SURGERY FOR ACQUIRED CARDIOVASCULAR DISEASE

SURGICAL STRATEGY FOR SEVERE TRICUSPID VALVE REGURGITATION COMPLICATED BY ADVANCED MITRAL VALVE DISEASE: LONG-TERM OUTCOME OF TRICUSPID VALVE SUPRA-ANNULAR IMPLANTATION IN EIGHTY-EIGHT CASES

Toshihiro Ohata, MD^b
Ikutaro Kigawa, MD^a
Yoichi Yamashita, MD^a
Yasuhiko Wanibuchi, MD^a

Objective: Although annuloplasty has been the most commonly performed surgical modality for severe tricuspid regurgitation, tricuspid valve supra-annular implantation has been performed in our hospital for more than a decade. The aim of this study was to assess the long-term outcome of tricuspid valve supra-annular implantation in a subgroup of patients with severe tricuspid regurgitation, those who also had advanced mitral valve disease.

Methods: Mitral valve replacement in conjunction with tricuspid valve supra-annular implantation was performed on 88 patients at our hospital between 1984 and 1998. The patients (mean age 57 ± 11 years) were followed up for an average of 7.2 ± 4.5 years after the operation (range 0-14 years); total follow-up was 643.1 patient-years. All patients except 2 (97.6%) were included in the follow-up. We evaluated the mortality, the cause of death, survival, the freedom from structural valve deterioration and reoperation, postoperative complications, and long-term echocardiographic findings.

Results: Overall survival at 14 years was $69\% \pm 7.7\%$. Freedom from structural valve deterioration at 14 years was 100% and from reoperation, $88\% \pm 9.4\%$. There were no instances of pulmonary thromboembolism or of complications associated with fatal arrhythmias. Echocardiography showed little residual tricuspid regurgitation, no atrophic and stenotic change in the native tricuspid valve, and no thrombus formation between native valve and the implanted bioprosthesis.

Conclusions: The procedure's simplicity, the good long-term durability of the bioprosthesis, and the absence of fatal arrhythmias and pulmonary thromboembolism indicate that tricuspid valve supra-annular implantation is a useful procedure for patients with severe tricuspid regurgitation complicated by advanced mitral valve disease. (*J Thorac Cardiovasc Surg* 2000;120:280-3)

From the Division of Cardiovascular Surgery, Mitsui Memorial Hospital,^a Tokyo, and the Division of Cardiovascular Surgery, Osaka Police Hospital,^b Osaka, Japan.

Received for publication Nov 3, 1999; revisions requested Dec 16, 1999; revisions received March 1, 2000; accepted for publication March 28, 2000.

Address for reprints: Toshihiro Ohata, MD, Division of Cardiovascular Surgery, Osaka Police Hospital, 10-31 Kitayama-cho, Tennoji-ku, Osaka 543-0035, Japan.

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0022-5223/2000 \$12.00 + 0 12/1/107486

doi:10.1067/mtc.2000.107486

Tricuspid valve regurgitation (TR) is usually accompanied by advanced mitral valve disease. It may be present in 10% to 50% of patients with severe mitral stenosis or regurgitation.¹ In a majority of patients, this condition is functional rather than organic, the result of pulmonary hypertension and right ventricular dilatation, leading to dilatation of the tricuspid annulus.² As spontaneous regression of functional TR after repair of the mitral lesion is almost impossible in cases of severe TR, surgical repair of TR has also been reported to be inevitable.^{1,3} Although tricuspid valve

Fig 1. Schema of tricuspid valve supra-annular implantation. A-V, Atrioventricular.

annuloplasty, such as semicircular or ring annuloplasty, has been the most common surgical modality for severe TR.⁴⁻⁶ tricuspid valve replacement (TVR) has been performed to prevent residual TR. However, TVR can result in prosthetic valve thrombus and pannus formation, necessitating late reoperation.⁷ A specific variety of TVR, known as tricuspid valve supra-annular implantation,⁸ has been performed in our hospital for more than a decade. Tricuspid valve supra-annular implantation is characterized by a reliable reduction of the tricuspid annulus without fatal arrhythmias or thromboembolism, while preventing residual TR by preserving the native tricuspid valve and implanting the bioprosthesis in the supra-annular position. The aim of this study was to investigate the long-term outcome of tricuspid valve supra-annular implantation in patients with severe TR complicated by advanced mitral valve disease.

