Tricuspid valve repair: is ring annuloplasty superior?†

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Abstract

OBJECTIVES: Tricuspid regurgitation (TR) secondary to left heart disease is the most common aetiology of tricuspid valve (TV) insufficiency. Valve annuloplasty is the primary treatment for TV insufficiency. Several studies have shown the superiority of annuloplasty with a prosthetic ring over other repair techniques. We reviewed our experience with different surgical techniques for the treatment of acquired TV disease focusing on long-term survival and incidence of reoperation.

METHODS: A retrospective analysis of 717 consecutive patients who underwent TV surgery between 1975 and 2009 with either a ring annuloplasty [Group R: N = 433 (60%)] or a De Vega suture annuloplasty [Group NR: no ring; N = 255 (36%)]. Twenty-nine (4%) patients underwent other types of TV repair. A ring annuloplasty was performed predominantly in the late study period of 2000–09. TV aetiology was functional in 67% (479/717) of the patients. Ninety-one percent of the patients (n = 649) underwent concomitant coronary artery bypass grafting and/or mitral/aortic valve surgery.

RESULTS: Patients who received a ring annuloplasty were older (67 ± 13 vs 60 ± 13 years; P < 0.001). Overall 30-day mortality was 13.8% (n = 95) [Group R: n = 55 (12.7%) and Group NR: n = 40 (15.7%)]. Ten-year actuarial survival after TV repair with either the De Vega suture or ring annuloplasty was 39 ± 3 and 46 ± 7%, respectively (P = 0.01). Twenty-eight (4%) patients required a TV reoperation after 5.9 ± 5.1 years. Freedom from TV reoperation 10 years after repair with a De Vega annuloplasty was 87.9 ± 3% compared with 98.4 ± 1% after the ring annuloplasty (P = 0.034).

CONCLUSIONS: Patients who require TV surgery either as an isolated or a combined procedure constitute a high-risk group. The long-term survival is poor. Tricuspid valve repair with a ring annuloplasty is associated with improved survival and a lower reoperation rate than that with a suture annuloplasty.

Keywords: Tricuspid valve repair • Outcome • Valve-related complications

INTRODUCTION

Tricuspid regurgitation (TR) secondary to left heart disease is the most common aetiology of tricuspid valve (TV) insufficiency [1–3]. Therefore, the majority of the patients who require TV surgery undergo concomitant mitral and/or aortic valve surgery [4, 5]. Uncorrected moderate and severe TR may persist or even worsen after mitral valve surgery, leading to progressive heart failure and death [6]. For patients requiring mitral valve surgery, TV annuloplasty should be considered even in the absence of significant regurgitation, when severe annular dilatation is present [7].

Secondary or functional TV insufficiency is primarily treated with a valve reconstruction which carries a lower operative risk than valve replacement [4, 5]. However, there is an ongoing debate whether the TV should be repaired using either a suture-based or a prosthetic ring annuloplasty [4, 5, 8–10].

Several authors have shown a better long-term and event-free survival, freedom from recurrent TV regurgitation and reoperation in patients who underwent a ring annuloplasty [4, 5, 9–11]. Others report excellent long-term results using De Vega’s annuloplasty [12]. There is a large body of literature reporting the operative results of both techniques; however, there are only a few long-term comparative studies available [4, 5, 9–11].

This study was undertaken to examine our experience with TV repair using either a De Vega suture or a prosthetic ring annuloplasty, with special focus on long-term survival, recurrence of TR and incidence and causes of reoperation.

MATERIALS AND METHODS

A total of 717 consecutive patients underwent TV repair at the Department of Cardiovascular Surgery, German Heart Center,
Technische Universität Munich from January 1975 to May 2009. The study population consisted of 688 patients who underwent TV annuloplasty with either a De Vega suture [Group NR = no ring; \(N = 255\) (37%)] or a prosthetic ring annuloplasty [Group R, \(N = 433\) (63%)]. Twenty-nine patients who underwent other types of TV repair or patients with Ebstein’s disease were excluded.

The average age at operation was 65 ± 13 years (range 5–86 years). During the study period, the mean age at operation increased from 53 ± 10 (1974–89) to 67 ± 13 years (2000–09) \((P < 0.001)\). Two hundred and seventy-one (49%) patients were men and 417 (61%) women.

Six hundred and sixty-one (96%) patients presented with TV regurgitation, one (0.1%) with valve stenosis and 12 (1.7%) with a combined stenosis and incompetence. In 14 (2%) patients, TV pathology could not be ascertained retrospectively. Four hundred and forty-two (62%) patients presented with functional TV regurgitation secondary to annular dilatation without morphological changes of the leaflets. Forty-two (6%) patients presented with TV endocarditis and 40 (6%) showed a rheumatic pathology. In 24 patients, TV regurgitation resulted from trauma or other causes. In 106 (15%) patients, the aetiopathology could not be ascertained retrospectively.

