Modified De Vega's Annuloplasty for Functional Tricuspid Regurgitation
—Early and Late Results—

SHIGEAKI AYOYAGI, KO TANAKA, HIROSHI HARA, MUNETAKA KUMATE, ATSUSHIGE ORYOJI, HIROSHI YASUNAGA, KENICHI KOSUGA AND KIROKU OHISHI

Department of Surgery, Kurume University School of Medicine, Kurume, 830 Japan

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Summary: From 1978 through 1987, 321 patients who had functional tricuspid regurgitation (TR) associated with mitral or combined mitral and aortic valve disease underwent tricuspid annuloplasty with our modification of the original De Vega’s annuloplasty technique. The modified De Vega’s annuloplasty consisted of two separate semicircular sutures placed around the anterior and lateral aspect of the tricuspid valve. Preoperatively, 229 (71.3%) of the 321 patients were in New York Heart Association functional class III or IV. There were nineteen early deaths (5.9%), and 15 patients died during a follow-up period of 15 to 126 months (mean follow-up, 26 months). Five patients (1.5%) required reoperation because of biological mitral valve failure and recurrence of mitral stenosis. The severity of TR was evaluated by two-dimensional and pulsed Doppler echocardiography, and was classified on a scale of 0 to Grade 3 according to the maximal distance and the flow pattern of the regurgitant signals in the right atrium. Postoperative echocardiographic evaluation of TR was performed in 121 randomly selected patients late after operation. TR reduced to Grade 1 or less in 107 (88.4%) of the 121 patients after operation. Ninety-six percent of the survivors were in New York Heart Association functional class I or II, postoperatively. The actuarial survival rate for the 321 patients with the modified De Vega’s annuloplasty including early deaths was 88.2% at 10 years and the actuarial rate of freedom from reoperation on the tricuspid valve was 97.6%. Our surgical experience indicated that the modified De Vega’s annuloplasty, as the method of first choice, is a simple, reliable procedure and resulted in reduction of the severity of TR in 88.4% of the patients with functional TR.

Key words: Tricuspid regurgitation — tricuspid annuloplasty — De Vega’s annuloplasty — tricuspid valve replacement — modified De Vega’s annuloplasty

Introduction

Tricuspid regurgitation (TR) may be present in 10% to 50% of patients with advanced mitral or combined mitral and aortic valve disease (Simon et al. 1980; Cohen et al. 1987; Goldman et al. 1987; Czer et al. 1989). In most cases, this TR is functional, secondary to pulmonary hypertension and right ventricular dilatation. The optimal surgical management of functional TR remains controversial. Surgeons have variously advocated conventional suture annuloplasty (Kay et al. 1965), prosthetic valve replacement (Breyer et al. 1976), annuloplasty with a prosthetic stent (Carpentier et al. 1974; Duran and Ubago, 1976), or semicircular suture annuloplasty (De Vega, 1972).

Since 1978, we have employed the
semicircular suture annuloplasty with a modification of the original technique described by De Vega (1972). In the present study, we evaluated the efficacy of our modified De Vega’s annuloplasty in 321 patients with functional TR by echocardiography, clinical status, and long-term results.

Materials and Methods

Between 1978 and 1987, 379 patients with functional TR underwent a mitral or combined mitral and aortic valve operation at Kurume University Hospital. Of the 379 patients, 321 patients underwent the modified De Vega’s annuloplasty for functional TR. Clinical characteristics of the 321 patients are shown in Table 1. There were 138 male and 183 female patients who ranged in age from 26 to 70 years, with a mean age of 47.8 years. Preoperatively, 1 patient was in New York Heart Association functional class I, 91 were in class II, 206 were in class III, and 23 were in class IV. Of the 321 patients, 173 had mitral valve disease, and 148 had combined mitral and aortic valve disease. Concomitant procedures (Table 2) carried out for left-sided valve lesions were mitral valve replacement or valve repair in 201 patients, mitral and aortic valve replacement in 60, mitral valve replacement and aortic valve repair in 35, mitral valve commissurotomy and aortic valve repair in 16, and mitral valve repair and aortic valve replacement in 9. None of the patients showed evidence of a tricuspid stenosis preoperatively.

