TABLE 1. Clinical data in 4 patients in whom early (3–44 months) valvular stenosis developed

Patient	Year of implant	Implant position and size	Indexed effective orifice area (EOA/BSA in cm ² /m ²)	Indication for explantation (aortic valve gradients in mm Hg)	Months implanted	Age at redo operation (y)	Operative findings
A	2002	Aortic, 23 mm	1.51/1.81 = 0.83	Aortic stenosis (AVA 1.0 cm ²), peak 44, mean 26	44	76	Thickened leaflets, small perforation 1 leaflet
B	2003	Aortic, 23 mm	1.51/1.99 = 0.76	Aortic stenosis (AVA 0.7 cm ²), peak 88, mean 45	14	74	Thickened leaflets (Figure 1, A)
C	2004	Aortic, 23 mm	1.51/1.83 = 0.83	Aortic stenosis (AVA 0.7 cm ²), peak 100, mean 60	19	70	Thickened leaflets, pannus
D	2007	Aortic, 25 mm	1.69/1.90 = 0.89	Aortic stenosis, peak 65, mean 42	3	73	Thickened leaflets, pannus (Figure 1, B)

AVA, Aortic valve area; BSA, body surface area; EOA, effective orifice area.

to be 97.4% by Botzenhardt and colleagues⁴ and 87.1% at 10 years by Riess and colleagues.² In the review by Riess and colleagues, there was no structural valvular deterioration at 10 years in patients aged more than 65 years.²

Improved valve durability in patients aged more than 65 years in reported studies^{2,3} was not seen in our patients. All 4 patients were aged more than 68 years at the time of implant, and all were aged 70 years or more at the time of the redo operation.

Patient–prosthesis mismatch was excluded as a cause of early stenosis because the indexed effective orifice area was greater than 0.75 cm²/m² in all 4 patients. Explanted valves were examined by a pathologist at the Washington University School of Medicine and by a pathologist after return of the valves to Medtronic Inc, and no cause for the stenosis could be determined in any case. The cause of early

valvular stenosis, whether it is related to patient factors or valve factors, remains unclear.

CONCLUSIONS

Continued close and long-term follow-up of patients receiving the Medtronic Mosaic porcine valve is imperative.

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Tricuspid valve regurgitation after heart transplantation

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Tricuspid valve regurgitation (TR) after orthotopic heart transplantation (OHT) is of concern owing to its correlation with right ventricular dysfunction and mortality.¹

Studies show that the bicaval anastomosis technique decreases the incidence TR when compared with biatrial techniques.² More recent studies show that modified surgical techniques, such as tricuspid valve annuloplasty or a modified inferior vena cava anastomosis, may alleviate moderate and severe TR after transplantation.^{3,4}

This study examines the long-term natural history of TR after OHT.

PATIENTS AND METHODS

From January 1997 to December 2005, 670 consecutive adults underwent heart transplantation with the bicaval anastomosis technique. The mean age was 53.4 ± 13.2 years (range, 18.3–70.5). The male recipients comprised 69.4% of the cohort. The etiology of cardiomyopathy before OHT was idiopathic dilated (45%), ischemic (39%), retransplant (6%), or other (10%). The mean ischemic time was 212.8 ± 71.4 minutes.

Donor hearts were flushed with a cold University of Wisconsin solution and reperfused with leukocyte-depleted blood.

Both routine echocardiogram reports and those monitoring clinical changes were retrospectively reviewed, and TR was considered present if TR was documented as greater than mild on any report. All recipients had at least a 1-year follow-up. A Kaplan–Meier model was used to measure freedom from TR (SPSS version 14 software; SPSS, Inc, Chicago, Ill), and to account for competing outcomes (either TR > mild or death) all recipients dying without TR were considered to have a follow-up time equal to survival time. A Kaplan–Meier curve was used to measure the survival difference between the TR $\leq$ mild and TR > mild groups, and a log-rank test was used to compare the two groups. For both Kaplan–Meier analyses, the length of follow-up was considered reliable so long as there were more than 35 recipients remaining at risk. The duration of follow-up was 9 years for the entire cohort and 5 years when comparing survival between TR $\leq$ mild and TR > mild groups. Cox regression analysis was performed to determine TR's correlation with survival, age, and ischemic time.

The research protocol was presented to the institutional review board, and the requirement for informed consent was waived.

RESULTS

Actuarial freedom from TR in the 670 patients was 78% at 9 years (Figure 1). The risk was highest in the first year after transplantation, with a lower but steady occurrence thereafter.

A total of 102 (14.9%) recipients had TR at some point in their follow-up. When examining survival between the TR $\leq$ mild and TR > mild groups, the largest difference occurred at 10 months (90.1% vs 75.7%, respectively). Five-

FIGURE 1. Actuarial freedom from TR in the 670 patients was 78% at 9 years. TR, Tricuspid regurgitation.

FIGURE 2. Five-year survival was 78.3% for those with TR $\leq$ mild and 65.3% for those with TR > mild. TR, Tricuspid regurgitation.

year survival was 78.3% for those with TR $\leq$ mild and 65.3% for those with TR > mild (Figure 2).

Regression analysis confirmed that TR was predictive of mortality, and that TR was not correlated with ischemic time or recipient age ($P = .001$, $.088$, and $.494$, respectively).

DISCUSSION

By examining the natural history of TR after OHT with bicaval anastomosis, our study assessed the effectiveness of the bicaval technique.

The study by Anderson and associates¹ examined TR after OHT with biatrial and bicaval techniques in 130 patients and determined that intraoperative TR negatively affects survival. The study by Aziz and coworkers,² following 201 patients for 4 years, found that the incidence of moderate-to-severe TR was 17% beyond 1-year follow-up. Our results supported these observations using a much larger cohort and a longer follow-up time. We also found that the incidence of TR was highest in the first year and that there continued to be a risk of new TR beyond that, although the late risk may have been aggravated by repeated biopsies.⁵

Bicaval anastomosis decreases the occurrence of TR when compared with previously standard OHT techniques; however, the actuarial freedom from TR at 9 years (78%) suggests the technique's imperfection for maintaining proper tricuspid valve function. The largest difference between the TR $\leq$ mild and TR > mild survival curves was observed 10 months after OHT, and afterward the two curves continued in parallel. The initially large survival difference between the two groups is consistent with recipients' early postoperative vulnerability, during which risk factors such

as allograft dysfunction, pulmonary hypertension, rejection, and infection can all wear down right ventricle reserve.

Bicaval anastomosis provides a durable but imperfect result for tricuspid valve function, and the addition of TR as a risk factor increases risk for mortality in the first year after transplantation. The results support prior studies that have not gained universal acceptance, such as those proposing annuloplasty in conjunction with the bicaval technique or a modified inferior vena cava anastomosis facilitating annuloplasty.^{3,4} Improving current surgical implantation practices has the potential to alleviate tricuspid insufficiency after heart transplantation, thus improving recipients' survival outcomes.

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