Preoperative TR was severe in 69%, moderate in 30% and minimal in 1%. One hundred and ninety-nine (29%) patients presented in sinus rhythm, 380 (55%) with atrial fibrillation, 52 (8%) had undergone a previous pacemaker implantation and seven (1%) presented with other heart rhythm disturbances. In 50 (7%) patients, we had no information regarding the preoperative electrocardiogram (ECG). Seventeen (2.5%) patients had a history of preoperative myocardial infarction, in an average of 8.6 ± 6 years prior to the operation.

In 597 (87%) patients, the preoperative NYHA functional class could be assessed retrospectively: 12 (2%) patients were in class I, 171 (28.6%) patients were in class II, 326 (54.6%) patients were in class III and 88 (14.7%) patients were in class IV. Haemodynamic data of 632 (92%) patients who underwent coronary angiography and left ventriculography at an average of 3.4 ± 9.6 months before the operation, were available for analysis. The preoperative clinical and haemodynamic data are summarized in Table 1. Two hundred and thirty-two (34%) patients had undergone 272 previous cardiac operations in an average of 14.7 ± 9.7 years prior to TV surgery. Table 2 summarizes the types of surgery.

### Operative data

Six hundred and eighty-eight patients underwent TV repair with either a De Vega suture [Group NR = no ring, \(N = 255\) (37%)] or a prosthetic ring annuloplasty [Group R, \(N = 433\) (63%)]. The De Vega annuloplasty was performed using a double armed 3.0 polypropylene suture. Starting at the anterosuperolateral commissure, the suture was passed along the junction of the annulus and the right ventricular wall in a clockwise direction to the posteroseptal commissure. In the early study period, the suture was tightened under direct vision until the valve ring was reduced to a size capable of accommodating three fingers of the surgeon. Three hundred and thirty-two (49%) patients received a Carpentier-Edwards ring (Edwards Lifesciences, Irvine, CA, USA) and 87 (20%) patients received an Edwards MC3 annuloplasty ring (Edwards Lifesciences). A prosthetic ring annuloplasty was performed mainly in the late study period 2000–09 (Table 3). The appropriate size of the annuloplasty ring was selected based on the length of the septal annulus and/or the area of the anterior leaflet.

The most commonly used size for the prosthetic ring was 32 and 34 mm (Fig. 1). Six hundred and sixty-eight (97%) patients were operated through a median sternotomy and 20 patients through a right anterolateral incision. Intraoperative myocardial protection was provided by systemic hypothermia (26–32°C), topical cooling of the heart and antegrade infusion of cold (4°C) crystalloid cardioplegia (Bretschneider solution) into the aortic root. Twenty-four (3.5%) patients were operated on an emergency bypass.
The mean cardiopulmonary bypass time was 127 ± 57 min. The mean aortic cross-clamp time was 80 ± 33 min. Six hundred and twenty-three (91%) patients underwent a concomitant procedure, such as mitral valve surgery in 532 (532/623 = 85%) patients, aortic valve surgery in 163 (163/623 = 26%) and coronary artery bypass grafting in 124 (124/623 = 20%). Fifty-six (8%) patients required implantation of a permanent pacemaker postoperatively. Twenty (3%) patients received an immediate postoperative intraaortic balloon pump support. Two patients required an assist device and one, an ECMO implantation. All patients who received a ring annuloplasty or a biological prosthesis in the mitral or aortic position were discharged on a regimen of phenprocoumon (coumadine) for the first 3 months postoperatively. Beyond 3 months, anticoagulant therapy was continued only in patients with chronic and intermittent atrial fibrillation.

Follow-up

A complete follow-up was achieved in 92% of the patients, yielding a cumulative total of 3372 patient-years (mean follow-up 4.9 ± 5.1 years, range 0–30 years, Group NR 7.3 ± 6.9 years, Group R 3.5 ± 2.7 years). The follow-up was closed on 31 December 2010. Fifty-five patients were lost to the follow-up after an average of 6.0 ± 6.3 years. The follow-up data were obtained from the patients’ follow-up visits, mailed questionnaires and by telephone interview with the patient, their families or physicians and included the activity level, current symptoms, results of diagnostic tests, occurrence of late cardiac events (e.g. reoperations, thromboembolic events) and medications being taken. Postoperative events were compiled and analysed according to the ‘Guidelines for Reporting Morbidity and Mortality after Cardiac Valvular Operations’ approved by the Society of Thoracic Surgeons [13].

All echocardiographic studies were performed as part of the routine clinical care. Tricuspid regurgitation was assessed from multiple transthoracic windows. The severity of TR was assessed considering TV morphology, colour flow TR jet and continuous wave Doppler (CW) signal of TR jet, vena cava (VC) width and hepatic vein flow. Tricuspid regurgitation was classified as none (0), mild (1), moderate (2) and severe (3). A total of 396 postoperative echocardiographic reports were available for analysis.

