Twenty-Five Year Outcomes of Tricuspid Valve Replacement Comparing Mechanical and Biologic Prostheses

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Background. **Tricuspid valve replacement (TVR) has historically been associated with high mortality and morbidity, and current knowledge of long-term results of TVR is limited. This study reviewed our experience from a consecutive series at 2 institutions.**

Methods. **Ninety patients (65 women [72%]; mean age, 53.8 ± 14.2 years; mean body surface area, 1.6 ± 0.2 m^2) underwent TVR between January 1980 and December 2005. The etiology was secondary to left-heart valve disease in 56 patients (62%), degenerative disease in 16 (18%), Ebstein anomaly in 7 (8%), and endocarditis in 11 (12%). Seventy patients (78%) were in New York Heart Association class III or IV. Sixty patients (67%) underwent redo procedures. TVR was with a mechanical valve in 46 patients (51%) and a biologic prosthesis in 44 (49%).**

Results. **The overall operative mortality was 17.7% (16 patients). During follow-up, 16 of the 74 survivors died. Kaplan-Meier survival at 5, 10, and 15 years was, respectively, 72%, 65%, and 63%. During follow-up, 16 patients (21.6%) underwent reoperation; among them, 8 with a mechanical valve underwent reoperation for tricuspid valve thrombosis and 6 with a biologic prosthesis for tricuspid valve deterioration. However, freedom from reoperation at 5 and 10 years was similar between mechanical (86% and 76%) and bioprostheses (97% and 83%). All 16 patients survived the reoperation.**

Conclusions. **The present experience suggests that the type of implanted prosthesis in the tricuspid position does not affect early and long-term outcomes or the reoperation rate. Timely referral before end-stage cardiac impairment develops could determine further outcomes improvement.**

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Tricuspid valve replacement (TVR) is rarely performed nowadays, especially compared with left-heart valves procedures, and is reserved for those few occasions where repair of the tricuspid valve is not feasible or attempts at repair have failed. TVR has historically been associated with high mortality and morbidity, and current knowledge of long-term results of TVR is limited [1–3]. With the refinement in surgical indications, myocardial protection, and perioperative and postoperative management, recent published series seem to demonstrate that TVR results are improving.

Debate still exists, however, regarding the valve of choice in the tricuspid position. Bioprostheses are generally preferable, but there are no data clearly showing the advantage of one type of tricuspid prosthesis over another. The aim of this study was to review our experience with patients who underwent TVR with a mechanical valve or a bioprosthesis during a 25-year period.

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Material and Methods

We retrospectively reviewed data of 90 consecutive patients who underwent TVR for different etiologies at 2 institutions during a 25-year period from January 1980 to December 2005. Data were extracted from the hospital's computerized database, with additional information obtained through retrospective record review. The Institutional Review Board approved the study and waived the need for informed consent in consideration of the retrospective nature of the study.

Patient Characteristics

Most patients (65 [72%]) were women, and the mean age at operation was 53.8 ± 14 years (range, 17 to 82 years). The etiology of tricuspid valve disease was secondary to left-heart valve disease (functional) in 56 patients (62%). Seventy patients (77.8%) were in New York Heart Association functional class III or IV before their operation. Dyspnea was present in 80 patients (89%), hepatic congestive symptoms in 44 (49%), and preoperative atrial fibrillation in 56 (62%). Sixty patients (67%) had under-

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gone previous cardiac operations, and 27 (30%) had undergone multiple previous operations.

All TVR procedures were performed through a midline sternotomy with cardiopulmonary bypass and mild hypothermia. Myocardial protection was achieved with antegrade cold crystalloid cardioplegia and topical heart cold irrigation. The tricuspid valve was replaced on cardiopulmonary bypass with the heart beating in 30 patients (33%) or under cardiac arrest with the aorta cross-clamped in 60 patients (67%). Whenever possible, the subvalvular apparatus was preserved to maximize as much as possible postoperative right ventricular function. Associated procedures were performed in 37 patients (41%). Among them, mitral valve replacement was performed in 18 patients, aortic valve replacement in 6, double-valve replacement in 4, and mitral valve repair in 6. Finally, direct suture of perivalvular mitral leak was performed in 3 patients.