Patients and methods

Patients. We studied 88 patients who had advanced mitral valve disease and severe TR and who underwent mitral valve replacement (MVR) and tricuspid valve supra-annular implantation at Mitsui Memorial Hospital between 1984 and 1998. The mean patient age at operation was 57 ± 11 years, and the patients were followed up for an average of 7.2 ± 4.5 years after the operation (range 0-14.6 years), total follow-up being 643.1 patient-years. Follow-up was 97.7% (86/88) complete. The surgical indication for tricuspid valve supra-annular implantation was a TR grade of 4/4 as evaluated by right ventriculography or Doppler echocardiography.

Operative technique. With the patient under general anesthesia, the ascending aorta and both venae cavae were cannulated through a median sternotomy, and cardiopulmonary bypass

Fig 2. Overall survival. The overall survivals at 5, 10, and 14 years after the operation were $88.3\% \pm 3.5\%$, $81.2\% \pm 4.7\%$, and $69.2\% \pm 7.7\%$, respectively. The numbers of patients alive at 5, 10, and 14 years were 78, 74, and 71, respectively.

was established. After moderate systemic hypothermia was reached, the ascending aorta was crossclamped and cold crystalloid cardioplegic solution was administered antegradely. MVR was performed with a bioprosthesis or mechanical valve through a conventional left atriotomy, after which the right atrium was opened and the tricuspid valve was thoroughly examined. After 2-0 Ticron (Cyanamid of Great Britain, Ltd, Gosport, United Kingdom) interrupted suture reinforced with a small hollow tube made of expanded polytetrafluoroethylene was placed around the annulus, avoiding the triangle of Koch, a bioprosthesis 31 or 33 mm in diameter (Carpentier-Edwards or Carpentier-Edwards pericardial valve; Baxter Healthcare Corp, Edwards Division, Irvine, Calif) was implanted in the supra-annular position. This procedure resulted in placing the coronary sinus on the right ventricular side (Fig 1). All patients received warfarin after the operation as an anticoagulant and were followed up by Doppler echocardiography after discharge.

Measurements. We evaluated mortality, its causes, complications due to thromboembolism or arrhythmias, the survival, freedom from structural valve deterioration (SVD), and freedom from reoperation. Echocardiography was used to examine the native tricuspid valve, thrombus formation between the native tricuspid valve and the implanted bioprosthesis, residual TR, and mean velocity between the bioprosthesis and native valve.

Statistics. Survival and freedom from SVD and from reoperation were expressed as mean $\pm$ standard error of the mean, and other figures were mean $\pm$ standard deviation. Survival and freedom from SVD and from reoperation were determined by the Kaplan-Meier method. Correlations between the groups were determined by the Pearson correlation coefficient. All analyses were performed with the StatView version 4.5 statistical package (Abacus Concepts Inc, Berkeley, Calif).

Fig 3. Freedom from SVD and from reoperation. Freedom from SVD was 100% (dotted line) and freedom from reoperation was $88.5 \pm 9.4\%$ at 14 years after the operation (solid line).

Results

Overall survival. Three patients died within 30 days of the operation and 3 died during hospitalization, yielding operative and hospital mortalities of 3.4% and 6.8%. The mode of death was cardiac failure in 3 patients and multiple organ failure in 3. Twelve patients died in the late postoperative period. One patient died of a cardiogenic cause, and 9 died of noncardiogenic causes: stroke ($n = 4$), multiple organ failure ($n = 3$), and neoplasm ($n = 2$). In 2 others, the cause was unknown. Overall survival at 5, 10, and 14 years after the operation was $88.3\% \pm 3.5\%$, $81.2\% \pm 4.7\%$, and $69.2\% \pm 7.7\%$, respectively (Fig 2).

Freedom from SVD and from reoperation. Freedom from SVD 14 years after the operation was 100% (Fig 3). Reoperation was required in 2 cases, and freedom from reoperation was $88.5\% \pm 9.4\%$ at 14 years (Fig 3). The cause of reoperation was pannus formation on all cusps, which resulted in severe TR due to chordal shortening in 1 case, and infectious endocarditis in another. The vegetation extended under the cusps of the bioprosthesis.