Statistical analysis

The data are expressed as proportions or as the mean ± standard deviation. The Kaplan–Meier method was used to study patient and event-free survival probability. The log-rank test was used to ascertain differences between the groups. The X² test (for categorical variables) and Mann–Whitney U-test (for continuous variables) were used to determine the statistical significance. The significant factors were entered into a multiple logistic regression model to assess the independent impact of potential risk factors. The predictors of survival were identified in a multivariable analysis with Cox proportional hazards modelling. The results were considered significant if P values were <0.05. Computations were carried out using the IBM-SPSS software, release 19 (IBM-SPSS, Chicago, IL, USA).

Table 3: Operative data of 688 patients who underwent TV repair with either a De Vega suture (Group NR) or a ring annuloplasty (Group R)

<table>
<thead>
<tr>
<th></th>
<th>All (N = 688)</th>
<th>Group NR (N = 255)</th>
<th>Group R (N = 433)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Date of operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1975–89</td>
<td>91</td>
<td>13</td>
<td>89</td>
<td>35</td>
</tr>
<tr>
<td>1990–99</td>
<td>121</td>
<td>18</td>
<td>116</td>
<td>45</td>
</tr>
<tr>
<td>2000–09</td>
<td>476</td>
<td>69</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>Right thoracotomy</td>
<td>20</td>
<td>3</td>
<td>9</td>
<td>3.5</td>
</tr>
<tr>
<td>Concomitant procedures</td>
<td>623</td>
<td>91</td>
<td>240</td>
<td>94</td>
</tr>
<tr>
<td>CABG</td>
<td>124</td>
<td>18</td>
<td>34</td>
<td>13</td>
</tr>
<tr>
<td>AV replacement</td>
<td>155</td>
<td>23</td>
<td>54</td>
<td>21</td>
</tr>
<tr>
<td>MV repair</td>
<td>199</td>
<td>29</td>
<td>35</td>
<td>14</td>
</tr>
<tr>
<td>MV replacement</td>
<td>333</td>
<td>48</td>
<td>191</td>
<td>75</td>
</tr>
<tr>
<td>Nonelective</td>
<td>77</td>
<td>11</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Postop IABP support</td>
<td>20</td>
<td>3</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Postop pacemaker</td>
<td>56</td>
<td>8</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>CPB time (min)</td>
<td>127 ± 57</td>
<td>113 ± 45</td>
<td>135 ± 61</td>
<td></td>
</tr>
<tr>
<td>Cross-clamp time (min)</td>
<td>80 ± 33</td>
<td>73 ± 29</td>
<td>83 ± 35</td>
<td></td>
</tr>
</tbody>
</table>

Continuous variables are expressed as mean ± standard deviation.
Patients of Group NR were significantly younger (60 ± 13 vs. 67 ± 13 years; P < 0.001) and more likely to be female (66 vs. 57%, P = 0.020) than those of Group R. No significant differences between both the patient groups were found regarding the mean pulmonary artery pressure (MPAP) (P = 0.121) and the left ventricular ejection fraction (LVEF) (P = 0.580).

Previous cardiac operations were more prevalent in Group NR (44 vs. 28%, P < 0.001). There was also a significant difference in the number of patients who received a permanent pacemaker, preoperatively (Group NR 10%, Group R 6%, P = 0.045). Patients who underwent a De Vega suture annuloplasty exhibited shorter cardiopulmonary bypass time (113 ± 45 vs. 135 ± 61 min, P ≤ 0.001) and aortic cross-clamp time (73 ± 29 vs. 83 ± 35 min, P ≤ 0.001). Concomitant procedures were also more frequent in Group NR (94 vs. 88%, P = 0.014). A total of 24 (3.5%) patients (n = 9 in Group NR and n = 15 in Group R) were operated on an emergency basis (within 24 h after admission) and 53 (8%) patients required an urgent operation (Tables 1 and 3).

Operative mortality

Overall 30-, 60- and 90-day mortalities were 13.8 (95/688), 16.9 (116/688) and 18.3% (126/688), respectively. Thirty-day mortalities in Groups NR and R were 15.7 (40/255) and 12.2% (58/476), respectively. Emergent and urgent operations were associated with a significantly higher 30-day mortality [emergent 37.5 (9/24) and urgent 15.1% (8/53)] than elective operations (11.7%) (P = 0.001). Thirty-day mortality after isolated TV surgery was 9.2 (6/65) compared with 14.3% (89/623) after TV surgery with a concomitant procedure (P = 0.015).

