Tricuspid Valve Repair With an Annuloplasty Ring Results in Improved Long-Term Outcomes

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Background—The purpose of this study was to compare the long-term results of tricuspid valve (TV) repair with or without an annuloplasty ring.

Methods and Results—702 patients underwent TV repair at our institution (1978 to 2003), of which 493 had, predominantly, a De Vega procedure (no ring) and 209 had an annuloplasty ring (ring). TV pathology was functional (secondary) in 74% of patients. Concomitant procedures consisted of mitral valve surgery in 80% of patients, aortic valve surgery in 33%, and coronary bypass in 14%. Clinical and echocardiographic follow-up data were obtained. Follow-up was 99% complete and was 5.9 ± 4.9 (mean ± SD) years long. Ring patients were younger (55 ± 14 versus 59 ± 14 years; P = 0.001) and less likely to have coronary artery disease (10% versus 17%; P = 0.02), more likely to be female (75% versus 65%; P = 0.01) and having had previous cardiac surgery (56% versus 42%; P = 0.001). Operative times were similar between the 2 groups. Long-term survival, event-free survival and freedom from recurrent TR were significantly better in the ring group, and there was a trend toward fewer TV reoperations. Multivariable analysis demonstrated that the use of an annuloplasty ring was an independent predictor of long-term survival (hazard ratio [HR], 0.7; 95% confidence interval [CI], 0.5 to 1.0; P = 0.03) and event-free survival (HR, 0.8; CI, 0.6 to 1.0; P = 0.04).

Conclusions—Placement of an annuloplasty ring in patients undergoing tricuspid valve repair is associated with improved survival and event-free survival. (Circulation. 2006;114[suppl I]:I-577–I-581.)

Key Words: outcomes ■ tricuspid valve ■ valve repair

Optimal management of tricuspid valve (TV) disease remains a challenge among cardiologists and cardiac surgeons, because patients are often asymptomatic. Organic TV disease often requires TV replacement surgery, but the procedure is rare and is associated with significant mortality and morbidity.1 The most common TV disease etiology in North America is tricuspid regurgitation (TR) secondary to left heart pathology, such as mitral valve disease and left heart failure.2 Secondary (also known as “functional”) TR can usually be corrected with TV repair, which is associated with lower perioperative risk than TV replacement. Without treatment, TR may worsen over time leading to severe symptoms, biventricular failure and death.3

Patients with symptomatic functional TR despite optimized medical therapy are candidates for TV repair.4,5 TV repair is also indicated in patients with asymptomatic moderate or severe TR undergoing concomitant cardiac surgery, particularly if pulmonary hypertension or right ventricular dilation are present.4,5 Functional TR secondary to annular dilation may be repaired with or without an annuloplasty ring. Current literature on recommendation of either repair technique remains controversial, and relatively few studies have reported long-term results. The current study was therefore undertaken to examine the long-term outcomes of TV repair with or without an annuloplasty ring.

Methods

From 1978 to 2003, 702 patients underwent TV repair at the Toronto General Hospital. Preoperative, and perioperative and postoperative data were entered prospectively into a computerized database. None of the patients who received a TV repair during this time period was excluded from the current study. The study was approved by our institution’s Research Ethics Board. Written informed consent was obtained from all patients.

Operations

TV repair was performed with an annuloplasty ring in 209 patients (ring) and without a ring in 493 patients (no ring). The choice of repair technique was at the attending surgeon’s discretion. In general, however, we tended to use a ring in patients with more severe tricuspid annular dilation or pulmonary hypertension. The annuloplasty device was a Carpentier ring (Edwards Lifesciences, Irvine, Calif) in 114 patients (54%), a Duran (Medtronic, Minneapolis, Minn) in 52 (25%), and a Cosgrove (Edwards Lifesciences) in 43 (21%). The Carpentier ring is a rigid device, whereas the Duran and Cosgrove rings are flexible. Patients undergoing TV repair without an annuloplasty ring underwent a classic De Vega procedure (single polypropylene suture from the anteroseptal to the posteroseptal commissure with a pledget at each end) or a modified De Vega...
(pledget placement between each entry site into the annulus). Concomitant procedures consisted of mitral valve surgery in 80% of patients, aortic valve surgery in 33%, and coronary bypass in 14%. Previous cardiac operations were performed in 46% of patients. TV repair was performed after other concomitant cardiac procedures were completed, usually with the aortic cross-clamp in place.