Echocardiographic evaluation of TR

We used an Aloka SSD-860 and 870 color Doppler system for the evaluation of TR. Real-time, two-dimensional images of intracardiac structure and blood flow were obtained with a 3.5 MHz ultrasound transducer placed on the chest wall. First, Doppler color mappings of the right ventricular inflow and four-chamber views were performed to obtain the extent and the direction of Doppler color flow of TR, and then pulsed Doppler study was performed to obtain the maximal distance and the flow pattern of regurgitant Doppler signals from the tricuspid orifice in the right atrium.
Tricuspid regurgitation was graded semi-quantitatively on a scale of 0 to Grade 3 according to the maximal distance and the flow pattern of the regurgitant signals from the tricuspid orifice: Grade 0 was assigned if regurgitant signals behind the tricuspid valve were either not detected or were localized during the early systolic phase; Grade 1 (mild TR)-for regurgitant signals less than 2 cm in size which continued until late systolic phase; Grade 2 (moderate TR)-if regurgitant signals longer than 2 cm that showed a wide-band velocity spectrum (the flow pattern was turbulant) were detected in the right atrium during the whole systolic phase; Grade 3 (severe TR)-for regurgitant signals longer than 2 cm that showed a narrow-band velocity spectrum (the flow pattern was laminar).

Operative procedure

All patients were operated on with cardiopulmonary bypass through a median sternotomy. Before cannulation of the venae cavae, a digital exploration of the tricuspid valve was made to confirm the severity of TR and the location of the regurgitant jet in the tricuspid orifice. The heart was arrested with cold crystalloid cardioplegia. After the mitral or the combined mitral and aortic valve repairs were performed, the tricuspid valve was examined. If there was a regurgitant signal of 20 mm or more as estimated by pulsed Doppler echocardiography preoperatively, or if the dilated annulus was more than 35 mm in diameter intraoperatively, annuloplasty was indicated.

The annuloplasty was done by our modified De Vega's annuloplasty procedure. The modified De Vega's annuloplasty procedures are shown in Fig. 1.

Fig. 1. Operative Procedures

The modified De Vega's annuloplasty consists of two separate semicircular sutures placed around the anterior and lateral aspect of the tricuspid valve. Both sutures are started at about 0.5 cm beyond the anteroseptal and posteroaseptal commissures, respectively, and are tied down on Teflon pledget at the middle of the annulus between the two commissures. Three Teflon pledgets are used in the modified De Vega's annuloplasty. The diameter of the annulus is reduced to 30 mm with an obturator.

A=anterior leaflet,  P=posterior leaflet,  S=septal leaflet,  C.S=coronary sinus
One 2-0 Nespolene suture with a Teflon felt pledget which was placed around the anterior aspect of the valve was started at about 5 mm beyond the anteroseptal commissure over the septal annulus. The other suture with a Teflon felt pledget was placed around the lateral aspect, and was started at about 5 mm beyond the posteroseptal commissure over the septal annulus. Both sutures ended at the middle of the annulus between the two commissures, and were tied down on another Teflon felt pledget. The diameter of the annulus was reduced to 30 mm with an obturator. After completion of the anuloplasty, the saline solution injection test was done to confirm valve competence.

Results

Early deaths

Nineteen (5.9%) of the 321 patients died within 30 days after operation. The causes of early death were low cardiac output syndrome in 13, multi-organ failure in 2, and acute renal failure in 2 patients, and cardiac tamponade and pneumonia in 1 patient each. There were no deaths related to the modified De Vega's annuloplasty itself.

Late deaths

Of the 321 patients, 302 patients who were discharged from the hospital were followed up from 15 months to 126 months, with a mean period of 26 months. The cumulative follow-up for the 302 patients was 1094.0 patient-years. Current information was obtained for all operative survivors by the use of questionnaires sent to patients and by telephone contact. Fifteen of the 302 patients (4.7%) died during the follow-up period. The causes of death were congestive heart failure in 6 and renal failure in 3 patients, and prosthetic valve endocarditis, cerebral bleeding, gastro-intestinal bleeding, and suicide in 1 patient each; in the remaining 2 patients, the causes of death were unknown. The actuarial survival rate including early deaths after the modified De Vega's annuloplasty was 88.2% at 10 years.

Reoperation

Five patients (1.5%) required reoperation on the tricuspid valve after the modified De Vega's annuloplasty. These patients had moderate TR due to deterioration of left-sided valve lesions (recur-

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![Fig. 2. Echocardiographic Evaluation of TR.]