A multivariate analysis of risk factors associated with a 30-day mortality revealed a longer duration of cardiopulmonary bypass (OR = 1.013; 95% CI 1.009–1.017, P = 0.001) as an independent predictor of early mortality. A ring annuloplasty was an independent predictor favouring survival (OR = 0.404, 95% CI 0.23–0.72, P = 0.002). Other parameters such as age, male sex, NYHA functional class ≥III, TV surgery with concomitant aortic/mitral valve surgery (combined procedure) had no significant influence on 30-day mortality. Nonelective surgery was associated with an increased risk of 30-day mortality.

Late mortality

Two hundred and twenty-one (32%) patients died late after an average of 5.5 ± 6 years. Ten-year actuarial survival after TV repair with either a De Vega suture or a ring annuloplasty was 39 ± 3 and 46 ± 7%, respectively (P = 0.01) (Fig. 2). Patients who underwent isolated TV repair showed superior late survival than those who underwent a combined procedure (actuarial survival at 10 years 69.8 ± 7 vs. 45.8 ± 3%, P = 0.011). The type of annuloplasty had no influence on late survival (4-year survival after TV repair with a Carpentier-Edwards ring 71.3 ± 2.5% and Edwards MC3 ring 68.5 ± 7.1%, P = 0.848). Variables assessed as possible multivariate predictors of long-term survival are listed in Table 4. TV ring annuloplasty was an independent predictor favouring long-term survival. Other independent predictors were increasing age, previous cardiac surgery and reduced LVEF.

The analysis of 289 echocardiographic examinations performed within the first month after the operation showed that 170 (58.8%) patients had no TR, 102 (35.3%) had trivial to mild, 15 (5.2%) had moderate and 2 (0.7%) presented with severe regurgitation. Ninety-four patients underwent a repeat echocardiography at an average of 1.8 ± 2.5 years. Twenty-eight (30%) patients presented with no regurgitation, 56 (60%) with mild and 10 (11%) with moderate regurgitation. Freedom from recurrent moderate or severe TR 10 years after surgery in Groups NR and R was 89 ± 3 and 96 ± 1% (P = 0.26), respectively.

Reoperations

Within an observation period of 30 years, 45 (6.5%) patients required a reoperation 2 days–22 years (mean 5.9 ± 5.5 years) after the initial operation (Group NR n = 34, Group R n = 11; P < 0.001). Twenty-eight (4%) patients required a TV-related reoperation (Group NR n = 23, Group R n = 5; P < 0.001). Twelve (43%) patients underwent a repeat TV repair, six patients received a biological prosthesis and 10 a mechanical prosthesis. Freedom from TV reoperation 10 years after repair with a

Table 4: Variables assessed as possible predictors of long-term survival

<table>
<thead>
<tr>
<th>Factor</th>
<th>P-value</th>
<th>HR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (male)</td>
<td>0.87</td>
<td>0.970</td>
<td>0.67–1.40</td>
</tr>
<tr>
<td>NYHA functional class ≥III</td>
<td>0.75</td>
<td>1.064</td>
<td>0.72–1.56</td>
</tr>
<tr>
<td>Concomitant procedure</td>
<td>0.73</td>
<td>0.879</td>
<td>0.43–1.81</td>
</tr>
<tr>
<td>Age &lt;0.001</td>
<td>1.065</td>
<td>0.72–1.56</td>
<td></td>
</tr>
<tr>
<td>Previous cardiac surgery</td>
<td>0.024</td>
<td>1.545</td>
<td>1.06–2.25</td>
</tr>
<tr>
<td>EF</td>
<td>0.022</td>
<td>0.984</td>
<td>0.97–1.00</td>
</tr>
<tr>
<td>TV ring annuloplasty</td>
<td>0.021</td>
<td>0.594</td>
<td>0.38–0.92</td>
</tr>
</tbody>
</table>

Variables assessed as possible predictors of long-term survival by Cox regression analysis. HR: hazard ratio; CI: confidence interval; TV: tricuspid valve.
De Vega annuloplasty was 87.9 ± 3% compared with 98.4 ± 1% after a ring annuloplasty (P = 0.034) (Fig. 3). There was a significant difference in probability of reoperation for all causes (freedom from reoperation at 10 years in Group NR 82.8 ± 3%; Group R 96 ± 1%; P = 0.031). No significant difference was found regarding the reoperation rate in patients who underwent isolated TV surgery or a combined procedure. The causes of reoperation are summarized in Table 5. Thirty-day and hospital mortality after the reoperation was 17.8 (8/45) and 26.7% (12/45), respectively. A total of 56 patients (Group NR n = 17, Group R n = 39; P = 0.001) required a permanent pacemaker implantation postoperatively. Ten-year actuarial freedom from a pacemaker implantation was 91.8 ± 2% in Group NR and 88 ± 2% in Group R; P = 0.013. Twenty-eight (4%) patients (Group NR n = 3, Group R n = 25) required a re-exploration for bleeding.