Prosthesis Selection Criteria and Temporal Trend

Prosthesis selection was mainly according to the surgeon's preference. However TVR with a mechanical prosthesis was indicated in patients who already had a mechanical valve on the left side or in multiple redo patients where a "definitive strategy" was desirable. In drug abuser patients with tricuspid valve endocarditis we always implanted a bioprosthesis. Indeed, these patients often show poor long-term prognosis, poor compliance with oral anticoagulation therapy, and venous access is difficult. Figure 1 depicts the temporal trend of prosthesis selection and in-hospital mortality during the study period. In our experience, no switch toward more bioprostheses' implantation occurred for the tricuspid position during the study period. A slight trend toward a reduction of in-hospital mortality was evident in the last 5-year period but did not reach statistical significance (Table 1).

Mechanical vs Bioprostheses Groups

With respect to the type of prosthesis implanted, 46 patients (51%) underwent mechanical valve implantation, and 44 (49%) were implanted with a bioprosthesis. Preoperative and intraoperative characteristics of the two groups are summarized in Table 2. The two groups were comparable in mean age, etiology, symptoms, and echocardiographic variables. Compared with the mechanical group, the bioprostheses group had more men (36% vs 20%; $p = 0.061$) and more patients at New York Heart Association (NYHA) class III/IV (86% vs 69%; $p = 0.072$), although these differences did not reach statistical significance.

Among mechanical prostheses, a Bicarbon bileaflet valve (Sorin Biomedica, Saluggia, Italy) was implanted in 34 patients (74%) implanted, and in the bioprostheses group, the Carpentier-Edwards Perimount valve (Edwards Lifesciences, Irvine, CA, USA) was implanted in 33 (75%). Mean diameter of implanted valves was 28.4 ± 2.4 in the mechanical group and 28.9 ± 2.1 mm in the bioprostheses group ($p = 0.310$). All patients who received a mechanical valve were anticoagulated, with an international normalized ratio target of 3 to 3.5, especially if 2 or more valves were implanted. Patients who received a bioprosthesis were anticoagulated for 3 months and then switched to aspirin.

Statistical Analysis

Results are presented as mean values ± standard deviation. The paired two-sided Student *t* test was used for comparison of continuous variables. A Wilcoxon two-sample test was used for comparison of continuous variables where the examined samples were small in numbers with unknown distributions. Fisher exact test (two-tailed) was used for categoric variables. A value of *p* of less than 0.05 was considered statistically significant.

Continuous and dichotomous variables were examined with one-way analysis of variance and the Fisher exact test, respectively, to test potential univariate predictors of outcome (in-hospital mortality and long-term mortality). Preoperative and intraoperative variables included in univariate and multivariate analysis were age, sex, body surface area, NYHA class, dyspnea, liver congestion,

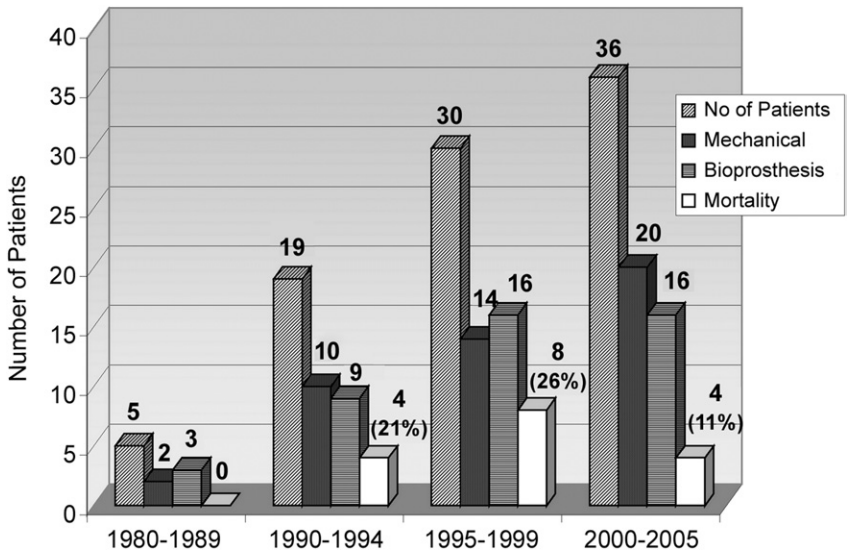

Fig 1. Tricuspid valve replacement: temporal distribution of patients, type of implanted prosthesis, and mortality rate.