**Follow-Up**
Research personnel contacted all patients and/or patient family members through mailed questionnaires and/or telephone calls from February to September 2004. Data regarding functional status and postoperative morbidity and mortality were tabulated. Patient clinical status and echocardiographic results were also obtained from referring cardiologists. Postoperative events were compiled and analyzed according to the Guidelines for reporting morbidity and mortality after cardiac valvular operations." Follow-up was 99% complete and spanned from 0 to 21 years (mean 5.9±4.9 years). The most recent transthoracic or transesophageal echocardiogram was obtained in 91% of the surviving patients and averaged 5.7±4.8 years long.

**Statistical Analysis**
Categorical patient variables were compared using the contingency table method or the Fisher exact test, when appropriate. The means of continuous variables were compared using Student t tests. Long-term survival and freedom from morbid events were compared using the Kaplan-Meier method. Independent predictors were determined by means of Cox multivariable analysis, with backward elimination of nonsignificant determinants.

**Statement of Responsibility**
The authors had full access to the data and take full responsibility for their integrity. All authors have read and agree to the manuscript as written.

**Results**

**Preoperative Characteristics**
Table 1 shows the characteristics of patients undergoing TV repair during the study period. Compared with the no ring group, patients who received an annuloplasty ring were younger, more likely to be female, less likely to have coronary artery disease and endocarditis, and more likely to have undergone a previous cardiac operation. Patients in the ring group also had fewer concomitant coronary artery bypass and aortic valve procedures. In terms of TV pathology, the majority of patients in both groups had functional (secondary) disease and regurgitation.

**Operative Outcomes**
Low cardiac output syndrome was more common in the group who received an annuloplasty ring than in the no ring group (18% versus 9%, respectively; P=0.001). Other perioperative outcomes were similar including in-hospital mortality (4% versus 7% for ring versus no ring; P=0.2), myocardial infarction (0.5% versus 0.4%; P=0.9), postoperative bleeding (6% versus 5%; P=0.8), stroke (1% in both groups; P=0.9), and endocarditis (4% versus 2%; P=0.06).

**Long-Term Outcomes**
There were 221 total deaths during follow-up (32% of entire population). Of these, 6% occurred perioperatively, 7% were valve-related, 10% were cardiac-related, and 9% were noncardiac-related. Of those patients who were alive during follow-up, New York Heart Association (NYHA) class III or IV symptoms were present in 20% of ring patients and 25% of no ring patients. The most recent echocardiographic examination showed that in the ring group, 15% of surviving patients had no TR, 55% had trivial to mild TR, and 30% had moderate to severe TR, whereas in the no ring group, 10% had no TR, 54% had trivial to mild TR, and 36% had moderate to severe TR. Figure 1 displays the long-term

### Table 1: Preoperative and Perioperative Characteristics of the 702 Patients Who Underwent Tricuspid Valve Repair at the Toronto General Hospital, 1978 to 2003

