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Editorial

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Early treatment of functional tricuspid regurgitation at the time of mitral valve surgery: an increased risk or an additional benefit?

Paolo Nardi, Calogera Pisano, Antonio Pellegrino, Fabio Bertoldo, Sabrina Ferrante, Monica Greci, Sara Rita Vacirca, Marco Russo, Giovanni Ruvolo

Department of Cardiac Surgery, Tor Vergata University Policlinic, Rome 00133, Italy.

Correspondence to: Dr. Paolo Nardi, Department of Cardiac Surgery, Tor Vergata University Policlinic, Viale Oxford 81, Rome 00133, Italy. E-mail: pa.nardi4@libero.it

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INTRODUCTION

Functional tricuspid regurgitation (FTR) refers to tricuspid insufficiency occurring secondarily to left-sided heart valve disease, especially mitral stenosis or regurgitation, in the absence of organic lesions of the tricuspid valve. In the late 1960s, the observation that mitral valve surgery sometimes led to an improvement in FTR suggested a conservative approach[1]. On the contrary, in the 1970s, Carpentier *et al*.[2] reported excellent results with tricuspid valve repair, arguing for systematic repair of FTR.

With the increasing population of long-term survivors of prosthetic mitral valve replacement, it has been observed that many patients developed late heart failure as the result of onset or progression of FTR in a severe form. Severe FTR is associated with substantially poorer functional outcomes and survival if untreated[3,4]. Moreover, data showing late development of severe FTR in patients with mild or mild-to-moderate regurgitation at the time of mitral valve surgery have more recently pushed towards early aggressive intervention on the tricuspid valve in concomitance with the treatment of mitral valve disease. This raised the question if FTR in the presence of a lesser degree of regurgitation should be treated during the first operation, supporting Carpentier's assertion that "surgical abstention" may be somewhat a dangerous policy. Moreover, when patients require reoperation for tricuspid valve dysfunction, a high operative mortality has been observed, mainly due to the irreversible right ventricular systolic or liver dysfunction[5-7]. Increasing data now support an early surgical treatment of FTR[8-11].

We have reviewed the current guidelines and several reports for recommending tricuspid valve repair, also in the light of our recent experience in the treatment of FTR. It is our opinion that a dysfunction of the tricuspid valve even if in the early stages of manifestation, should be corrected at the time of concomitant left-sided heart surgery, i.e., mitral valve surgery.

AMERICAN AND EUROPEAN GUIDELINES

The 2014 American Heart Association/American College of Cardiology guidelines indicate that surgery for the treatment of FTR is required for patients affected by a severe degree of regurgitation (stages C and D of the tricuspid valve disease) undergoing left-sided valve surgery[12]. This type of indication is in Class I, with Level C of evidence. Risks and benefits of tricuspid valve surgery should be carefully evaluated in the presence of severe right ventricle systolic dysfunction or irreversible pulmonary hypertension, potentially causing a right ventricle failure after operation. In Class IIa with Level B of evidence, it is recommended the repair of FTR in the presence of mild or moderate tricuspid regurgitation (stage B of the tricuspid valve disease) at the time of left-sided valve surgery either in the presence of tricuspid annular dilation or with prior evidence of right heart failure. In Class IIb with Level C of evidence tricuspid valve repair may be recommended in the presence of moderate FTR (stage B) and pulmonary artery hypertension at the time of left-sided valve surgery. The 2017 European Society of Cardiology/European Association for Cardio-Thoracic Surgery guidelines focus on the timing of surgical intervention based on the concept that surgery of the tricuspid valve should be carried out sufficiently early to avoid late irreversible right ventricular dysfunction or progression of FTR[13].

In presence of FTR, adding tricuspid valve repair, if indicated during left-sided surgery, not only does not increase the operative risk, but also has been demonstrated to provide reverse remodeling of the right ventricle and to improve the functional status. The indication with Level C of evidence in Class I, IIa, IIb are similar to those reported by the American guidelines, with the exception of Class IIb, where it is stated that surgery may be considered in patients with mild or moderate FTR, even in the absence of annular dilatation, when previous right heart failure has been documented. In both American and European Guidelines the annulus dilatation of the tricuspid valve defined as greater than 40 mm or 21 mm/m^2 by 2D echocardiography represents a surgical indication for the treatment. In fact, a diastolic diameter greater than 40 mm or 21 mm/m^2 increases the risk of persistent or progressive FTR after isolated mitral valve surgery.

