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Tricuspid Valve Repair Using Autologous Pericardium Annuloplasty in Adults

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ABSTRACT

Uncorrected functional tricuspid regurgitation can lead to long-term morbidity and mortality. To evaluate our results using autologous pericardium annuloplasty to treat tricuspid regurgitation, we retrospectively reviewed 59 consecutive adult patients aged 19 years to 83 years (58.7 ± 15.5 years) who underwent tricuspid valve annuloplasty between 2000 and 2003. Concomitant procedures consisted of mitral valve surgery in 83% of patients, aortic valve surgery in 28%, coronary bypass in 31%, and atrial-septal defect correction in 28%. Annuloplasty was performed using a strip of pericardium treated in glutaraldehyde 0.6% for 10 min. Two rows of continuous horizontal mattress Gore-Tex sutures were used to secure the pericardium to the tricuspid annulus. Follow-up was performed in 100% of the patients, and the mean follow-up was 4.4 ± 1.2 years (range, 2.4 to 7 years). Postoperative death within 30 days occurred in 1 of 59 patients (1.6%). None of the patients required reoperation related to tricuspid regurgitation or stenosis. The actuarial survival rate was 98.4% at 7 years after operation. Echocardiography was performed in 58 of 58 surviving patients (100%). Up to 7 years postoperatively, tricuspid regurgitation was trace in 67.2% of patients, mild in 31%, and moderate in 1.8%; there was no occurrence of severe regurgitation on follow-up. Our results indicate that autologous pericardium tricuspid annuloplasty is a useful procedure in patients with moderate or severe tricuspid regurgitation. This procedure provides a durable, reproducible annuloplasty of the tricuspid valve.

INTRODUCTION

Left heart pathology is the leading cause of tricuspid regurgitation [Cohn 1994; Tang 2006]. It is well known that without treatment, tricuspid regurgitation may worsen over time, leading to severe symptoms, biventricular failure, and death [McCarthy 2004]. Tricuspid valve repair is associated with lower perioperative risk than tricuspid valve replacement [McCarthy 2004, Tang 2006]. Surgical valve repair is not needed for mild tricuspid regurgitation, because relief of the left-sided valve lesion will suffice to decrease the pulmonary pressure and regurgitation. However, in symptomatic patients with functional tricuspid regurgitation and asymptomatic patients with moderate (2+ to 3+) or severe (4+) tricuspid regurgitation, repair of the tricuspid valve may prevent further tricuspid regurgitation [Bonow 1998].

Synthetic prostheses and different annuloplasty techniques using sutures are available for tricuspid annuloplasty. These offer the advantage of being presized and in some instances can reform the tricuspid annulus. Disadvantages include cost and risk of infection. Autologous pericardium allows for an inexpensive custom tailoring of the annulus. We assessed our follow-up results of tricuspid valve repair using annuloplasty with autologous pericardium.

PATIENTS AND METHODS

We retrospectively reviewed 59 consecutive adult patients who underwent tricuspid valve repair by annuloplasty with autologous pericardium at a single institution. The study population consisted of 32 (54.2%) male and 27 (45.7%) female patients with a mean age of 58.7 ± 15.5 years (range, 19 to 83 years). Preoperative patient characteristics are listed in Table 1.

Preoperative, operative, and postoperative variables were retrieved from the University of California, Los Angeles (UCLA) medical center database and from the referring cardiologist. The institutional review board at UCLA approved this study.

Tricuspid regurgitation was graded as 0 for no regurgitation, 1+ for trivial regurgitation (flow within 0.5 cm of the tricuspid valve), 2+ for mild regurgitation (flow did not extend beyond the line from the third of the tricuspid annulus to the posterior wall of the right atrium), 3+ for moderate regurgitation (band jet was greater than 2 cm in diameter and extended to the middle third of the right atrium), or 4+ for severe regurgitation (flow extended broadly into the distal aspect of the right atrium and the width of the flow was greater than 3 cm) [McCarthy 2004; Wang 2005].