Table 1. Preoperative and Intraoperative Characteristics Comparison Among Different Study Periods

Variable[a]	1980–89	1990–94	1995–1999	2000–2005	*p* Value[b]
Patients, No.	5	19	30	36	
Age, years	36 ± 12	50 ± 11	58 ± 11	54 ± 16	0.005
Male sex	1 (20)	3 (16)	6 (20)	15 (42)	0.118
Etiology					0.240
Functional	4 (80)	12 (63)	19 (63)	21 (58)	
Degenerative	0 (0)	3 (16)	6 (20)	7 (19)	
Endocarditis	1 (20)	0 (0)	3 (10)	7 (19)	
Congenital	0 (0)	4 (21)	2 (7)	1 (3)	
NYHA class > II	4 (80)	13 (68)	24 (80)	2 (81)	0.747
Dyspnea	2 (40)	17 (89)	29 (96)	32 (89)	0.003
Liver congestion	1 (20)	11 (58)	17 (57)	15 (42)	0.288
Ejection fraction	0.54 ± 0.07	0. 53 ± 0.05	0.58 ± 0.06	0.57 ± 0.06	0.044
Redo operation	2 (40)	14 (74)	22 (73)	22 (61)	0.373
Type of prosthesis					0.853
Mechanical	2 (40)	10 (53)	14 (47)	20 (56)	
Bioprosthesis	3 (60)	9 (47)	16 (53)	16 (44)	
In-hospital mortality	0 (0)	4 (21)	8 (26)	4 (11)	0.268

[a] Categoric variables are presented as number (%) and continuous variables as mean ± standard deviation. [b] Values of $p < 0.05$ are significant.

NYHA = New York Heart Association.

etiology, ejection fraction, left and right ventricular dimension, tricuspid annulus diameters, pulmonary artery pressure, reoperation, type and size of the prosthesis, extracorporeal circulation and aortic cross-clamp time, postoperative inotropic support, and complications. Variables with value of *p* of less than 0.1 were entered into logistic multivariate analysis.

Calibration of the model was assessed with the Hosmer-Lemeshow goodness-of-fit test. Kaplan-Meier analysis with log-rank test was applied for estimation of long-term survival and freedom from reoperation. Valve-related complications were reported according to the American Association for Thoracic Surgery Guidelines for reporting morbidity and mortality after cardiac valvular operations [4].

Results

Overall Early and Long-Term Results

Mean bypass time was 95 ± 46 minutes (range, 26 to 181 minutes) and cross-clamp time was 44 ± 25 minutes (range, 30 to 123 minutes). Postoperative inotropic support (defined as the isolated infusion of dopamine > 5 μg/kg/min or in association with another inotrope) was required in 60 patients (67%). Mean inotropic support duration was 4 ± 6 days (range, 1 to 37 days). Mean intensive care unit stay was 7 ± 16 (range, 1 to 105 days). The overall 30-days mortality rate was 17.7% (16 patients, 11 women) in patients who were a mean age of 57 ± 14 years (range, 27 to 81 years). No further deaths occurred at 60 or 90 days. All of these early deaths were non–valve-related deaths, namely due to cardiac failure in 10 patients (62%), multiorgan failure syndrome in 5 (31%), and a cerebrovascular event in 1 (7%).

Early complications were observed in 25 patients (34%). Postoperative right heart failure in 4 patients required high-dose inotropic support, and 5 returned to the operating room for excessive postoperative bleeding. Transient acute renal failure requiring continuous veno-venous hemofiltration was observed in 4 patients, and respiratory complications necessitating prolonged mechanical ventilatory support occurred in 4 patients. Finally, 8 patients required implantation of definitive pacemaker for complete A-V block.

No difference in early mortality was observed between those undergoing TVR on cardiopulmonary bypass with the heart beating and those operated on under cardioplegic arrest. Logistic regression multivariate analysis showed postoperative low-output syndrome ($p = 0.001$) and liver congestion, defined as clinical liver enlargement associated with hepatic serum enzymes values (transaminases and/or total bilirubin) two-fold greater than normal value; ($p = 0.058$) were independent predictors of in-hospital mortality (Hosmer-Lemeshow goodness-of-fit test: $\chi^2 = 0.021$; $p = 0.884$; Table 3).

