Acta Medica Okayama

Volume 46, *Issue* 2 1992 *Article* 9

APRIL 1992

Factors influencing the efficacy of DeVega's annuloplasty for secondary tricuspid regurgitation.

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Abstract

DeVega's annuloplasty was performed on 41 patients with tricuspid regurgitation (TR) associated with combined valvular disease and results were assessed based on Doppler echocardiographic findings in an attempt to examine the applicability of this surgical technique. TR was quantitatively evaluated via Doppler echocardiography before and after surgery. Clinical symptoms, cardiac function, and surgical results were assessed, and the severity of left ventricular myocardial degeneration was determined using electron microscopy. There were no differences in the following factors between the TR recurrence and TR improvement groups: previous heart surgery, number of involved valves, presence or absence of a giant left atrium, preoperative New York Heart Association (NYHA) functional class, and type of prosthetic valve (Bjork-Shiley vs. St. Jude Medical). We found no differences between these two groups in TR severity and tricuspid annulus diameter measured during surgery. Severity of myocardial degeneration was closely associated with the recurrence of TR. Clinically, most had diminished cardiac function before surgery. DeVega's technique appears to be remarkably effective in patients with well-preserved myocardium because no TR recurrence was detected even in examinations with the most accurate Doppler echocardiography. However, such long-term effectiveness of DeVega's technique cannot be expected in patients with degenerated myocardium.

KEYWORDS: tricuspid reguritation, DeVega's annuloplasty, Doppler echocardiography, myocardial score

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*PMID: 1575058 [PubMed - indexed for MEDLINE]

Acta Med Okayama 46 (2) 123-128 (1992)

Factors Influencing the Efficacy of DeVega's Annuloplasty for Secondary Tricuspid Regurgitation

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DeVega's annuloplasty was performed on 41 patients with tricuspid regurgitation (TR) associated with combined valvular disease and results were assessed based on Doppler echocardiographic findings in an attempt to examine the applicability of this surgical technique. TR was quantitatively evaluated via Doppler echocardiography before and after surgery. Clinical symptoms, cardiac function, and surgical results were assessed, and the severity of left ventricular myocardial degeneration was determined using electron microscopy. There were no differences in the following factors between the TR recurrence and TR improvement groups: previous heart surgery, number of involved valves, presence or absence of a giant left atrium, preoperative New York Heart Association (NYHA) functional class, and type of prosthetic valve (Björk-Shiley vs. St. Jude Medical). We found no differences between these two groups in TR severity and tricuspid annulus diameter measured during surgery. Severity of myocardial degeneration was closely associated with the recurrence of TR. Clinically, most had diminished cardiac function before surgery. DeVega's technique appears to be remarkably effective in patients with well-preserved myocardium because no TR recurrence was detected even in examinations with the most accurate Doppler echocardiography. However, such long-term effectiveness of DeVega's technique cannot be expected in patients with degenerated myocardium.

Key words : **tricuspid regurgitation, DeVega's annuloplasty, Doppler echocardiography, myocardial score**

Tricuspid regurgitation (TR) frequently occurs secondary to severe combined valve disease. Accurate diagnosis and appropriate corrective measures are extremely important for treating TR. In recent years, positive surgical correction has become a common procedure for TR, and plastic surgery, rather than valve replacement, has been the mainstay of TR therapy. However, there are various plastic procedures, and procedural selection remains controversial. Moreover, no consensus has been reached on the evaluation criteria for therapeutic effect. Thus, many issues remain unresolved. In this study, we assessed the severity of TR via Doppler echocardiography in 41 patients undergoing DeVega's annuloplasty (1) to evaluate surgical results.

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Materials and Methods

Study subjects (41 adults) included 26 patients with TR associated with mitral valve disease (12 men, 14 women), and 15 patients with TR associated with combined mitral and aortic valve disease (8 men, 7 women) whom we had treated between January 1981 and December 1990. Thirty of the patients had mitral stenosis (MS) and 11 had mitral regurgitation (MR). All of these patients underwent mitral valve replacement. Ten patients had aortic regurgitation (AR) and 5 aortic stenosis (AS). These underwent aortic valve replacement. All of them underwent DeVega's annuloplasty for TR. TR severity was quantitatively evaluated via echocardiography one month before and one month after surgery, and thereafter every 12 months postoperatively. In addition, clinical symptoms, cardiac function, and surgical results were assessed, and the severity of left ventricular myocardial degeneration was determined via electron microscopy. The follow-up period ranged from 12 to 120 months (the mean: 56 ± 36.2 months).

