PRESERVATION OF TRICUSPID VALVE IN TRIPLE VALVE DISEASE:
An analysis of five year experience(*)

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Twenty-six triple valve interventions were performed in a period of 57 months. In sixteen patients double valve replacement and tricuspid annuloplasty, and in the other cases various types of interventions were performed. Tricuspid valve replacement (TVR) was not performed in any of the patients. Hospital and late mortality were 7.7% and 8.3% respectively. The efficiacy of the DeVega and Carpentier ring annuloplasties were measured with echocardiographic and hemodynamic studies. Improvement of regurgitation from the tricuspid annulus, following surgical treatment was 45.6±12.7 to 10.2±8.5 mm (p<0.001). Following the annuloplasties in 65.4% of the patients tricuspid regurgitation (TR) disappeared, 31.8% remained mild, 3.8% remained moderate. In 3.8% patients there was no improvement in TR. Following DeVega annuloplasties a residual gradient of 3-7 mmHg, and Carpentier ring annuloplasties a gradient of 2-3 mmHg remained. It is beleived that TVR should be the last choice of treatment in tricuspid valve disease and valve annuloplasty is an acceptable mode of therapy. Operative repair of concomittant TR and Tricuspid stenosis (TS) associated with mitral or mitro-aortic valve disease always should be considered.

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Acquired tricuspid insufficiency is mostly identified in patiens with concomitant mitral or mitro-aortic valve disease often of rheumatic origin. In other words this situation results from enlargement of the orifice, incident to congestive heart failure with right ventricular dilatation, due to the left ventricular disease. Tricuspid regurgitation(TR) is often functional and may vanish when the left heart disease is treated. However it may be permanent with long standing right ventricular decompansation. Tricuspid stenosis (TS) caused by severe calcifications of the valve is a clear indication for valve replacement. What is still being debated is whether to treat TR and TS

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without calcification, secondary to left sided valve disease.

Materials and Methods

From January 1985, to May 1990, 26 triple valve interventions were performed. This represents 2.4% of the 1076 patients undergoing valvular surgery, and 0.8% of the 3299 total open heart procedures. The patients ranged from 19 to 63 years old, with a mean of 41 years. 19 (73%) of the patients were female.

The preoperative New York Heart Association (NYHA) functional class, clinical characteristics and hemodynamic features are presented in Table I and II.

The hemodynamic valvular lesions were assessed by means of preoperative cardiac catheterization, bidimensional and Doppler echocardiogram, and by the surgeon at the time of operation. In twenty-six patients, besides mitral and aortic valve lesions, various degrees of tricuspid regurgitation and stenosis were present.

Indications for tricuspid reconstruction are presented in Table III.

Table I. Preoperative clinical characteristics in 26 triple valve patients.

	No	%
Gender		
Male	7	27
Female	19	73
Age (Mean)	41±22	
NYHA functional class		
I	0	0
II	2	7.7
III	11	42.3
IV	13	50.0
Reoperation	4	15.4
Emergency operation	0	0
Endocarditis	1	3.8
CHF	15	57.6
CTI over 60%	21	80.8

CHF: Congestive heart failure,
CTI: Cardiothoracic index.

Table II. Preoperative and postoperative hemodynamic values in 26 patients undergoing triple valve surgery.

	Preoperative	Postoperative
CI (L/min/m^2)	2.3±0.6	3.0±0.3
LVEDP (mmHg)	13.2±5.0	9.0±1.1
PCWP (mmHg)	21.3±5.3	9.4±2.1
PAP (mean) (mmHg)	29.7±12.5	18.6±8.2
RVEDP (mmHg)	11.3±3.1	5.5±2.2
RAP (mmHg) (v wave)	18.1±6.0	8.4±4.1

CI: Cardiac index.
LVEDP: Left ventricular end diastolic pressure
PCWP: Pulmonary capillary wedge pressure
PAP: Pulmonary artery pressure
RVEDP: Right ventricular end diastolic pressure
RAP: Right atrial pressure

Standard bypass techniques were used by the surgeons involved in this study. Myocardial preservation was applied with systemic moderate hypotermia (26°C), and topical cooling. St Thomas II crystalloid cardioplegic solution was delivered after cross clamping the aorta, with intermittant application every 20 minute intervals. Before reperfusion warm blood cardioplegia was also performed after 1987. Hemodilution was performed until Htc was 25%.