The mean time to last follow-up was 8.9 ± 7.6 years (range, 1 to 28 years), and total follow-up was 803 patient-years. Of the 74 survivors, 16 patients (22%) died after discharge: 9 of heart failure, 1 of cerebral hemorrhage, and 6 of noncardiac causes. At multivariate analysis, the risk factors associated with long-term mortality were age older than 60 years ($p = 0.004$) and systolic pulmonary hypertension ($p = 0.009$; Hosmer-Lemeshow goodness-of-fit test: $\chi^2 = 6.171$; $p = 0.628$; Table 4). Considering overall mortality (in-hospital and follow-up), Kaplan-Meier survival at 5, 10, and 15 years was 72%, 65%, and 63% respectively (Fig 2).

Table 2. Preoperative and Intraoperative Characteristics Between Mechanical Group and Bioprostheses Group

Variable[a]	Mechanical Valve	Bioprostheses	*p* Value
Patients	46	44	
Age, years	53.9 ± 14 (25–82)	53.7 ± 14 (17–77)	0.935
Sex			0.061
Males	9 (19.6)	16 (36.4)	
Females	37 (80.4)	28 (63.6)	
Body surface area, m^2	1.63 ± 0.16 (1.35–2.00)	1.71 ± 0.23 (1.37–2.27)	0.064
Etiology			0.663
Functional	28 (60.9)	28 (63.6)	
Degenerative	7 (43.8)	9 (56.3)	
Endocarditis	6 (54.5)	5 (45.5)	
Congenital	5 (10.9)	2 (4.5)	
NYHA class > II	32 (69.6)	38 (86.3)	0.072
Dyspnea	41 (89)	39 (88)	0.601
Liver congestion	22 (47)	22 (50)	0.502
Ejection fraction	0.57 ± 0.06 (0.35–0.65)	0.59 ± 0.035 (0.40–0.66)	0.335
Systolic PAP, mm Hg	47.3 ± 10.8 (30–80)	45.7 ± 13 (30–60)	0.739
Redo operation	29 (63)	31 (70)	0.301
ECC time, min	81 ± 40 (26–220)	94 ± 45 (38–246)	0.215
Aortic cross-clamp	27 (59)	33 (75)	0.078
Aortic cross-clamp, min	40 ± 23 (0–180)	47 ± 21 (0–167)	0.399
Associated procedures	15 (44)	19 (56)	0.207
Inotropes use	29 (63)	31 (70)	0.301
Inotropes length, days	3.1 ± 0.8 (1–37)	4.2 ± 1 (1–33)	0.422
ICU stay, days	6.5 ± 2 (1–90)	8 ± 3 (1–105)	0.678
In-hospital exitus	7 (15.2)	9 (20.5)	0.354
Follow-up length, years	8.6 ± 6.5 (1–24)	9.2 ± 8.6 (1–34)	0.693
Follow-up exitus	9 (23)	7 (19)	0.525

[a] Categoric variables are presented as number (%) and continuous variables as mean ± standard deviation (range).

ECC = extracorporeal circulation; ICU = intensive Care Unit; NYHA = New York Heart Association; PAP = pulmonary artery pressure.

Table 3. Risk Factors Determining In-Hospital Mortality at Univariate and Multivariable Stepwise Forward Logistic Regression Analysis

Risk Factor[a]	Survivor	Nonsurvivor	*p* Value
NYHA > II	55 (74)	15 (94)	0.079
Pre-op liver congestion	30 (40)	14 (87)	0.001
Redo operation	46 (62)	14 (87)	0.043
ECC, min	88 ± 41	125 ± 54	0.014
Post-op inotropic support	44 (59)	16 (100)	0.001
Inotropes duration, days	2.7 ± 4	9 ± 8	0.001
Post-op low-output syndrome	5 (7)	11 (69)	0.001
Post-op complications	25 (34)	12 (75)	0.003

Variable	Coeff	SE	*p* Value	Exp (B)	95% CI
Post-op LOS	–2.709	0.782	0.001	0.067	0.014–0.309
Liver congestion	−1.661	0.877	0.058	0.190	0.034–1.059
Constant	0.761	0.658	0.248		

[a] Categoric variables are presented as number (%) and continuous variables as mean ± standard deviation (range).