Postoperative echocardiographic evaluation of TR were performed in 121 patients who were randomly selected from the 302 operative survivors. Preoperative Grade 3 of TR had completely disappeared in 21 patients, and had been reduced to Grade 1 in 5 patients after the modified De Vega's annuloplasty. Preoperative Grade 2 of TR had disappeared in 45 patients, and had been reduced to Grade 1 in 19 patients postoperatively, but TR remained in Grade 2 in 8 patients. Preoperative Grade 1 of TR had disappeared in 13 patients, however, TR remained in Grade 1 in 4 patients, and worsened into Grade 2 in 2 patients after the modified De Vega's annuloplasty.

Preop. = preoperative, Postop. = postoperative, Grade 0-3 = severity of TR evaluated by echocardiography. A number in square indicates number of patients.
rence of mitral stenosis, 3 patients; failure of the biological mitral valve, 2 patients), and a second tricuspid annuloplasty was performed 6 to 156 months (mean of 109 months) after the initial operation. Reoperation-free rate after the modified De Vega’s annuloplasty was 97.6% at 10 years postoperatively.

Echocardiographic Evaluation

In 121 randomly selected patients, the severity of TR was evaluated by two-dimensional and pulsed Doppler echocardiography before and after operation (Fig. 2). The severity of TR in the 121 patients was classified preoperatively as Grade 1 in 19, as Grade 2 in 72, and as Grade 3 in 30 patients. After the modified De Vega’s annuloplasty, Grade 1 of TR had completely disappeared in 13 of 19 patients; however, TR showed no improvement in 4, and worsened into Grade 2 in 2 patients. Grade 2 of TR had disappeared in 45 of 72 patients, and had been reduced to Grade 1 in 19 patients; but, in 8 patients TR remained in Grade 2. Grade 3 of TR had disappeared in 21 of 30 patients, and had been reduced to Grade 1 in 5 patients. However, TR remained in Grade 2, and Grade 3 in 2 patients for each Grade, postoperatively. Consequently, 107 (88.4%) of the 121 patients repaired with the modified De Vega’s annuloplasty showed either disappearance of TR or reduction of the severity of TR to Grade 1, and only 14 (11.6%) patients exhibited no improvement or deterioration (Grade 2 or 3) of TR after the modified De Vega’s annuloplasty. The tricuspid annulus was significantly reduced from 53.8±5.2 mm as measured during operation to 26.2±3.7 mm after operation.

Influence of left-sided valve lesions and preoperative catheterization data on residual TR

In 9 of 14 patients who had Grade 2 or 3 of TR in the late postoperative period, deterioration of left-sided valve lesions (failure of biological mitral valve in 3 patients, periprosthetic leakage in 1, recurrence of mitral stenosis in 3, mitral valve regurgitation after commissurotomy in 1, and aortic regurgitation in 1) was recognized. The echocardiogram showed that the tricuspid annulus was

| TABLE 3

<table>
<thead>
<tr>
<th>Patients with moderate to severe TR after operation</th>
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<tr>
<td>14 Patients</td>
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<tr>
<td>9 Deterioration of Left-Sided Valve Lesions</td>
</tr>
<tr>
<td>3: Failure of Biological Mitral Valve</td>
</tr>
<tr>
<td>3: Mitral Restenosis</td>
</tr>
<tr>
<td>1: Periprosthetic Leakage</td>
</tr>
<tr>
<td>1: Aortic Regurgitation</td>
</tr>
<tr>
<td>1: Mitral Regurgitation</td>
</tr>
<tr>
<td>2 Degeneration of Tricuspid Leaflet</td>
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<tr>
<td>3 Dilatation of Tricuspid Annulus</td>
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TR remained moderate or severe (Grade 2 or 3) in 14 of the 121 patients after the modified De Vega’s annuloplasty.
Residual TR resulted from deterioration of left-sided valve lesions in 9, degeneration (thickening and shortening) of the tricuspid leaflets in 2, and dilatation of the tricuspid annulus (≥35 mm) in 3 patients.
not enlarged, but the valve leaflets were thickened and foreshortened in 2, and the diameter of the tricuspid annulus was still dilated over 35 mm in 3 patients (Table 3).

The 121 patients were divided into two groups, according to the severity of TR, which was evaluated after operation; one group with Grade 0 to 1 of TR, the other group with Grade 2 to 3 of TR. Preoperative data of cardiac catheterization in these 121 patients are shown in Table 4. Although right ventricular systolic pressure and total pulmonary arterial resistance were slightly higher in the group with Grade 0 to 1 of TR than in the group with Grade 2 to 3 of TR, there were no significant differences in any preoperative data of cardiac catheterization between the two groups.