The need for annuloplasty and/or commissurotomy of the tricuspid valve was determined by the surgeon at the time of operation. As a clinical policy, severe structural damage with extensive calcification of the valve and subvalvular apparatus was the only indication for TVR.

Before and after cardiopulmonary bypass(CPB), the cardiac performance

Table III. Indications for tricuspid valve reconstruction.
1. TR greater than 30 mm from the annulus by pulse Doppler study. 2. MRAP greater than 10 mm Hg at rest by hemodynamic study. 3. TR moderate to severe by digital palpation performed intraoperatively. 4. TR occuring when cold saline delivered via pulmonary artery during cross-clamp.
MRAP: Mean right atrial pressure

was optimized by regulating preload and afterload. Postbypass low cardiac output (LCO) was defined as hypoperfusion despite adequate preload, and afterload reduction. In such cases inotropic support, IABP or other means of mechanical assist devices were required.

Operations performed and types of prostheses implanted are shown in tables IV and V. Double valve replacement with tricuspid annuloplasty was the most common procedure performed. There was no TVR. The tricuspid operations included 10 (38.4%) DeVega annuloplasties and 16 (61.6%) Carpentier flexible ring insertions. The annuloplasties were performed as described before[14,18,24,25].

Mitral valve preservation was always the first choice of surgical intervention. In 8 patients (30.8%), by inserting a Carpentier ring, mitral annuloplasty was performed. Bidimensional echocardiographic and pulse Doppler studies were performed at the 2nd postoperative week. In every patient control hemodynamic study was performed in the 6th postoperative month.

All of the patients were anticoagulated with sodium-warfarin (Coumadine), and adjunct antiaggregant therapy was obtained with salycilates and dipyridamole.

Table IV. Operations performed to 26 patients with triple valve disease.

	No	%
AVR-MVR-TAP	16	61.5
De Vega	6	
Carpentier	10	
AVR-MAP-TAP-TV	8	30.8
De Vega	4	
Carpentier	4	
AAP-MVR-TAP-TV	2	7.7
Carpentier	2	

TAP : Tricuspid annuloplasty,
MAP : Mitral annuloplasty
AAP : Aortic annuloplasty
TV : Tricuspid valvotomy

Results

Hospital death (within 30 days after operation) occured in two patients (7.7%). One patient died from LCO, and the other from respiratory failure respectively (TableVI). Early mortality for class II and III patients were none, while for the 13 Class IV patients 15.3%.

Because of the small number of the patients, assesement of the correlation of post operative mortality with specific valvular lesions, or with the tecnique of intraoperative myocardial preservation was not possible. The age or previous cardiac procedures did not influence mortality.

There were 2 late deaths (8.3%) from 4 to 57 months following the operation. One patient died from congestive heart failure at 6th postoperative month and the other because of cerebral thromboembolism due to prosthetic valve thrombosis at postoperative 13 th month (Table VI).

Twenty-three (88.4%) of the patients were alive at the end of the first year, and 22 (84.6%) at the end of the third year (Fig.1). The 57- month survival(mean 18 months) of the preoperative functional group of II and III is

Table V. Mechanical or bioprosthetic prostheses implanted in 26 triple valve operations.

Prosthetic valve	Mitral		Aorta	
	No	%	No	%
St Jude Medical	6	23	8	33.4
Carbomedics	1	3.8	2	8.3
Björk Shiley	3	11.5	6	24.9
Biocor	5	19.3	—	—
Liotta	3	11.5	—	—
Carpentier ring	8	30.9	—	—
Medtronic -Hall	—	—	8	33.9

91% (10/11). The cummulative survival of preoperative functional class IV is 76.9% (10/13) during this period (Fig.2).

Postoperative complications are presented in Table VII.

The efficiacy of DeVega and Carpentier ring annuloplasties were measured with two dimensional and pulse Doppler echocardiography at the 2nd week following the operation. In 65.4% (13/22) of the surviving patients tricuspid regurgitation had disappeared, 31.8% (7/22) remained mild, while 3.8% (1/22) had a moderate TR. In 3.8% (1/22) severe TR continued (Fig.3, Table VIII).