TRICUSPID VALVE REPAIR TECHNIQUES

Repair techniques for the treatment of FTR have been introduced by Kay *et al.*[14] in 1965 and De Vega[15] in 1972. Kay's technique provides the obliteration of the posterior tricuspid leaflet by placement of several sutures across the posterior segment of the tricuspid valve annulus making the valve as bicuspid. De Vega's technique provides the annuloplasty by placement of two semicircular sutures around the annulus anchored with two pledgets (2-0 Ti-cron), starting from the anterior-septal commissure and ending in front of the origin of the coronary sinus.

Ring annuloplasty, first introduced by Carpentier *et al.*[2] in 1974, is thought to offer the best long-term outcomes for severe FTR, by means of a more complete annular stabilization. However, this procedure leads to prolongation of the operation and cardiopulmonary bypass time. Therefore intervening on moderate functional TR in the context of another cardiac procedure may become a decision-making dilemma.

CURRENT EARLY AND LATE RESULTS OF THE REPAIR TECHNIQUES

Marquis-Gravel *et al.*[16] examined the outcomes of 926 cases of tricuspid valve surgery performed over a 30-year period. Of them, 792 patients underwent tricuspid valve repair (85%) more frequently in concomitance

with mitral valve surgery (85%). Tricuspid valve repair was done by the use of De Vega or ring annuloplasty. Operative mortality was 14%, 15-year survival 34%. Risk factors for late mortality included the preoperative severity > 3+ of the FTR, whereas tricuspid valve surgery concomitantly performed with mitral and/or aortic surgery was not a predictive factor for increased mortality[16]. Chan *et al.*[17] studied 624 mitral valve replacement patients. They performed in 125 out of 231 patients having preoperatively a FTR > 2+ tricuspid repair using De Vega or ring annuloplasty techniques. During a mean follow-up of 6.8 years among patients who had preoperative FTR > 2+, the regurgitation worsened in 10 (8%) patients who received repair compared with 85 (17%) who did not. Moreover, the progression of FTR was less developed in the repair group ($P = 0.008$)[17]. Navia *et al.*[18] have compared the effectiveness of several tricuspid valve repair techniques in 2277 patients who had undergone left-sided valve surgery. At 10 years of follow-up, the use of a rigid prosthetic ring provided the most sustained reduction of FTR[18].

On the other hand, Yilmaz *et al.*[19] in a series of 699 patients undergoing mitral valve repair, showed that at 3 years of follow-up, a clinically silent non-severe FTR was unlikely to progress. Huang *et al.*[20] in a series of 448 patients undergoing tricuspid annuloplasty with concomitant procedures, evaluated the results of the De Vega (216 patients) or ring (232 patients) annuloplasty. The indication to FTR treatment was done on the symptomatic tricuspid regurgitation grade (4+) (91.3%) or in presence of moderate FTR (< 4+) or marked tricuspid annular dilatation (diameter > 4.0 cm) (8.7%). With both types of tricuspid valve repair techniques postoperative echocardiography showed significant improvement of the FTR grade (from 3.4 preoperatively to 0.6, $P < 0.05$); 5-year freedom from reoperation (81% *vs.* 75%, $P = 0.124$) was similar. They concluded that the De Vega annuloplasty is an acceptable strategy, improving both clinical and echocardiographic status of the patients during long-term follow-up, although the event-free survival appeared to be lower in comparison with that observed for the ring annuloplasty (74.5% *vs.* 78.8%, P = NS)[20].

Finally, Takano *et al.*[21] in a smaller series of 71 patients undergoing mitral valve replacement and tricuspid valve repair, but with a follow-up period of 20 years, identified the preoperative moderate grade of FTR as a significant risk factor for the development of late severe tricuspid regurgitation. They claimed that an aggressive early treatment of FTR at the time of mitral valve surgery may prevent the late progression of the FTR.

In our recent experience, from January 2015 to October 2017, on a series of 156 patients treated for left-sided heart valve disease (mitral, mitral and aortic valve disease), 57 patients (36.5%) underwent suture annuloplasty techniques (De Vega, 49 patients; Kay, 8 patients). In the mitral surgery group of patients ($n = 114$), FTR was treated in 35 cases (30.7%). Indication for the surgical treatment was given in the presence of symptomatic severe or moderate FTR, or when the diameter of the tricuspid valve annulus reached 40 mm, regardless of symptoms[22,23]. We have adopted those tricuspid valve repair techniques because they require less surgical time in comparison with the use of a ring implant. The increased incidence of the surgical treatment of FTR observed in our series is in accordance with that reported in the database of the Society of Thoracic Surgeons. The trend of the tricuspid valve surgery increased with the time: 11,405 patients treated in the first period of analysis (2000-2003), 21,804 and 21,166 in the last periods (2004-2007 and 2008-2010). In this report operative mortality declined from 10.6% in 2000 to 8.2% in 2010 ($P < 0.001$)[24].