We evaluated TR severity following the criteria — based on Doppler echocardiographic findings — that our department established (2). When the range of TR signals was 0 to 1.5 cm, TR was classified as grade I; when 1.5 to 4.5 cm, grade II; and when 4.5 cm or greater, grade III. All patients were classified into two groups, 1) the TR improvement group; patients who showed little or no (grade I) tricuspid regurgitation after surgery, 2) the TR recurrence group; patients who showed no TR or grade I TR just after surgery, and then experienced a recurrence of TR in the follow-up periods.

The following items were evaluated: clinical symptoms (NYHA class), cardiac rhythm, cardiothoracic ratio (CTR), extracorporeal circulation time, presence or absence of a giant left atrium, history of open-heart surgery, and long-term surgical results. The following parameters were measured during cardiac catheterization one month before surgery as indexes of cardiac function: mean pulmonary arterial pressure (PAP), left ventricular end-diastolic pressure (LVEDP), and right ventricular end-diastolic pressure (RVEDP). Left atrial dimension (LAD), left ventricular end-diastolic dimension (Dd), left ventricular end-systolic dimension (Ds), fractional shortening (FS), mean circumferential fiber shortening velocity (mVcf), ejection fraction (EF), and cardiac index (CI) were determined via echocardiography. The cardiac function was estimated to be diminished when EF, FS and mVcf were less than 0.5, 30%, and 0.9 circ/sec, respectively.

To semi-quantitatively evaluate morphological changes in the myocardium, we performed a biopsy on the left ventricular apex during surgery in the manner previously reported by our department (3,4). Based on the electron microscopic findings of biopsy specimens, the following six factors considered to be directly involved in myocardial contraction were evaluated with scores of 0 to 3 (5–7): 1, fragmentation and depletion of myofibrils; 2, change in mitochondria; 3, intracellular edema; 4, opening and enlargement of intercalated disks; 5, swelling of capillary endothelial cells; and 6, deposit of degenerated substances. The total score was designated as the myocardial degeneration score, and the higher the score, the greater the degeneration.

Valve replacement was done with patients under moderate body hypothermia. Both St. Thomas cardioplegic solution and topical cooling techniques were used.

Analysis of data. The average value of ten cycles of echocardiographic recording was used. All results were expressed as the mean $\pm$ SD. The student's t test was used and differences were considered significant if $p < 0.05$.

Results

Comparison between TR improvement group and TR recurrence group. Clinical characteristics in the two groups are listed in Table 1. There were no differences in the following factors between the TR recurrence and TR improvement groups: age at time of operation, cardiac rhythm, number of involved valves (M + T vs. M + A + T), presence or absence of a giant left atrium, previous surgery, preoperative NYHA functional class, and type of prosthetic valve (Björk-Shiley vs. St. Jude Medical). Likewise, there were no differences between these two groups in TR severity (Table 1).

Pre- and post-operative cardiac function in the two groups are described in Table 2. These examinations were undertaken one month before and one year after surgery. There were significant differences before surgery in the following factors between the TR recurrence group and the TR improvement group: mean pulmonary artery pressure, LVEDP, RVEDP, FS,

Table 1 Clinical characteristics in both groups

	TR[a]	
	Improvement group ($n=28$)	Recurrence group ($n=13$)
Age (years)	51.6 ± 9.0	49.5 ± 8.4
Cardiac rhythm		
Atrial fibrillation	26	13
Sinus rhythm	2	0
Kind of valve lesion		
M[b] + T[c]	17 (61 %)	9 (69 %)
M + A[d] + T	11 (39 %)	4 (31 %)
Giant left atrium	5 (18 %)	3 (23 %)
Previous heart surgery	11 (39 %)	6 (46 %)
NYHA class	IV(10) III(13) II(5)	IV(9) III(4)
Grade of TR	III(19) II(9)	III(10) II(3)
Kind of valve prosthesis		
Mitral position		
Björk-Shiley	6	8
St. Jude Medical	22	5
Aortic position		
Omniscience	3	3
Omnicarbon	6	3
Muscle score (points)		
3	9	0
4	13	2
5	6	0
7	0	6
8	0	3
10	0	2

a: Tricuspid regurgitation, *b*: Mitral valve, *c*: Tricuspid valve, *d*: Aortic valve.

mVcf and EF. Postoperatively we found significant differences in the following factors in both groups: Dd, Ds, FS, mVcf, EF and CI. The TR recurrence group showed no improvement of left ventricular function one year after the operation.