Valve-related complications

Overall 24 (3.5%) patients experienced a thromboembolic event. Freedom from thromboembolism 10 years after TV repair was 92.6 ± 2%. There was no significant difference between patients of Groups NR and R (freedom from TE at 10 years Group NR 92.4 ± 2% and Group R 92.4 ± 4%; P = 0.626). Eight patients presented with a bleeding complication. Freedom from bleeding complications 10 years after TV repair was 98.1 ± 1% (Group NR 99 ± 1%, Group R 93.5 ± 5%; P = 0.001). There was no difference in the combined rate of bleeding, thromboembolism and reoperation from all causes between both the patient groups (Group NR 76 ± 4%, Group R 84 ± 5%, P = 0.252).

Event-free survival was defined as freedom from thromboembolisms, major bleeding events, reoperations for all causes and death. The patients in Group R showed a higher event-free survival when compared with Group NR (at 10 years 42 ± 3 vs. 36 ± 3%). However, the difference did not reach significance (P = 0.097).

DISCUSSION

Tricuspid regurgitation most commonly occurs as a result of left heart insufficiency in patients with mitral or aortic valve disease and is caused by subsequent right ventricular and tricuspid annular dilatation, displacement of papillary muscles and leaflet tethering [1-3]. Thus, the majority (89-94%) of the patients who require TV surgery undergo concomitant mitral and/or aortic valve surgery [4, 5, 14, 15]. TV surgery is recommended for symptomatic patients with the signs of right heart failure and severe TV regurgitation, but there is growing evidence that even patients presenting with annular dilatation without significant regurgitation benefit from valve repair [4, 7, 16, 17]. Uncorrected moderate and severe TR may persist or even worsen after mitral valve surgery, leading to progressive heart failure and death [6]. Functional TV regurgitation is primarily treated by annuloplasty. Valve replacement is rarely necessary and is associated with a worse outcome [15]. However, there is an ongoing debate on whether the TV should be repaired using either a suture-based or a prosthetic ring annuloplasty.

The De Vega suture annuloplasty proposed as an easy and fast, cost-effective method for TV repair, which preserves the flexibility of the annulus and avoids prosthetic material has been the most commonly used TV repair technique in the past [18]. Various authors have reported good long-term results. Bernal et al. [19] analysed 232 consecutive patients undergoing TV repair including 93 patients with a De Vega annuloplasty and report a 12-year actuarial survival rate of 55% and freedom from reoperation rate of 75%. Morishita et al. [12] studied 408 patients and report a 30-day mortality of 3.4%. The 15-year actuarial survival and freedom from reoperation were 74 and 91.6%, respectively. These results have been questioned by other authors who report a high incidence of recurrent TV regurgitation following the De Vega annuloplasty. In a large series, Tang et al. [5] compared 493 patients with a De Vega annuloplasty and 209 with a ring annuloplasty. Echocardiographic data could be obtained in 91% of the 481 survivors. At the latest follow-up (5.7 ± 4.8 years), 30-36% of the patients presented with moderate or severe TV regurgitation. The patients who underwent a ring annuloplasty showed a significantly higher freedom form recurrent TV regurgitation (82% at 15 years) compared with those with a De Vega annuloplasty (39% at 15 years). The patients with a ring annuloplasty also had a significantly improved long-term survival (49 vs. 36% at 15 years) and event-free survival (34 vs. 17%). The authors assumed that the improved survival in the ring group may be related to a better prevention of annular dilatation and right ventricular volume overload and failure.