Improvement of regurgitation distance from the tricuspid annulus was measured by pulse Doppler echocardiography. The mean preoperative regurgitation distance of 45.6±12.7 mm. was improved to 10.2±8.5 mm. ($p<0.01$) (Fig.4., Fig.5.).

The comperative pre and postoperative hemodynamic data are presented in Table II.

Table VI. Hospital and late mortality (Overall mortality is 15.3%).

	No
Hospital mortality (7.7%)	
Low cardiac output	1
ARDS	1
Late mortality (8.3 %)	
Congestive heart failure	1
Cerebrovascular accident	1

ARDS: Adult respiratory distress syndrome

Following triple valve surgery, significant improvement in almost all of the parameters are seen. The mean value of CTI, which was 64.7% decreased to 58.1%.

31.8%(7/22) of the surviving patients improved two functional classes while 50% (11/22) improved one class. 18.2% 4 of the patients did not show any improvement following surgery (Fig.6).

Transtricuspidal gradient decreases after annuloplasties were measured 6th postoperative month. After De Vega annuloplasties a gradient of 3-7 mm. Hg, and following Carpentier ring annuloplasties 2-3 mm Hg pressure gradients were detected (Table II).

Discussion

Combined surgical intervention of the mitral, aortic and tricuspid valves, a relatively uncommon operative procedure, accounts for less than 5% of all patients undergoing valve replacement, and about 15 to 25% of patients who have combined aortic and mitral surgery[1-3]. Although recent advances in cardiac surgery, triple valve patients still remain a substantial high risk group, with a hospital mortality ranging from 10 to 27%[3-5]. In this study the hospital mortality was 7.7%, while long term mortality was 8.3% with an overall mortality of 15.3%.

Among the predictors of operative outcome, preoperative functional class for heart failure was a very important factor. 75% of the

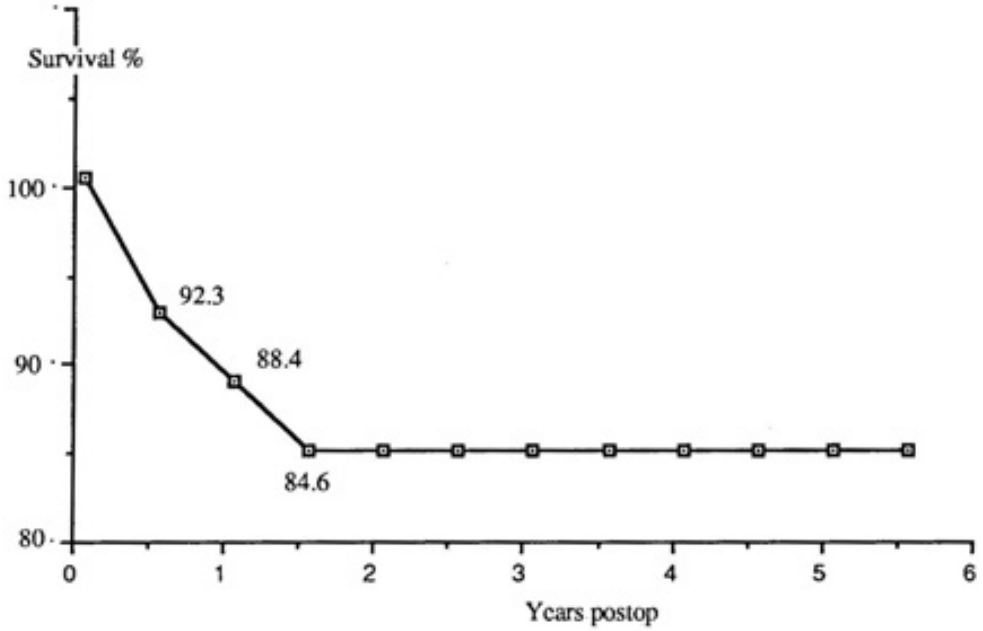

Fig.1. Actuarial survival following triple valve surgery in 26 patients. 84.6% of the patients survived at the end of fifty-seventh month.

nonsurviving patients were in class IV. The actuarial survival at the end of 57 months was 76.9% in class IV, and 91% in class II-III patients respectively. Similar results are reported from other series[2,5].