Comparison of clinical findings and hemodynamics between these two groups is listed in Table 3. There were significant differences in CTR, numbers of patients who had diminished cardiac function and myocardial score. However, we found no significant differences between both groups in NYHA class, extracorporeal circulation time and tricuspid annulus diameter.

Discussion

Secondary TR is said to occur in 22 % to 35 % of patients with combined valve disease (8). Patients with TR often have cachexia and damage to multiple organs, including the liver. Even with today's advanced cardiac surgery, surgical results for this disease are not wholly satisfactory. It is generally believed that TR cannot be cured by treating the primary lesions of the mitral and

Table 2 Pre- and post-operative cardiac function in both groups

		Preoperative data		Postoperative data	
		TR improvement group	TR recurrence group	TR improvement group	TR recurrence group
PAP[a]	(mmHg)	36.7 ± 10.0	28.9 ± 9.6[k]	....	....
LVEDP[b]	(mmHg)	7.2 ± 1.8	11.5 ± 3.0[k]	....	....
RVEDP[c]	(mmHg)	7.4 ± 1.8	10.9 ± 1.6[k]	....	....
LAD[d]	(mm)	51.0 ± 10.9	52.4 ± 9.6	43.5 ± 7.4	51.3 ± 6.2
Dd[e]	(mm)	56.0 ± 10.4	59.3 ± 9.2	50.0 ± 9.8	60.2 ± 7.6[k]
Ds[f]	(mm)	36.5 ± 8.4	41.9 ± 8.6	32.3 ± 6.2	43.7 ± 9.2[k]
FS[g]	(%)	34.8 ± 6.8	29.3 ± 5.7[k]	35.4 ± 5.4	27.4 ± 4.8[k]
mVcf[h]	(circ/sec)	1.49 ± 0.24	0.88 ± 0.21[k]	1.62 ± 0.21	0.83 ± 0.18[k]
EF[i]		0.59 ± 0.14	0.45 ± 0.11[k]	0.60 ± 0.13	0.48 ± 0.28[k]
CI[j]	(1/min/m^2)	3.8 ± 1.2	3.4 ± 0.9	3.5 ± 0.8	2.8 ± 0.6[k]

a: Pulmonary arterial pressure, *b*: Left ventricular end-diastolic pressure, *c*: Right ventricular end-diastolic pressure, *d*: Left atrial dimension, *e*: End-diastolic dimension, *f*: End-systolic dimension, *g*: Fractional shortening, *h*: Mean circumferential fiber shortening velocity, *i*: Ejection fraction, *j*: Cardiac index, *k*: Significant difference between corresponding values in the two groups. $p < 0.05$

Table 3 Comparison of clinical findings between the two groups

	TR	
	Improvement group ($n=28$)	Recurrence group ($n=13$)
NYHA class (mean)	3.2 ± 0.6	3.8 ± 0.5
Cardiothoracic ratio (%)	63.2 ± 7.6	74.3 ± 6.3[b]
Grade of TR (mean)	2.7 ± 0.3	2.8 ± 0.2
ECC[a] time (minutes)	144 ± 30	158 ± 42
Diameter of tricuspid annulus (finger breadth)	3.9 ± 0.3	3.8 ± 0.4
Myocardial score (mean)	3.9 ± 0.3	7.2 ± 0.9[b]

a: Extracorporeal circulation, *b*: Significant difference between corresponding values in the two groups. $p < 0.05$

aortic valves alone. Mortality from combined valve disease associated with the complication of TR is higher than mortality from single-valve disease. Consistent with this observation, cause of death is usually LOS shortly after surgery or heart failure long after surgery.