![Figure 3: Freedom from TV-related reoperation. The Kaplan-Meier estimate of freedom from reoperation for patients who underwent TV repair with the De Vega suture (Group NR = solid line) or prosthetic ring annuloplasty (Group R = dotted line). Freedom from TV reoperation 10 years after TV repair with either the De Vega suture or the prosthetic ring annuloplasty was 87.9 ± 3% and 98.4 ± 1%, respectively (P = 0.034).](image-url)
However, the patients in their ring group were younger (55 vs. 59 years) and less likely to have coronary artery disease (CAD) (10 vs. 17%). McCarthy et al. [4] analysed 790 patients who underwent TV repair with four different techniques including the De Vega procedure and ring annuloplasty with different semi-rigid and flexible devices. They reported a low reoperation rate of 2.9% per year by 10 years. Freedom from reoperation was 97% at 8 years. Despite this low reoperation rate, 15% of their patients showed recurrent TR grades 3+ and 4+ one month postoperatively. During the follow-up, regurgitation evolved differently among the four repair techniques. The proportion of patients with severe TV regurgitation rose sharply in the first 6 months of the follow-up and was more pronounced in the patient group with a De Vega annuloplasty compared with a ring annuloplasty with a Carpentier-Edwards or Cosgrove ring. According to McCarthy et al. [4], the discrepancy between the high recurrence rates of TV regurgitation and the low reoperation rates may be explained by the fact that TV repair is associated with a high mortality and thus, these patients are managed medically as long as possible before referral to surgery. Rivera et al. [9], in a prospective randomized trial of 159 patients comparing the De Vega annuloplasty with the Carpentier ring annuloplasty, have also shown a higher recurrence of moderate and severe TV regurgitation following the De Vega repair. Nava et al. [10] studied more than 2000 patients with functional TV regurgitation and report a high recurrence rate of TR. By 3 months after surgery, 34% of the patients had moderate or severe regurgitation, which increased to 45% at 5 years. The best results could be achieved in the patient group with a rigid annuloplasty ring (Carpentier-Edwards or MC3). Again, patients with a De Vega annuloplasty had worse results compared with those with a rigid ring annuloplasty. A higher degree of preoperative regurgitation, poor left ventricular function, the presence of a trans-tricuspid pacing lead and TV annuloplasty without using an annuloplasty ring were independent risk factors for worsening regurgitation [4]. According to Rivera et al. [9], patients with a high total pulmonary resistance or organic TV disease are also at increased risk for recurrent regurgitation irrespective of the type of annuloplasty. In our series, the incidence of TV reoperation was only 4%. The majority of the patients 23/28 (82%) who required a TV reoperation had undergone a De Vega suture annuloplasty. Recurrent TV ring dilatation or suture disruption were the main causes for reoperation. The patients who underwent a ring annuloplasty showed a significantly higher freedom from reoperation at 10 years compared with those with a De Vega annuloplasty (87.9 ± 3 vs. 98 ± 1%). This corresponds with the results of Tang et al. [5] who report a lower but nonsignificant incidence of TV reoperations in the patient group with a ring annuloplasty. In contrast to the study of McCarthy et al. [20] who report 15% of their patients with recurrent TR grades 3+ and 4+ one month postoperatively, we had only two patients with severe TV regurgitation. Preoperative leaflet tethering, the size of the tricuspid annulus, pulmonary artery pressure and right- and left ventricular functions are the most important factors for the persistence of functional TV regurgitation after surgery. In a study on 39 patients, Fukuda et al. [20] demonstrated that preoperative TV leaflet tethering (tethering height and area) and postoperative LV dysfunction are predictors of residual or recurrent TV regurgitation after annuloplasty.

Unfortunately, the dimensions of the tricuspid annulus were not systematically measured, particularly at the beginning of the present series, and therefore could not be used for analysis. We also do not have consistent echocardiographic data on leaflet tethering in our study population. The focus of the current techniques of TV repair is to reduce annular dilatation. However, for those patients with a severe leaflet tethering, additional repair techniques may be beneficial [21, 22]. According to McCarthy et al. [4], the presence of a transtricuspid pacing lead is a risk factor for worsening TR and therefore, they recommend the replacement of the tricuspid leads by epicardial leads. Pfannmüller et al. [23], analysing 116 patients with a right ventricular pacemaker undergoing TV repair, recommend removal only in those patients with a pacemaker lead-related leaflet injury.

Today, consensus has not been reached regarding the optimal choice of the annuloplasty ring. Pfannmüller et al. [24] report an increased risk of ring dehiscence predominantly at the septal leaflet portion of the annulus for classic Carpentier-Edwards rings. Nava et al. [10], however, could achieve the best results using a rigid ring. In the present study, we found no difference in the reoperation rate with regard to the type of annuloplasty ring. However, due to the shorter follow-up period and the smaller sample size of the patient group with the MC3 annuloplasty ring, we cannot yet reach a final conclusion regarding the superiority of one annuloplasty ring over the other.

Operative and late mortality

TV repair is usually associated with a lower perioperative risk and improved long-term outcome compared with valve replacement [15]. Nevertheless, the reported mortality rates are considerable and range between 4 and 12% [4, 5, 14, 19, 23]. Most of the patients are in poor clinical condition, with 31–97% of the patients being in NYHA functional class III or IV [4, 5, 14, 15]. Thus the need for TV surgery reflects an advanced stage of heart disease with a severe right ventricular dysfunction and explains the high operative mortality.

The various risk factors for hospital-operative mortality have been identified, such as advanced age, male gender, renal insufficiency, NYHA functional class II, preoperative hemoperamgmatomegaly, severity of preoperative pulmonary oedema, high preoperative bilirubin level, MPAP >40 mmHg, pulmonary vascular resistance >6 Wood units, cardiopulmonary bypass time, number of additional valves replaced, previous cardiac surgery and emergency operation [5, 14, 15, 19]. In our study, the duration of cardiopulmonary bypass was an independent predictor of 30-day mortality. A ring annuloplasty was an independent predictor favouring early and late survival.