<table>
<thead>
<tr>
<th></th>
<th>Ring (n=209)</th>
<th>No Ring (n=493)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preoperative</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex, female</td>
<td>75%</td>
<td>65%</td>
<td>0.01</td>
</tr>
<tr>
<td>Mean age, y</td>
<td>55±14</td>
<td>59±14</td>
<td>0.001</td>
</tr>
<tr>
<td>LVEF, &lt;40%</td>
<td>15%</td>
<td>18%</td>
<td>0.4</td>
</tr>
<tr>
<td>NYHA III-IV</td>
<td>88%</td>
<td>84%</td>
<td>0.4</td>
</tr>
<tr>
<td>Prior cardiac surgery</td>
<td>56%</td>
<td>42%</td>
<td>0.001</td>
</tr>
<tr>
<td>CAD</td>
<td>10%</td>
<td>16%</td>
<td>0.03</td>
</tr>
<tr>
<td>Diabetes</td>
<td>11%</td>
<td>12%</td>
<td>0.8</td>
</tr>
<tr>
<td>Hypertension</td>
<td>18%</td>
<td>23%</td>
<td>0.1</td>
</tr>
<tr>
<td>PVD</td>
<td>2%</td>
<td>3%</td>
<td>0.3</td>
</tr>
<tr>
<td>Renal failure</td>
<td>2%</td>
<td>2%</td>
<td>0.8</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>4%</td>
<td>10%</td>
<td>0.04</td>
</tr>
<tr>
<td>TV pathology</td>
<td></td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>Secondary (74%)</td>
<td>72%</td>
<td>75%</td>
<td></td>
</tr>
<tr>
<td>Rheumatic (11%)</td>
<td>11%</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>Congenital (9%)</td>
<td>13%</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td>Other (6%)*</td>
<td>4%</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td><strong>TV disease</strong></td>
<td></td>
<td></td>
<td>0.02</td>
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<tr>
<td>Regurgitation (94%)</td>
<td>90%</td>
<td>95%</td>
<td></td>
</tr>
<tr>
<td>Stenosis (2%)</td>
<td>2%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Mixed (4%)</td>
<td>8%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td><strong>Perioperative</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Concomitant procedures†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CABG</td>
<td>10%</td>
<td>17%</td>
<td>0.02</td>
</tr>
<tr>
<td>AV repair</td>
<td>3%</td>
<td>3%</td>
<td>0.03</td>
</tr>
<tr>
<td>AV replacement</td>
<td>23%</td>
<td>32%</td>
<td></td>
</tr>
<tr>
<td>MV repair</td>
<td>12%</td>
<td>16%</td>
<td>0.2</td>
</tr>
<tr>
<td>MV replacement</td>
<td>67%</td>
<td>65%</td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>1978 to 1989 (n=123)</td>
<td>72%</td>
<td>28%</td>
<td></td>
</tr>
<tr>
<td>1990 to 1996 (n=239)</td>
<td>30%</td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>1997 to 2003 (n=340)</td>
<td>14%</td>
<td>86%</td>
<td></td>
</tr>
<tr>
<td>Cross clamp time, minutes</td>
<td>83±41</td>
<td>90±2</td>
<td>0.049</td>
</tr>
<tr>
<td>CPB time, minutes</td>
<td>122±45</td>
<td>126±58</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Continuous variables are expressed as mean±standard deviation. LVEF indicates left ventricular ejection fraction; NYHA, New York Heart Association; CAD, coronary artery disease; PVD, peripheral vascular disease; TV, tricuspid valve; CABG, coronary artery bypass graft; AV, aortic valve; MV, mitral valve; CPB, cardiopulmonary bypass.

*Other pathologies included endocarditis, leaflet tear/prolapse, chordal rupture, papillary muscle rupture, and a myxomatous or degenerative tricuspid valve.
†Procedures are not mutually exclusive.
freedom from recurrent TR for the 2 groups of patients. Tricuspid valve repair without a ring was associated with TR recurrence over time. Figure 2 depicts the long-term outcomes of the 2 groups of patients. Event-free survival was defined as the freedom from thromboembolism (including stroke), valve thrombosis, structural valve dysfunction, major bleeding event, endocarditis, TV reoperation, and death. The ring group had significantly improved long-term survival and event-free survival, as displayed in Figure 2. There was a nonsignificant trend toward fewer TV reoperations in the ring group. Valve-related mortality was any death caused by structural and nonstructural valve dysfunction, valve thrombosis, major bleeding event, or operated valvular endocarditis. Deaths related to TV reoperation and sudden, unexpected, or unexplained death were also included in this outcome.4 Freedom from valve-related mortality was similar between the 2 patient populations (86 ± 5 years versus 77 ± 5 years for no ring versus ring group, respectively; P = 0.6 by log-rank).

We also examined whether the degree of residual mitral regurgitation (MR) was associated with TR recurrence. Among the 323 patients who had combined TV and MV surgery and received echo follow-up, there was a nonsignificant trend toward more TR recurrence in patients with moderate to severe residual MR compared with those with none to mild residual MR (23% versus 10%; P = 0.08).

Variables assessed as possible multivariate predictors of long-term outcomes in TV repair are listed in the Appendix. Cox regression revealed that an annuloplasty ring was the only independent predictor favoring long-term survival and event-free survival (Figure 3). Other independent predictors of late death were increasing age, male sex, hypertension, diabetes, renal failure, previous cardiac surgery, and urgency of the procedure.

Discussion

Tricuspid regurgitation is a significant clinical problem that may be undertreated by cardiologists and surgeons.3 Moder-
ate and severe TR has been associated with poor short-term and long-term survival, independent of ventricular function and pulmonary arterial pressure. Similar to other reports, we found that a majority of patients undergoing TV repair have secondary ("functional") regurgitation, caused by progressive annular dilation and decreased leaflet coaptation.

TV repair in patients with secondary TR does not add a lot of time or complexity to most cardiac operations. In patients with concomitant mitral valve disease, correcting the mitral valve lesion without treating the TV may improve or even alleviate mild TR. However, uncorrected moderate and severe TR may persist or even worsen after mitral valve surgery, leading to progressive heart failure and death. In addition, reoperation for residual TR carries significant risks and may suggest a poor prognosis. It has therefore been recommended by some experts that a more aggressive approach should be taken in cardiac surgery patients with concomitant TR.