Because of the small number of patients, correlation of operative mortality with specific valvular lesions was not possible. Recent studies have shown that aortic valve lesion; especially aortic stenosis, and tricuspid

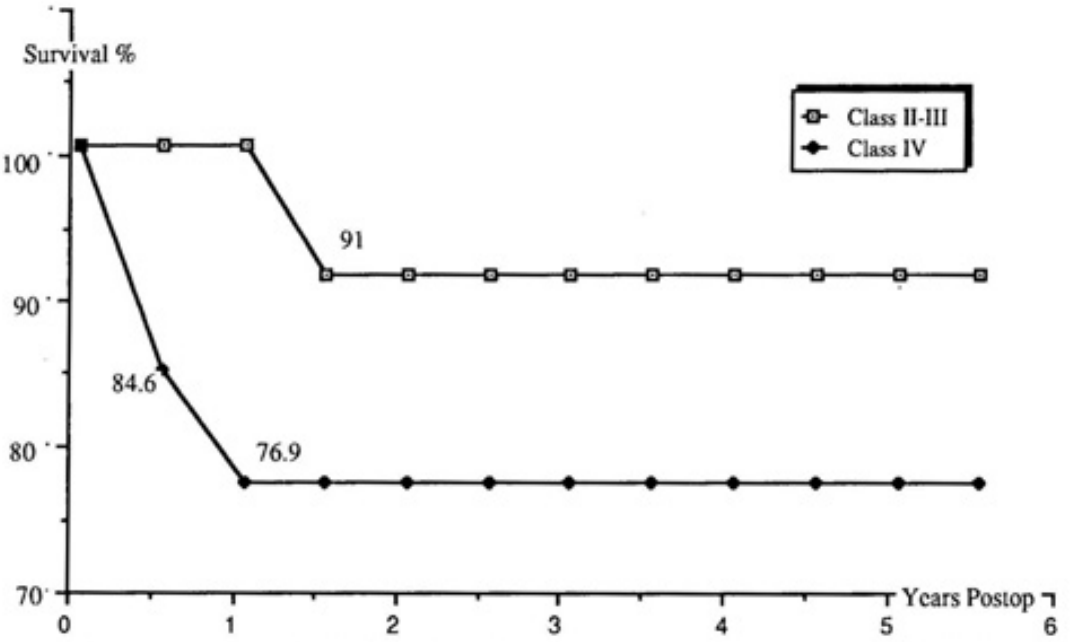

Fig.2. Actuarial survival of 26 triple valve operations according to preoperative NYHA functional class. The cummulative survival of Class II-III group is 91%, while Class IV is 76.9% at the end of fifth-seventh mount.

Fig. 3. Echocardiographic apical four-chamber view of a preoperative triple valve disease patient. Double valve replacement and a DeVega annuloplasty was performed