Shafie (9) and Simon (8) indicated that when there is the complication of TR, treating the mitral valve alone will not only be unsuccessful in eliminating TR but may also aggravate it in some case. King (10) reported that patients who underwent mitral valve replacement (MVR) but received no treatment for TR suffered heart failure from aggravated TR long after surgery and eventually required additional surgery for TR. Because the pattern of tricuspid annulus dilatations is not uniform and there is some degree of variation, the applicability of surgical therapy and selection procedure are subjects of controversy. TR is usually treated with annuloplasty by the DeVega (1), Kay (11), Bex (12) and Carpentier (13) methods or with valve replacement. Also, it is sometimes left untreated.

Since 1981, we have routinely performed DeVega's semicircular annuloplasty. Our policy is to actively use TAP for TR of grade II or higher. DeVega (1) explained the procedure as follows: the tricuspid annulus is sutured beginning at the anterior cusp-septal commissure 0.5 cm toward the septal cusp and finishing at the septal cusp 0.5 cm beyond the posterior cusp-septal commissure. Strictly following this procedure, we reduced the annulus diameter to approximately 2.5 finger breadth.

There have been a number of reports comparing the results of DeVega's annuloplasty to the results of other surgical procedures (14–16). However, few reported the results of DeVega's annuloplasty assessments based on pre- and post-surgical Doppler echocardiographic findings. Compared to the conventional method (17,18), Doppler echocardiography is an extremely sensitive blood-flow detection technique, particularly useful for detecting tricuspid regurgitation. In this study, we examined Doppler echography in 41 patients before and after DeVega's annuloplasty and found recurrences of TR grade II or higher in 13 patients (32%) long after the operation. This unexpectedly high incidence of TR is noteworthy. Severity of myocardial degeneration was closely associated with the recurrence of TR. Clinically, most had diminished cardiac function before surgery. These findings indicate that long-term effectiveness of DeVega's annuloplasty can not be expected in patients with pre-surgical myocardial degeneration. In some of our patients, TR grade II or III recurred a few years after surgery, despite the fact that TR had disappeared shortly after surgery. The preoperative cardiac function of these patients was markedly diminished. Kulshrenstha (19) reported some patients who experienced a recurrence of TR 3 to 8 years following DeVega's annuloplasty and pointed out that those patients had poor left ventricular functions. In our study, we also experienced 13 TR recurrence patients whose cardiac functions reduced preoperatively and did not improve one year after surgery. Those patients showed higher myocardial scores than the TR improvement group. In contrast, patients with well-preserved cardiac function before surgery experienced almost complete disappearance of TR and improvement of clinical symptoms after DeVega's annuloplasty.

Nagao (2) listed right ventricular systolic pressure (RVs) and RVEDP as factors associat-

ed with improved TR. He pointed out that the TR recurrence group had lower RVs and higher RVEDP (over 10 mmHg) before surgery than the TR improvement group did. In our study, RVEDP increased to 10 mmHg or over in the TR recurrence group, while the TR improvement group showed significantly lower RVEDP than the TR recurrence group. This evidence suggests that the right ventricular function in the TR recurrence group is impaired before surgery. These facts suggest that even if pulmonary hypertension raises right ventricular pressure, right ventricular function will be preserved as long as RVEDP remains within the normal range. However, as TR develops, systemic circulation works to compensate for the failed right ventricle. In this stage, apparent right ventricular pressure is low, but in many patients RVEDP is elevated and advanced myocardial degeneration occurs. Rivera (20) pointed out from their angiographic evaluations that the circumstances associated with the failure to control TR, using the DeVega technique are in the maintenance of high stress in the ventricular wall (high pulmonary resistances). Pulmonary resistance is increased by left ventricular dysfunction, so that it is strongly suggested that diminished cardiac function due to degenerated myocardium is one of the most important factors related to the recurrence of TR.

DeVega's technique is remarkably effective in patients with well-preserved myocardium because no TR recurrence was detected even in examinations with the most accurate Doppler echocardiography. However, judging from the fact that patients in the TR recurrence group had significantly high myocardial degeneration scores, long-term effectiveness of DeVega's technique cannot be expected in patients with degenerated myocardium.

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Received December 13, 1991; accepted January 30, 1992.