CI = confidence interval; Coeff = coefficient; ECC = extracorporeal circulation; Exp (B) = exponentiation of the B coefficient; LOS = length of stay; NYHA = New York Heart Association; Post-op = postoperative; SE = standard error.

Table 4. Risk Factors Determining Long-Term Mortality at Univariate and Multivariable Stepwise Forward Logistic Regression Analysis

Risk Factor[a]	Survivor	Nonsurvivor	*p* Value
Age, years	52 ± 14	64 ± 11	0.002
Systolic PAP, mm Hg	43 ± 8	56 ± 11	0.001
Redo operation	46 (62)	14 (87)	0.043
Post-op inotropic support	46 (62)	14 (87)	0.043
Inotropes duration, days	3 ± 5	6 ± 8	0.050
ICU length of stay, days	5 ± 11	16 ± 20	0.010

Factor	Coeff	SE	*p* Value	Exp (B)	CI
Age	0.082	0.029	0.004	1.085	1.026–1.148
Systolic PAP	0.206	0.079	0.009	1.229	1.053–1.433
Constant	−6.176	1.785	0.001		

[a] Categoric variables are presented as number (%) and continuous variables as mean ± standard deviation (range).

CI = confidence interval; Coeff = coefficient; Exp (B) = exponentiation of the B coefficient; ICU = intensive care unit; PAP = pulmonary artery pressure; Post-op = postoperative; SE = standard error.

Mechanical Valves vs Bioprostheses Results

Extracorporeal circulation time (81 ± 40 vs 94 ± 45 minutes; $p = 0.215$) and aortic cross-clamp time (39 ± 43 vs 47 ± 41 minutes; $p = 0.399$) were similar in the two groups. Inotropes use, inotropes duration, and intensive care unit stay were comparable between the two groups (Table 2). Similarly, the 30-day mortality rate was 15.2% in the mechanical group vs 20.5% in the bioprostheses groups, which was not significantly different ($p = 0.354$). Mean follow-up was 8.6 ± 6.5 years (95% confidence interval, 6.6 to 10.5 years) vs 9.2 ± 8.7 years (95% confidence interval, 6.6 to 11.9 years; $p = 0.693$). The groups had similar long-term mortality: 23% in the mechanical group vs 20% in the bioprostheses group ($p = 0.525$). Kaplan-Meyer survival analysis showed the type of prosthesis was not an independent predictor of long-term mortality, and the survival rates at 5, 10, and 15 years, respectively, were 73%, 67%, and 63% in the mechanical group and 70%, 60% and 57% in the bioprostheses group ($p = 0.658$; Fig. 3).

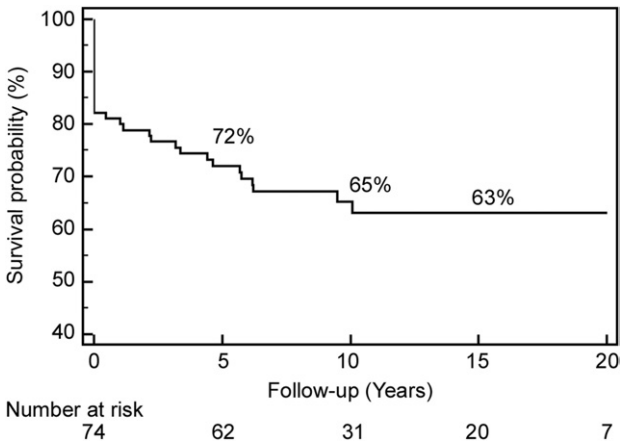

Fig 2. Kaplan-Meyer long-term cumulative survival is shown for the overall population undergoing tricuspid valve replacement.