Patients who require TV surgery are a very heterogeneous group. Therefore, the comparison of surgical results is difficult. In our study, the 30-day mortalities in Groups NR and R were 15.7 and 12.7%, respectively. Tang et al. [5] report an in-hospital mortality for patients who underwent TV repair with or without ring annuloplasty of 4 and 7%, respectively. Both the patient groups differed significantly with respect to age, female sex, prior cardiac surgery, CAD, TV pathology and concomitant procedures. In contrast to the study of Tang et al., the patients in our series who underwent TV ring annuloplasty were older (68 ± 13 vs. 55 ± 14 years) and less likely to be female (66.5 vs. 75%), with a higher prevalence of concomitant procedures. McCarthy et al. [4] report a low 30-day mortality of 6% in a series of 790 patients. However, they do not report the prevalence of emergent or urgent operations, which are usually
associated with a considerable operative mortality (in our series 37.5%). Thus, the difference in operative mortality may be more influenced by the patient condition and comorbidities as well as the elective/non elective status of surgery rather than the type of TV repair. There are only a limited number of studies with a large patient collective reporting long-term results after TV repair. The reported actuarial survival rates for patients who received a De Vega procedure range between 55 and 75% [12, 19]. In the study of McCarthy et al. [4], the 8-year overall survival was 50%, with no reported difference between the four types of TV repair applied. Tang et al. [5], however, found a significantly improved long-term survival (49 vs. 36% at 15 years) and event-free survival (34 vs. 17%) for patients who underwent a ring annuloplasty compared with the De Vega procedure. In our series, the patients who underwent a ring annuloplasty despite being older showed a significantly improved survival when compared with those who underwent a De Vega suture (at 10 years 46 ± 7 and 39 ± 3%). In accordance with the study of Tang et al., TV ring annuloplasty was an independent predictor favouring long-term survival. Other predictors were increasing age, previous cardiac surgery and reduced LVEF.

The improved long-term survival might be related to a better prevention of annular dilatation and right ventricular volume overload and a lower reoperation rate, which is usually associated with a considerable operative mortality [5].

Study limitations

Our study is a retrospective study with all of the inherent limitations. Unfortunately no consistent, accurate echocardiographic data (especially from the early study period) were available. Thus, we have limited information about the development of recurrent TR and right ventricular dysfunction for these patients who were operated in the early years and predominantly received a De Vega annuloplasty. Therefore, the prevalence of recurrent TR may be underestimated. Furthermore, as with all studies of clinical experience, the data may be subject to selection bias. Symptomatic patients might have been more likely to receive the follow-up echocardiography than asymptomatic patients. During the 30-year study period, pre- and intraoperative diagnostic evaluation, surgical technique, anaesthesiologic management and intensive care changed considerably and it is difficult to take into consideration all the factors that might have influenced the results. We compared two different surgical techniques for TV repair. The De Vega suture annuloplasty was performed from 1974 and the ring annuloplasty was applied mainly in the late study period. Patients in the De Vega group had a longer follow-up and the sample sizes of both the patient groups were different. This might have influenced the late clinical results. A prospective randomized trial would provide more definitive conclusions regarding the superiority of a particular technique.

TV surgery is associated with a considerable operative and late mortality. Thus, the influence of the competing risk of death has to be considered when the event-free survival from valve-related complications such as thromboembolism, bleeding or reoperation is calculated by the Kaplan–Meier method, because the probability of reoperation, for example, may be overestimated when the patients who died before the event occurred are censored. Despite all these limitations, this study is one of very few to have followed up patients over a period of 30 years.

CONCLUSION

Patients who require TV surgery constitute a high-risk group. Operative and late mortality are considerable. The incidence of reoperation is low. TV repair with a ring annuloplasty is associated with improved survival and a lower reoperation rate.

Conflict of interest: none declared.

REFERENCES

APPENDIX. CONFERENCE DISCUSSION

Dr M. De Bonis (Milan, Italy): This interesting study addresses the long-term outcome of ring annuloplasty. An important limitation of the study is that the population is very heterogeneous, including patients with tricuspid regurgitation but also tricuspid stenosis, mixed stenosis and regurgitation and, in 14 patients, the tricuspid valve pathology could not even be established retrospectively. The reoperation rate was very low at 4%, but only 16% of the discharged patients had an echocardiogram at follow-up.

The first point I would like to make is that patients undergoing De Vega repair, although younger, were more frequently redo cases, had more concomitant procedures, higher preoperative rate of atrial fibrillation and pacemakers, and this of course might have significantly influenced the results, because the differences are important. So the first question is, don’t you think that propensity score matching would have been useful in terms of adjusting for these preoperative differences? In your multivariate analysis I didn’t see atrial fibrillation and pacemakers, which are well known predictors of repair failure. So that is my first question.