In our series the operative mortality for mitral valve repair (29 patients) and mitral plus tricuspid valve repair (9 patients) was similar (0% *vs.* 0%), as well as that observed for mitral valve replacement (50 patients) and mitral valve replacement plus tricuspid valve repair (26 patients) (2% *vs.* 3.6%, P = NS).

As compared to preoperative period, clinical status of patients surgically treated for FTR during the short-term follow-up showed a significant improvement in NYHA class (3.0 ± 0.7 preoperatively *vs.* 1.4 ± 0.6 at follow-up), pulmonary artery pressure mean value (60 ± 22 *vs.* 32 ± 10 mmHg), mean value of FTR (2.8 ± 1.0/4+ *vs.* 0.7 ± 0.6/4+) ($P < 0.001$, for all comparisons). None of the patients required permanent pacemaker

Table 1. Early and late results of the FTR surgical repair

Authors	Repair techniques	Operative mortality	Late survival	Freeedom from recurrence of significant FTR
Marquis-Gravel *et al*.[16]	De Vega, ring implant	14%	55% at 10 years	46% at 10 years
Chan *et al*.[17]	De Vega, ring implant	3%	80% at 10 years	75% at 10 years
Navia *et al*.[18]	De Vega, Kay, ring implant		44% at 10 years	98% at 5 years
Huang *et al*.[20]	De Vega, ring implant	1.1%	84%, 97% (De Vega *vs*. ring) at 5 years	75%, 79% (De Vega *vs*. ring) at 5 years
Takano *et al*.[21]	Ring implant	0	59% at 15 years	93% at 15 years
Filsoufi *et al*.[25]	Ring implant	5.3%	85% at 2 years	100% at 2 years
Fukuda *et al*.[26]	Ring implant	0	100% at 1 year	70 at 1 year
Ghanta *et al*.[27]	Kay, ring implant	6.4%	75%, 61% (Kay *vs*. ring) at 3 years	75%, 69% (Kay *vs*. ring) at 3 years
Chang *et al*.[28]	De Vega, Kay	3.4%	96% at 8 years	72% at 8 years
Tang *et al*.[29]	De Vega, ring implant	7%, 4% (De Vega *vs*. ring)	36%, 49% (De Vega *vs*. ring) at 15 years	39%, 83% (De Vega *vs*. ring) at 15 years
McCarthy *et al*.[30]	De Vega, ring implant	8%	50% at 8 years	67%, 83% (De Vega *vs*. ring) at 8 years
Our recent experience, 2015-2017	De Vega, Kay	0	100% at 1 year	100% at 1 year

FTR: functional tricuspid regurgitation

implantation at discharge, or during follow-up. Early and late results of surgical treatment of FTR are summarized in Table 1, reporting either data above mentioned than other surgical series.

CONCLUSIONS

Current data suggest that tricuspid valve repair together with early elective surgical intervention for mitral valve disease should be done in order to improve late outcomes and avoid the risk of a late redo operation due to progression of FTR. In the presence of severe FTR, surgery continues to be recommended in Class I. Annular dilatation and history of congestive heart failure symptoms are important to take the decision to early repair of FTR, although more recent guidelines continue to indicate surgical intervention in these specific subgroup of patients in Class II. We agree that a dysfunction of the tricuspid valve, even if not associated with a severe insufficiency, should be corrected at the time of a surgical operation on the mitral valve, especially if the technique used to repair the tricuspid valve requires a short time of execution.

DECLARATIONS

Authors' contributions

Study design: Nardi P
Development of methodology: Nardi P
Collection of data: Ferrante S, Greci M, Vacirca SR, Russo M
Analysis and/or interpretation of data: Pisano C, Pellegrino A, Bertoldo F
Writing of the manuscript: Nardi P
Supervision: Ruvolo G

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Conflicts of interest

There are no conflicts of interest.

Patient consent

Not applicable.

Ethics approval

Not applicable.

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