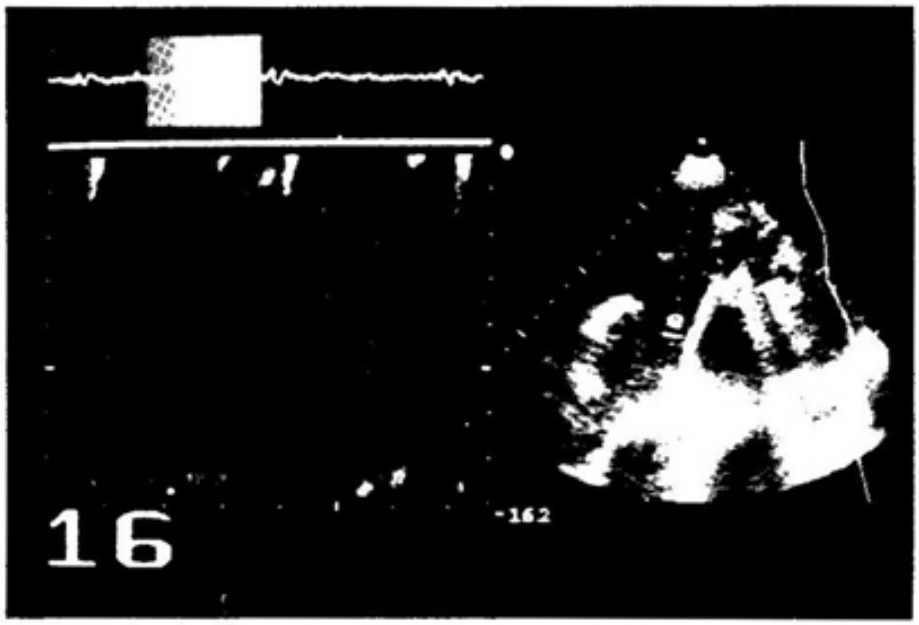

Fig. 4. Echocardiographic view of the same patient at the second postoperative week. Note that the severe tricuspid insufficiency has disappeared following the annuloplasty.

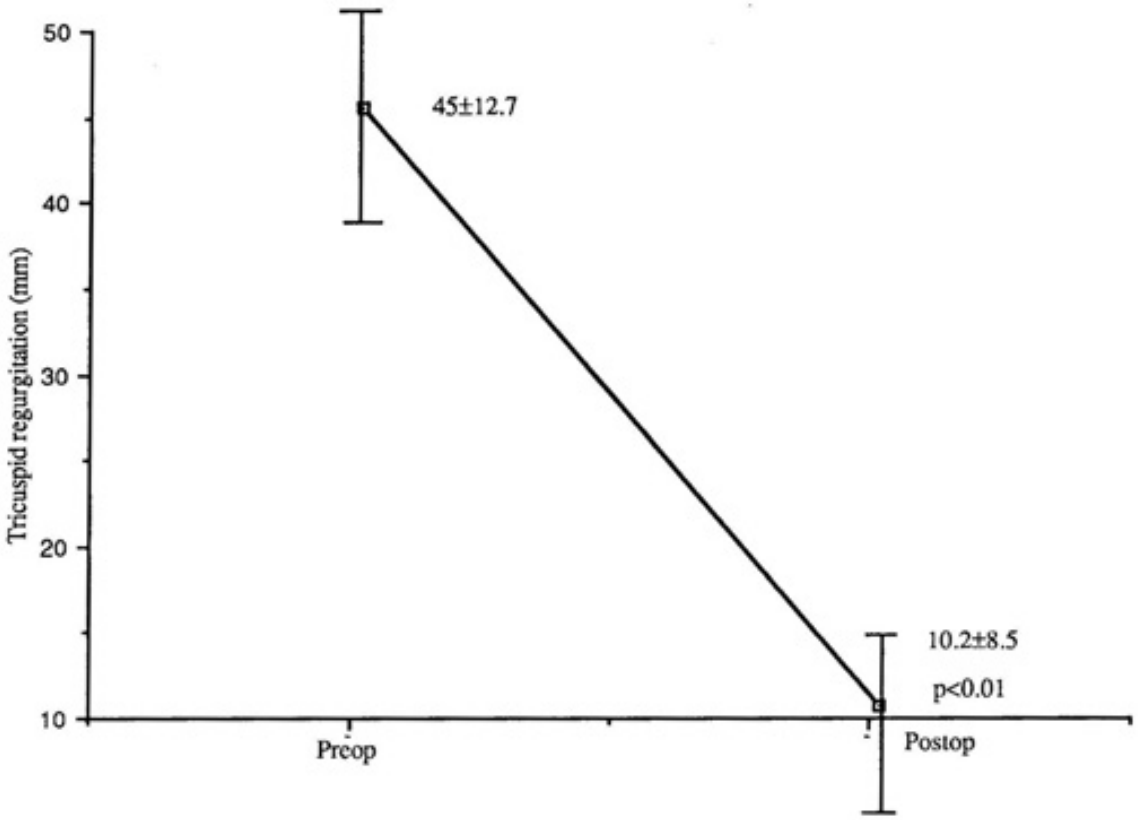

Fig.5. Postoperative improvement of regurgitation distance from the tricuspid annulus measured by pulse Doppler echocardiography.Significant improvement was detected following tricuspid annuloplasty($p<0.01$).