Reoperation was required in 16 patients (21.6%) after a mean of 7 ± 6 years (range, 1 to 24 years) from the first operation, including 9 in the mechanical group and in 7 in bioprostheses group (p = NS). The major causes of reoperation were valve thrombosis in 8 patients (88%) in the mechanical group and structural valve degeneration (SVD) in 6 (85%) in bioprostheses group. The mean time to reoperation was 9 ± 5 years in the bioprostheses group vs 6 ± 7 years in the mechanical group, which was significantly longer. At Kaplan-Meyer analysis, however, the type of prosthesis was not an independent predictor of reoperation, and freedom from reoperation (valve thrombosis or SVD) at 5, 10, and 15 years was, respectively, 86%, 76%, and

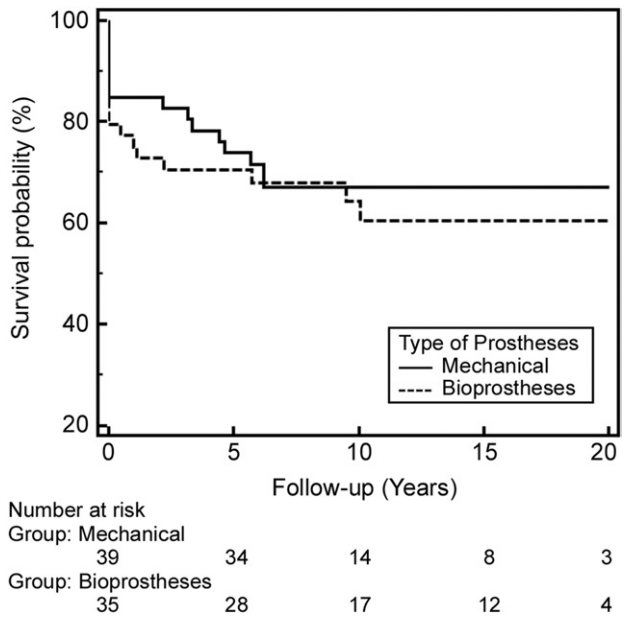

Fig 3. Kaplan-Meyer long-term cumulative survival is shown according to the type of implanted prosthesis (mechanical, solid line; bioprosthesis, dashed line).

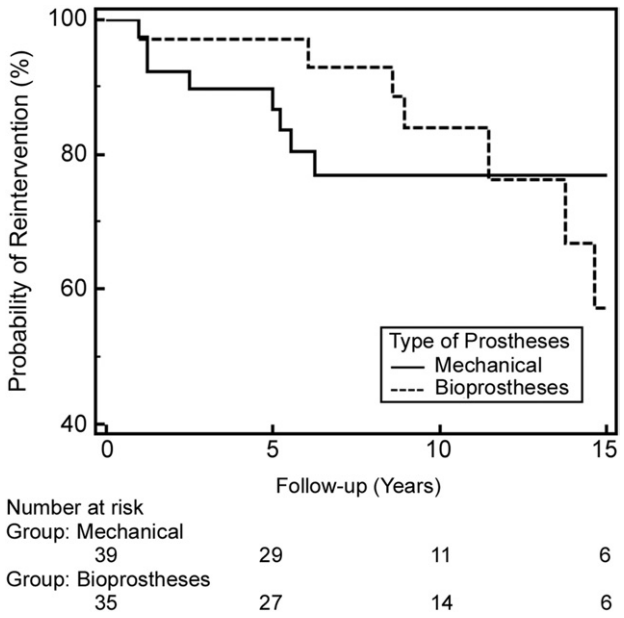

Fig 4. Kaplan-Meyer freedom from reoperation (valve thrombosis or structural valve deterioration) is shown according to the type of implanted prosthesis (mechanical, solid line; bioprosthesis, dashed line).

70% in mechanical group and 97%, 83%, and 57% in the bioprostheses group ($p = 0.762$; Fig 4).

Comment

Functional tricuspid valve disease is the most common cause of tricuspid regurgitation in the developed countries and is normally amenable to tricuspid valve repair. For this reason TVR is nowadays rarely performed in Western countries and is reserved for when repair attempts fail, when the disease process involves multiple valves with advanced lesions, or for patients with organic tricuspid valve disease. The major findings of our study are:

1. The type of implanted prosthesis (mechanical or biological) does not affect early and long-term survival.
2. The reintervention rate at follow-up is similar between patients who receive a mechanical valve or a bioprosthesis, with bioprosthetic degeneration rate being equivalent to the mechanical thrombosis rate.
3. The timing for late reoperation occurs significantly later for the bioprosthetic group.