Clinical Status

The cardiothoracic ratio decreased significantly from a preoperative mean value of 64.5±10.3% to a postoperative mean value of 59.5±7.3%. New York Heart Association functional class was reduced from a preoperative average of 2.7±0.6 to a postoperative average of 1.3±0.6.

**Discussion**

Tricuspid regurgitation may be present in 10% to 50% of patients with a severe mitral valve disease or combined mitral and aortic valve disease (Simon et al. 1980; Cohen et al. 1987b; Goldman et al. 1987; Czer et al. 1989). Yet, the surgical management of acquired TR remains controversial. There is a general consensus that an organically diseased or deformed valve should be replaced, however, for surgical management of functional TR, opinions vary as to whether to expect spontaneous regression of the TR after repair of left-sided valve lesions or to perform tricuspid annuloplasty or even valve replacement. This controversy may be partly due to lack of precise diagnostic method for TR (Cohen et al. 1987a; Goldman et al. 1987; Czer et al. 1989). Cardiac catheterization is not consistently helpful in identifying patients with severe TR, since the data obtained are modified by preoperative medical management. On right ventriculography, influence of the catheter on tricuspid valve function has been reported to cause artificial reflux in the presence of a competent valve

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**TABLE 4**

**Influence of preoperative hemodynamics on residual TR**

<table>
<thead>
<tr>
<th>Hemodynamic Parameters</th>
<th>Postoperative severity of TR</th>
<th>p value</th>
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<tr>
<td></td>
<td>Grade 0 or 1</td>
<td>Grade 2 or 3</td>
</tr>
<tr>
<td>C.I</td>
<td>3.1±1.0</td>
<td>2.8±0.5</td>
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<tr>
<td>PC (m)</td>
<td>19.5±8.8</td>
<td>18.0±5.1</td>
</tr>
<tr>
<td>PA (m)</td>
<td>31.4±13.7</td>
<td>25.7±6.9</td>
</tr>
<tr>
<td>RV (s)</td>
<td>50.2±20.5</td>
<td>41.4±10.9</td>
</tr>
<tr>
<td>RV (edp)</td>
<td>7.0±3.8</td>
<td>6.7±4.0</td>
</tr>
<tr>
<td>RA (m)</td>
<td>7.6±3.8</td>
<td>8.0±4.3</td>
</tr>
<tr>
<td>PAR</td>
<td>91.1±71.4</td>
<td>69.6±36.7</td>
</tr>
</tbody>
</table>

C.I=Cardiac Index, PC=Pulmonary Capillary Wedge Pressure, (m)=Mean Pressure, PA=Pulmonary Artery Pressure, RV=Right Ventricular Pressure, (s)=Systolic Pressure, (edp)=End-diastolic Pressure, RA=Right Atrial Pressure, PAR=Pulmonary Arterial Resistance, TR=Tricuspid Regurgitation
There are also some problems in the routine intraoperative diagnosis of TR by palpation. The efficacy of echocardiography for preoperative evaluation of mitral regurgitation has been demonstrated. Miyatake et al. (1982) and Abe et al. (1989) also reported that the severity of TR by echocardiography correlated relatively well with that obtained by ventriculography. Two-dimensional and pulsed Doppler echocardiography directly image blood flow in the beating heart and thus may provide a more physiologic evaluation of the presence and severity of TR. Therefore, we have used these echocardiographies for evaluation of TR.

Braunwald et al. (1966) suggested that functional TR will regress after adequate correction of left-sided valve lesions, but this is not always the case. Duran et al. (1980) noted that 53% of patients who did not undergo operative correction of the tricuspid valve at the time of mitral valve repair had persistent TR. King et al. (1984) also described 14 patients with normal prosthetic mitral valve function who required a subsequent tricuspid valve operation for TR. These results suggest that surgical repair of moderate to severe TR is necessary in a number of patients to obtain a better prognosis.

