provide effective alternatives for inoperable and high-risk patients.

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