Echocardiographic findings. Neither atrophic nor stenotic changes were found on the native tricuspid valve in any patient. The mean velocity between bioprosthesis and native tricuspid valve was 1.4 ± 0.2 m/s, and no tricuspid stenosis was found. No thrombus formation was observed between the implanted bioprosthesis and the native tricuspid valve in any patient.

Postoperative TR at discharge was 0.2 ± 0.1 grade and that at long-term follow-up was 0.9 ± 0.1 . The residual TR was less than grade 1/4 at 14 years after the operation.

Thromboembolism and postoperative arrhythmias. There was no case of obvious pulmonary embolism. No thrombus formation was present on the cusps in the explanted 2 bioprostheses. Anti-coagulation-related bleeding occurred in 2 patients who died of cerebral bleeding at 1 year and 12 years after the operation. Minor cerebral infarction was found in 2 other patients. Although spontaneous ventricular tachycardia occurred in 3 patients, temporary atrioventricular block in 2, and atrial fibrillation bradycardia in 1, neither complete atrioventricular block nor fatal arrhythmias occurred during the post-operative periods. Late pacemaker implantation was not necessary.

Discussion

TR may be functional or organic. Functional TR is commonly caused by severe mitral valve stenosis or regurgitation, both of which lead to dilatation of the right ventricle and the tricuspid annulus. Organic TR may be caused by rheumatic fever, trauma, or subacute bacterial endocarditis. Secondary TR generally resolves after a successful mitral valve operation if the TR grade is not severe.⁴ Ring annuloplasty and suture annuloplasty have been the most common surgical modalities for severe TR.^{4,5,9} However, tricuspid valve supra-annular implantation has been performed in our hospital for patients with severe TR complicated by advanced mitral valve disease because of its reliability, little residual TR, lack of complications related to fatal arrhythmias and thromboembolism, and simplicity of the procedure. Tricuspid valve supra-annular implantation differs from orthotopic TVR in its preservation of the native tricuspid valve and implantation of the bioprosthesis in the supra-annular position.

Tricuspid annuloplasty should be selected for moderate to severe TR because the clinical results for ring annuloplasty have been reported to be acceptable for clinical use.⁹ However, in some cases it is not advisable and may not completely resolve severe TR. For patients with congestive liver dysfunction caused by severe TR, it is controversial which procedure is more effective to prevent liver failure.¹⁰

Prosthetic valve thrombus, pannus formation, and pacemaker insertion are the long-term problems of TVR.^{7,11} However, with regard to thromboembolism and pannus formation, the long-term results of tricuspid valve supra-annular implantation appear to be better than those of TVR.^{7,11} Valve replacement with a bioprosthesis, not a mechanical valve, may reliably prevent thromboembolism. Furthermore, implantation

of a bioprosthesis in the supra-annular tricuspid position appears not to cause fatal arrhythmic complications. Late pacemaker insertion was reported to occur in 6% of patients who underwent MVR and TVR, and the actuarial incidence increased 25% up to 10 years.¹¹ In our series, however, no pacemaker insertion was required. This excellent outcome is the result of the method of implanting the bioprosthesis.

In general, the durability of bioprostheses in the mitral position has not been satisfactory when compared with that of mechanical valves, especially in younger patients.^{12,13} On the other hand, bioprostheses such as the Hancock valve (Medtronic, Inc, Minneapolis, Minn) and the Carpentier-Edwards pericardial valve in the tricuspid position have provided good long-term outcomes with a low incidence of SVD and reoperation.^{14,15} Freedom from SVD 14 years after the operation was 100%, a significant improvement compared with the previous reports on this procedure.^{14,15} Critical issues related to long-term follow-up include bioprosthesis-related thromboembolism in the pulmonary circulation, weakness of the right atrial wall at the implantation site, and the status of the native tricuspid valve, such as the presence of cusp calcification or atrophic change. As our follow-up data on tricuspid valve supra-annular implantation show that this procedure largely resolves these problems, tricuspid valve supra-annular implantation is recommended as the appropriate procedure for patients with severe TR complicated by advanced mitral valve disease.

In summary, we examined the outcomes of MVR and tricuspid valve supra-annular implantation in 88 patients with severe TR complicated by advanced mitral valve disease between 1984 and 1998. The procedure's simplicity, the good long-term durability of the bioprosthesis, and the absence of complications of fatal arrhythmias and pulmonary thromboembolism indicate that tricuspid valve supra-annular implantation is a useful procedure for patients with severe TR complicated by advanced mitral valve disease.

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