A high operative mortality rate is almost constant in the literature, ranging from 12% to 26% in the most recent published series [5, 6]. A meta-analysis of studies published between 1994 and 2003 found a mortality of 19% in 1,258 patients from 11 series [7]. Reasons for these disappointing results greatly depend on the population's characteristics, and we have previously demonstrated that age, preoperative clinical status, pulmonary hypertension, and redo operation are major determinants of early and long-term mortality [8].

Moreover, prompt referral is the key to a successful outcome. In our experience, however, this is still an unsolved problem. We noticed a significant difference in referral between patients being monitored by cardiologist at our institution and those referred by external cardiologists or general practitioners. In recent years, we have periodically organized round-table discussions with cardiologists and general practitioners of our region to address this issue and to present and discuss guidelines, clinical cases, and results for coronary and valvular interventions.

The choice between mechanical and biologic prostheses for TVR is a subject of ongoing debate, and conclusive data are lacking. The published series of TVR are few and are limited by small sample size, often spanning from the 1960s through 1990s. We identified 10 reports including a number of patients similar to our study that compared biologic and mechanical valves in the tricuspid position; however, 6 of the 10 studies were unbalanced, having implanted more mechanical valves [9, 10] or bioprostheses [11–14]. None of these studies found any difference between the mechanical and tissue valves in survival and reoperation rate. However, given the high early rate death in the TVR population, an unbalanced study population leaves in the smaller group very few patients for the long-term analysis, so that, in our opinion, conclusions can be arguable. The remaining four studies [2, 3, 5, 7] included the largest experiences of TVR, with roughly half the patients receiving a mechanical or tissue valve, even if none were matched.

In our study, early and long-term survival were not affected by the type of implanted prosthesis: survival at 5, 10, and 15 years was, respectively, 73%, 67%, and 63% in the mechanical group and 70%, 60%, and 57% in the bioprostheses group. These results are consistent with the meta-analysis by Rizzoli and colleagues [7], who compared 646 biologic and 514 mechanical prostheses from 11 studies without finding any difference in the early and late survival or reoperations. Ratnatunga and colleagues [3] did a retrospective UK Heart Valve registry study of all valve operations done between 1986 and 1997 and reported 425 patients with TVR (225 biologic and 200 mechanical). Early mortality in their study was 17.3%, with an 18.6% mortality rate for bioprosthesis and 15.6% for mechanical valves. Survival at 10 years was similar between the two groups (47% in bioprostheses vs 34% in mechanical valves), but was considerably worse compared with the most recent published experiences (including our study).

The absence of any difference in the survival data supports the opinion that there is no "gold standard" for prosthetic TVR. Therefore, we believe that the choice between mechanical or biologic prostheses in the tricuspid position should be individualized according to clinical judgment, age, the cardiac disease, etiology, and the habits of the patient. Some authors [12, 15] have advocated the use of bioprostheses in the tricuspid position based on the concept that low pressure and low stress in

the right heart seem to provide higher valve durability compared with valves located in systemic circulation. Furthermore the use of biologic prostheses, even in young patients, has been advocated by Carrier and coworkers [12] because of limited life expectancy unrelated to the type of tricuspid prostheses at long-term follow-up. We disagree with their position, because in our experience, late survival of hospital-discharged patients was 65% at 10 years and 63% at 15 years, so that many patients are exposed to the risk of valve deterioration.

Reoperation for the tricuspid position is an important consideration during prosthetic valve selection. The major issue against the use of a mechanical valve in the right heart is the higher rate of valve thrombosis compared with left heart implants. Different mechanisms have been advocated to explain the higher rate of mechanical valve thrombosis in the right position, such as the lower pressure of the right system, the right ventricular morphology, and the low prostacyclin concentration of venous blood [16]. We have experienced an incidence rate of valve thrombosis of 2.1% patient/years, which is consistent with the reported rates of 0.5% to 3.3% in different studies [17]. However many retrospective reports included earlier-generation mechanical prostheses, such as cage ball, tilting disc, or monoleaflet valves, which showed higher thrombogenicity compared with the new bileaflet valves [18]. Recently, Nakano and associates [17] reported one valve thrombosis in 39 patients with St. Jude Medical valve (St. Jude Medical, St. Paul, MN) during 14 years of follow-up. Furthermore, tight control of individualized anticoagulation levels and regular education of the patients are the most important measures to prevent thrombotic complications [19].