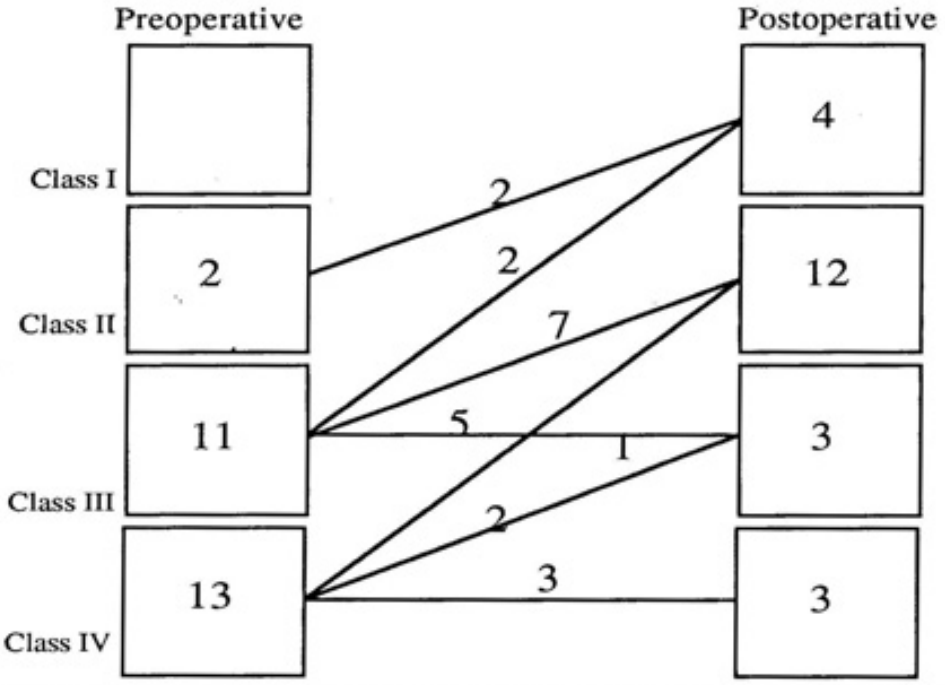

Fig.6. Functional improvement in the surviving patients: 50% (11) of the patients improved one functional class, 31.8% (7) of the patients improved two functional classes, and 18.2% (4) patients did not show any improvement.

Table VII. Causes of early and postoperative complications.

	Total	(%)
In hospital complications		
Low cardiac output	5	19.2
Hemorrhagia	1	3.8
Ventricular fibrillation	1	3.8
Late complications		
Thromboembolism	3	7.7
Prosthetic valve endocarditis	2	3.8

regurgitation were found to be independent predictors of post operative mortality and low cardiac output[3-6]. It has been stated that peak systolic aortic valve gradient is an important predictor of post operative ventricular dysfunction[7]. Patients with aortic stenosis were found to be at higher risk of complications than patients with aortic regurgitation or mixed valvular disease. In these patients there is a correlation between perioperative ischemic injury and degree of ventricular hypertrophy, and myocardial necrosis is often found at autopsy[1,2,8]. In this study myocardial necrosis at autopsy has not been encountered. All of the patients who had postoperative low cardiac output had significant degrees of aortic valve lesion, especially stenosis.

Preoperative tricuspid regurgitation and increased systemic hypertension is found to be an incremental risk factor for hospital and late death[6,9,10]. Functional TR may result from right ventricular decompensation or dilatation related to pulmonary hypertension. History of pulmonary edema or elevated pulmonary artery pressure are again independent predictors of mortality[10]. In a recent study it was reported that elevation of mean pulmonary artery and right atrial pressures correlated strongly with operative morbidity and mortality. In this study it was stated that while the mean pulmonary artery and right atrial pressures were 33±10 mm Hg and 9.0±7 mmHg respectively, patients that had mortality had elevated pressure of 41±10.9 mmHg and 13±7.1 mmHg respectively, which showed significance[3].