The second one is more a consideration from a statistical point of view. You showed that there is a statistically significant difference in overall survival at 10 years in favour of the ring group. However, if you look at the Kaplan-Meier curves, the number of patients at risk at 10 years is very low, less than 10 patients (at least in one of the two groups). Therefore, don’t you think that, from a statistical point of view, the conclusion should be drawn at a shorter follow-up interval, meaning five or six years, when the number of patients at risk is significantly higher?

Dr Günther: We have the problem that this is a retrospective analysis and with a retrospective analysis we cannot rule out all the possible factors that might have biased the study. Both patient groups differed significantly regarding age, sex distribution and previous cardiac surgery. So you are perfectly right, the next step would be to perform a propensity score analysis in order to rule out all these various influences. Nevertheless, there is only a limited number of studies available with a long-term follow-up of 30 years. And to answer the second question, we had 52 patients who had pacing wires in the RV, and we usually remove the pacing wires when we perform a repair and put on epicardial wires.

Dr De Bonis: So you had no patients with pacing wires through the tricuspid ring? You removed them and you put them epicardially?

Dr Günther: Not at the time of reoperation. We had 28 patients who had to be reoperated, and 11 of these patients had to be reoperated because of an isolated tricuspid valve problem.

Dr De Bonis: What about the other consideration? Probably the results would be more meaningful from a statistical point of view if you look at them not at 10 years but probably at six. If you look at the patients at risk and at the shape of the curve, you have six patients at risk at 10 years, and this applies to survival but also to freedom from reoperation, freedom from recurrent TR. So I really advise that you look at those results when the number of patients at risk is higher. Don’t you agree with that?

Dr Günther: You are perfectly right. On the other hand, we know that tricuspid regurgitation recurs quite early after surgery. Some authors report a recurrence rate of 15% one month postoperatively. Nevertheless, I appreciate your suggestion to perform the analysis at a shorter follow-up.

Dr M. Antunes (Coimbra, Portugal): I may have missed it, but in what percentage of cases of mitral valve surgery, both at the primary surgery or at reoperation, do you perform some intervention on the tricuspid valve?

Dr Günther: In what percentage of patients?

Dr Antunes: Today in what percentage of patients do you do a tricuspid annuloplasty?

Dr Günther: In the same time period we operated on 1,700 mitral valve patients; about one-fourth of our patients underwent concomitant tricuspid valve surgery at the time of mitral valve surgery.

Dr Antunes: Well, I have also the same difficulties that Dr De Bonis pointed out about the long-term follow-up and the divergence of the curves. I am still a strong supporter of suture annuloplasty. Don’t you think that suture annuloplasty is less reproducible and that it varies a lot with the degree of tightening of the annulus that you produce, while the ring is probably more standardized and perhaps not influenced as much by that size?

Dr Günther: We only used the classic De Vega technique, and we don’t have experience with the technique that you proposed, but probably with your technique we would have achieved other results. But I can’t comment on that.

Dr Antunes: Have you completely abandoned suture annuloplasty?

Dr Günther: Yes.

Dr A. Sarraj (Madrid, Spain): Do you think that we have to use a ring in all cases? Do you think that is necessary to use a ring to repair a tricuspid valve with moderate dilatation of the annulus and moderate pulmonary hypertension? Is it necessary? And another question. Why did you shift from a classic Carpenter ring to a McCarthy ring? What is the reason when you use the classic one, when you use the three-dimensional ring? Do you think that is necessary to use a rigid ring for all cases?

Dr Günther: I am not sure if I got your question right. We changed our policy in 1999 because of the reported high recurrence rate of tricuspid regurgitation in those patients who had a suture annuloplasty. We prefer rigid rings, and we do have a very low reoperation rate in these patients, and we did not see, in contrast to others, any ring displacement or dehiscence.

Dr Sarraj: I have a question for you, if it is possible.

Dr De Bonis: For me?

Dr Sarraj: Yes. In your presentation, you used actually relatively small rings, 28 and 30, for undersizing the tricuspid annulus ring. So do you prefer undersizing the ring more than augmentation of the valve?

Dr De Bonis: Augmentation of the leaflet you mean?

Dr Sarraj: Because if you undersize the ring, you also increase the tethering distance.

Dr De Bonis: Well, that is important only if you have important tethering of the leaflets, but that is just the exception. Important tethering of the leaflets is usually present in long-standing functional TR in redo cases, and you can measure that. You are right, if you undersize you are probably going to force the coaptation but increase the tethering. So you have to be very aggressive in terms of undersizing. Now those were not really patients with a huge right ventricle or high tethering, even though we did not measure that, but they were not those type of cases.

So to answer your question, the increase of the surface of the anterior leaflet, for instance, is a technique you can use; we have been using that, but only when you have very important dilatation of the right ventricle or important tethering. I do not advise using that technique for normal tricuspid annuloplasty. In that case I would just undersize slightly, and that’s it. I don’t see the role in this setting for enlarging the surface of the leaflets.