At operation, the decision of whether to repair or replace is crucial. Tricuspid annuloplasty is attractive because it is a simple and short procedure. Three annuloplasty repairs have been applied to functional TR. Bicuspidarization annuloplasty, described by Kay et al. (1965), Boyd et al. (1974) is a simple technique, and has a satisfactory late result (Nakano et al. 1988). Semicircular suture annuloplasty (De Vega et al. 1972) and annuloplasty with a flexible prosthetic ring (Duran and Ubago, 1976) are performed to shorten the tricuspid annulus, and annuloplasty with a rigid prosthetic ring advocated by Carpentier et al. (1974) is performed for remodeling the annulus. Grondin et al. (1975) reported that the De Vega’s annuloplasty and Carpentier’s annuloplasty were superior to the bicuspidarization procedure in hemodynamic studies carried out 10 and 11 months after operation. On the other hand, Peterffy et al. (1980) reported that the Kay’s annuloplasty and the De Vega’s annuloplasty gave similar late results in about 70% of their patients. We have preferred the semicircular suture annuloplasty with the modification of the original technique described by De Vega (1972), because it is a simple and short procedure, and it does not disturb the pathway of the His bundle or the valve architecture.

In the present study, the efficacy of the modified De Vega’s annuloplasty was evaluated for a relatively short period after operation. In 107 (88.4%) of the 121 patients evaluated by echocardiography, TR had disappeared or had been reduced to Grade 1. Only 14 patients (11.6%) still had Grade 2 to 3 of TR (moderate to severe TR) postoperatively. The actuarial survival rate for the 321 patients after the modified De Vega’s annuloplasty was 88.2% at 10 years, and the actuarial rate for freedom from reoperation on the tricuspid valve was 97.6%.

The modified De Vega’s annuloplasty makes it possible to perform controlled regional plication of the annulus. When TR is dominant in the anterior region of the tricuspid orifice, the anterior annulus and the anteroseptal commissure will be plicated tightly, and when TR is dominant in the posterior region, the posterior annulus and the anteroposterior and posteroseptal commissures will be plicated tightly. Hachida et al. (1986) documented that the distension of the tricuspid annulus was usually seen to the same degree in the anterior and posterior annulus, and increasing the preoperative right ventricular end-diastolic volume index resulted in the distension of the an-
terior and posterior annulus, while elevation of mean pulmonary arterial pressure resulted in the distension of the anterior annulus. Moreover, holding forces rest mostly on the two Teflon pledgets placed on the end of the semicircular suture in the original De Vega’s annuloplasty, and this often resulted in late suture insufficiency of the annuloplasty secondary to break-down of the tricuspid annulus and loosening of the knots (Imamura et al. 1981). On the other hand, three pledgets are used in our modified De Vega’s annuloplasty, and this may decrease the possibility of the break-down of the tricuspid annulus and loosening of the knots.

Like other annuloplasty procedures, the original De Vega’s annuloplasty as well as our technique present problems. Overrepair of TR may lead to stenosis and underrepair to residual regurgitation. Reed and Cortes (1976) recommended “measured tricuspid annuloplasty.” In our surgical management, annuloplasty was performed to reduce the tricuspid orifice with an obturator to a normal tricuspid orifice of 30 mm. We found no evidence of stenosis at postoperative echocardiographic evaluations. Although proper correction of the tricuspid valve is of fundamental importance for good late results, the efficacies of tricuspid repair depend on postoperative improvement of left-sided valve lesions, pulmonary circulation, and right ventricular function (Carpentier et al. 1974; Grondin et al. 1975; Duran et al. 1980; Simon et al. 1980). In our series, 9 of the 14 patients in whom the severity of TR was evaluated as Grade 2 to 3 postoperatively, demonstrated deterioration or persistence of left-sided valve lesions, and 5 of the 9 patients required reoperation on the tricuspid valve.

Pluth and Ellis (1969) and Breyer et al. (1976) reported that valve replacement was appropriate in patients with moderate to severe TR because of the unsatisfactory results of tricuspid annuloplasty. Although tricuspid valve replacement results in complete repair of the tricuspid valve in patients with severe congestive heart failure and in predictable early results, a high incidence of valve thrombosis and a high early mortality in tricuspid valve replacement were reported (Thorburn et al. 1983). It was also documented that long-term survival rate in patients with tricuspid valve replacement was lower than in those with tricuspid annuloplasty (Kratz et al. 1985). Therefore, Kratz et al. (1985) concluded that tricuspid valve replacement should be avoided except when the tricuspid valve is destroyed or cannot be repaired.

In conclusion, our early and long-term results at 10 years in 321 patients who underwent the modified De Vega’s annuloplasty were encouraging with low early and late mortality and morbidity. Our surgical experience suggests that the modified De Vega’s annuloplasty, as the method of first choice, resulted in reduction of the severity of TR in 88.4% of patients with functional TR.

References


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