Operative repair of concomitant TR associated with mitral or aortic valve disease has been a subject of controversy among surgeons. In most instances the tricuspid lesion is functional secondary to pulmonary hypertension and right ventricular dilatation. Therefore according to some authors, TR would regress after the repair of other lesions[12]. Conservative management of the tricuspid lesions concomitant to multivalvular heart disease has been proved to be unsatisfactory. It has been shown that the course of relative tricuspid regurgitation is unpredictable, even pulmonary artery pressure, pulmonary vasculary resistance, and Doppler findings cannot forsee the eventualy outcome[13]. It has been shown that the regression of pulmonary hypertension after correction of the other lesions is unforseeable, and also the postoperative decrease in pulmonary artery pressure is not the only determinant parameter of the TR[11,13,14]. Several authors have observed a very high incidence of persistent TR, despite the favourable developments in right ventricular hemodynamics, after the surgical correction of mitral or mitro-aortic valve disease. In a few of these patients a worsening of TR has been

Table VIII. Echocardiographic evaluation at the postoperative second month.

Degree of TR	Grade	No Patients	(%)
None	—	15	68.2
Mild	1-2/4	5	22.7
Moderate	3/4	1	4.5
Severe	4/4	1	4.5

Table IX. Right atrial-right ventricular pressure gradients following tricuspid annuloplasty.

Method	Patient		Gradient	Author
	n	%	(mmHg)	
DeVega	12/24	50	2-8	Haerten
Carpentier	13/25	48	5	Hamania
De Vega	5/7	71	2-7	Angelsen
Duran	17/55	31	3-5	Duran
Carpentier	16/22	73	2-3	Yakut
DeVega	6/22	27	3-7	Yakut

reported[15,17]. Several factors can explain the persistance or worsening of TR after mitral or mitro-aortic surgery[11,18,19].

1. Persistant or recurrent mitral disease.
2. Persistance of high pulmonary vascular resistances.
3. Long standing and perhaps irreversible ventricle enlargement. In such situations the systolic shortening of the tricuspid, annulus is interfered. Thus, tricuspid incompetence that does not dissapear promptly by intensive decongestive treatment preoperatively, and is therefore fixed, is more likely to persist late postoperatively if not repaired.
4. Organic TR is usually associated with some degree of stenosis.

As a result it should be considered that it is important to control TR in all cases where the insufficiency is of greater than mild degree even if it is accepted functional and reversible.

There are many studies advocating valve replacement, stating satisfactory results[2,11,20-22]. However an increased incidence of AV block, prosthetic valve thrombosis, and a higher mortality rate has been reported after TVR. The given early mortality rate after TVR was 12% to 48%[20-22].

Three basic reconstructive methods: plication of the posterior leaflet,[23] remodeling of the tricuspid annulus[24], and semicircular annuloplasty[25] have been described with several modifications of each one of them. A common point of the various techniques is the reduction of valve annulus, even though different solutions are proposed[19].

Hemodynamic and angiographic evaluation has demonstrated that in the presence of organic tricuspid disease or in abnormally high total pulmonary vascular resistance, the incidence of postoperative TR is high with all annuloplasty techniques. In the absence of such factors, Carpentier open ring annuloplasty seems to be more effective for the correction of TR[19, 26-29]. At the present, the policy of many centers with experience in valvular surgery prefer the Carpentier method for severe TR, and semicircular annuloplasty or its modifications for mild TR. Some surgeons claim that tricuspid reconstruction is not necessary in mild TR[26, 27, 30].

Although many authors consider organic tricuspid valve disease as an absolute indication for replacement, a more conservative treatment could be chosen. Because calcification occurs very rarely, stenosis usually is due to fibrotic commissural fusion, and if the involvemet of subvalvular apparatus is not seen, anteroseptal and posteroseptal commissurotomy, with an additional annuloplasty would be the right choice of treatment. In this serie 3 combined tricuspid comisissurotomy and annuloplasties were performed.

In this study we have seen that, there has been decrease in tricuspid requrgitation measured by pulse Doppler echocardiography. The mean regurgitation amount of 45±12 mm has been found to decrease to 10.2±8.5 mm. This means that although there were 9% (2/11) of moderate and severe TR, the annuloplasty procedure has reached a success. 59% of the

patients were found to be free of TR. Postoperative hemodynamic studies revealed that there has been a minimal right atrial, right ventricular pressure gradients after reconstruction. These results show a correlation with other series (Table IX).

In this experience of triple valve surgery in a period of 5 years 50% of the patients have improved one, 31.8% of the patients have improved two functional classes with an overall mortality of 15.3%. 18.4% of the patients have not gained benefit from operation and maintained their preoperative functional status.

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