Excellent long-term durability of the bioprosthesis in the tricuspid position has been reported by several authors [20]. Guerra and colleagues [21], in their experience with 45 TVR with a Hancock bioprosthesis, reported a 14-year freedom from SVD of 68%. However, Nakano and coworkers [22] showed that besides the reoperation cases, echocardiographic examination revealed subclinical prosthetic dysfunction in 35% of patients who were monitored for longer than 5 years. Our patients experienced an incidence rate of SVD of 1.4% patient/years, which is consistent with the reported rates of 0.4% to 2.2% in different studies [3].

Another important concept regarding reoperation after TVR is that, despite there being no difference between thrombosis and SVD rates, these two complications occur at different follow-up times. Mechanical valve thrombosis occurs more frequently in the first years postoperatively, and its incidence significantly declines 5 to 7 years after the operation. Rizzoli and coworkers [7] reported that bioprosthetic valve degeneration increased at a steeper rate after 7 years. This was also confirmed in our study, as valve thrombosis occurred at a mean follow-up of 6 years and SVD occurred at an average of 9 years after TVR.

The growing enthusiasm for transcatheter valve replacement is forcing many surgeons to implant an increasing number of bioprostheses, even in young patients, on the basis that SVD will be addressed in the future percutaneously. Although transcatheter aortic valve replacement is a consolidated procedure, for native aortic valve disease and for bioprosthesis degeneration, only a few experiences of transcatheter atrioventricular valve replacement have been reported [23, 24]. In our opinion, more experience in transcatheter TVR with longer follow-up is needed before the use of bioprosthesis for TVR is expanded, even in young patients. However, the evolving feasibility of transcatheter valve-in-valve replacement will open a new clinical scenario in the near future for these high-risk patients.

In conclusion the present experience suggests that the type of implanted prosthesis in the tricuspid position does not affect early and long-term outcomes or the reoperation rate. Given that type of prosthesis seems to confer no survival advantage, oral anticoagulation must be carefully managed in patients who receive a tricuspid mechanical valve because they are at increased risk of prosthesis thrombosis. Patients who receive bioprostheses must be carefully evaluated with periodic echocardiograms, especially after 7 to 10 years, for detecting clinical and subclinical signs of SVD.

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INVITED COMMENTARY

Tricuspid valve replacement is rarely required and was performed in less than 2% of all valve operations [1]. Accordingly, most institutional series include a small number of patients, and this makes it difficult to perform any statistical analysis to evaluate the performance of the prosthesis. Dr Garatti and associates [2] reported a single institutional experience of tricuspid valve replacement comparing mechanical and biological prosthesis over 25 years. The number of patients was relatively large (n = 90), and the mean follow-up period was close to 9 years. Moreover, the authors have a clear message, as follows: (1) type of implanted prosthesis does not affect early and long-term survival; (2) the reintervention rate was similar between mechanical and bioprosthetic valves; (3) mechanical valve thrombosis occurs more frequently in the first postoperative year whereas bioprosthetic valve degeneration increased at a steeper rate after 7 years postoperatively; and (4) thus, the timing of reoperation occurs significantly later for the bioprosthetic valves. The authors should be congratulated for their excellent contribution to the literature.

Unsolved problems still remain, though. First, the operative mortality associated with tricuspid valve replacement (17.3% in their series [2], 12% to 26% in others [3]) was much higher than that of other valve replacements. That is partly because the majority of patients selected for tricuspid valve replacement were in New York Heart Association functional class III/IV (68% to 80%), which indicates that referral to the surgeons may be just too late. Second, the indication for tricuspid valve replacement was not clearly defined [4]. The only practical indication is "patients who require surgical intervention for tricuspid valve, but not feasible for tricuspid valve repair or attempts at repair have failed" [2]. One possible solution is cooperative follow-up of these candidates as a heart team (cardiologists and surgeons) before surgical indication is warranted.

At this point, a prospective randomized study may be difficult because the number of cases in each institution is small. I would propose a multidisciplinary (cardiology and cardiac surgery) registry to precisely monitor these patients. That is probably the best way to determine the optimal timing for surgery in patients who require tricuspid valve replacement. The tricuspid valve should not be left as "the forgotten valve."

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