The optimal technique to repair the TV remains uncertain. Bicuspidalization (ie, plication of the posterior leaflet) is now rarely performed even though reported outcomes have been reasonable, especially for rheumatic patients. The De Vega suture annuloplasty technique involves plication of the annulus surrounding the anterior and posterior leaflets and is the most commonly used TV repair technique. A number of series have reported its short and long-term success. However, other investigators have reported a relatively high recurrence rate for the De Vega technique, particularly in patients with severe tricuspid annular dilation and/or pulmonary hypertension. It has been recommended that such patients undergo TV repair with an annuloplasty ring. A number of series have reported its short and long-term success.

Our results reveal that an annuloplasty ring confers significant improvements over the De Vega repair in long-term survival and event-free survival, as well as recurrence of TR. However, the lower TR recurrence in the ring group was associated with only a trend toward fewer TV reoperations and no difference in valve-related mortality. The precise reason why an annuloplasty ring would improve survival is unclear, but may be related to prevention of annular dilation, right ventricular volume overload, and right ventricular failure. It should be noted that the beneficial effects of a TV annuloplasty ring were independent of the type of mitral valve surgery performed, and that the recurrence of TR was not significantly associated with the recurrence of MR.

Several other studies support our finding of the superiority of TV repair with an annuloplasty ring. A prospective randomized study of 159 patients conducted by Rivera et al comparing the De Vega suture to Carpentier ring annuloplasty demonstrated a higher recurrence of moderate and severe TR in the De Vega group at 45-month follow-up (Carpentier 4 of 40, De Vega 14 of 41; P<0.01). Similarly, in a study of 790 patients who underwent TV repair for secondary TR, McCarthy et al reported an earlier recurrence and progressive increase of moderate and severe TR after pericardial and De Vega suture repairs (P=0.002 and P=0.06, respectively, compared with the Carpentier ring). A similar study in 45 patients by Matsuyama et al showed a 45% recurrence of 2+ to 3+ TR in De Vega compared with only 6% in the Carpentier repair group (P=0.027). Freedom from moderate and severe TR at a mean follow-up of 39±23 months was 45% in the De Vega group and 94% in the Carpentier group. Other small studies have demonstrated similar results. These findings suggest that an annuloplasty ring is recommended in patients undergoing TV repair, particularly in those with more severe TR, to avoid future recurrence and adverse long-term sequelae.

We previously believed that the De Vega suture annuloplasty technique was sufficient to manage most TR cases and because of cost effectiveness and relative ease of the De Vega repair, we consequently performed a higher number of these procedures over the time period of this study (Table 1). Unfortunately, we did not record whether patients underwent a classic or modified De Vega repair (ie, with pledges between every suture) in the current study and are therefore unable to comment on this technique. It is possible that the long-term results may be better in patients who underwent a modified De Vega repair, because this technique has been reported to lower the risk of suture dehiscence and recurrent TR. Nonetheless, we were surprised to find a marked benefit of tricuspid annuloplasty rings and our results have prompted a change in surgical practice at our institution.

Study Limitations
Our study has several limitations. As noted, we did not record whether a modified De Vega procedure was performed, because this information was missing from most of the operative reports. Furthermore, we did not compare TV surgery patients to those who had cardiac surgery but untreated TV disease, because these patients are not identified by our database. Another limitation of our study is that TV repair technique could be biased by surgeon preference. In general, however, we have used annuloplasty rings when there is severe tricuspid annular dilation or markedly elevated pulmonary arterial pressures. Therefore, we would expect worse long-term outcomes for the ring group. The fact that patients who received an annuloplasty ring exhibited better long-term results further supports our conclusions that annuloplasty rings should be used more frequently in TV repair surgery.

Conclusions
Placement of an annuloplasty ring during tricuspid valve repair is associated with a decreased recurrence of TR, and with improved long-term survival and event-free survival. An annuloplasty ring should therefore be used more routinely in tricuspid valve surgery.

Appendix
Variables assessed as multivariate predictors of long-term survival and event-free survival in patients who had tricuspid valve repair.

- Age
- Sex
- Left ventricular dysfunction
- New York Heart Association class
Hypertension
Diabetes
Peripheral vascular disease
Transient ischemic attack/stroke
Renal failure
Endocarditis
Previous cardiac surgery
Combined cardiac surgery
● CABG
● AV surgery
● MV surgery
Reason for urgent surgery
TV ring
TV stenosis

Disclosures
None.

References
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