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Table 1. Preoperative and Perioperative Characteristics of the Study Patients

Patients (N = 59)	
Male	54.2%
Mean age, years	58.7 ± 15.5
Left ventricular ejection fraction <40%	8%
New York Heart Association class III-IV	91%
Prior cardiac surgery	41%
Coronary artery disease	29%
Diabetes	4%
Hypertension	20%
Peripheral vascular disease	2%
Renal failure	1%
Endocarditis	9%
Tricuspid valve pathology	
Secondary	81.5%
Rheumatic	11.8%
Congenital	6.7%
Tricuspid valve disease:	
Regurgitation	96%
Stenosis	2%
Mixed	2%
Concomitant procedures	
Coronary artery bypass graft	31%
Aortic valve repair	10%
Aortic valve replacement	18%
Mitral valve repair	34%
Mitral valve replacement	54%
Ventricular septal defect closure	8.4%
Atrial septal defect closure	28%
Aortic wrap	1.5%
Preoperative mitral regurgitation:	
Grade 3	30%
Grade 4	59%

Chamber dimensions (left ventricular end-diastolic dimension, left ventricular end-systolic dimension, left atrial dimension, and left ventricular fractional shortening) were obtained from M-mode findings. Left ventricular function was measured using the scale described by Kuduvalli et al [2006], as follows: good left ventricular function included patients with left ventricular ejection fraction (LVEF) >50%, moderate with LVEF 30% to 50%, and poor with LVEF <30%.

Preoperative tricuspid regurgitation was grade 4+ in 67.3% of patients and grade 3+ in 32.7%. Mean LVEF was 47.1% ± 7.9%.

Surgical Technique

The surgery was performed through a conventional median sternotomy. Moderate hypothermic cardiopulmonary bypass was established using bicaval and ascending aortic cannulation. Pericardial strip annuloplasty was performed in the entire cohort. Autologous pericardium was immersed for 10 min in a solution of sterile gluteraldehyde 0.625% and phosphate buffer (pH 7.4) and fluorescein 0.02%, then rinsed in 3 water baths. The gluteraldehyde solution for clinical use was locally prepared by the UCLA Medical Center pharmaceutical technology laboratory under aseptic conditions by ultrafiltration and tested for sterility by culturing before use. A double-running horizontal mattress suture of 2-0 Gore-Tex was used for the annuloplasty, and the annulus was reduced, usually to about 28 mm. In contrast to a De-Vega stitch, an intercalated advance was used (Figure 1). This stretches the strip, which is presized on a conventional valve sizer, to prevent late dilatation of the annulus as it is fixed to the stretched pericardial strip. The created ring extends along the annulus, excluding the septal leaflet portion to prevent harm to the conduction system.

Follow-up

From November 2006 to January 2007, patients and/or patient family members were contacted through telephone calls. Data regarding functional status and postoperative morbidity and mortality were collected and tabulated. Patient clinical status and echocardiographic results were also obtained from referring cardiologists. Follow-up was performed in 100% of the survival patients, and the mean follow-up was 4.4 ± 1.2 years (range, 2.4 to 7 years).

During the follow-up period the success of repair of tricuspid regurgitation was judged using echocardiography. The most recent echocardiogram results were obtained in 100% of the surviving patients and averaged.

Statistical Methods

All statistical analyses were performed using SPSS 13.0 software (SPSS, Inc. Chicago, IL, USA). Continuous variables were reported as mean ± SD or percentage where appropriate. Categorical variables were reported as number and percentage. Actuarial survival and freedom from reoperation were displayed with the Kaplan-Meier method. Results were analyzed according to the guidelines for reporting morbidity and mortality after cardiac valvular operations [Edmunds 1996].

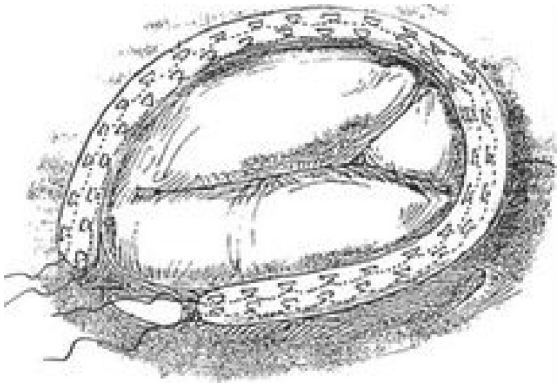

Figure 1. The pericardial strip is stretched over a conventional valve sizer to estimate the final dimension of the annuloplasty. The Gore-Tex suture is advanced along the strip, with each entry going back 2-3 mm from the previous exit point. This procedure stretches and locks the strip to prevent excessive narrowing of the annulus, which can occur with a De Vega–type stitch.

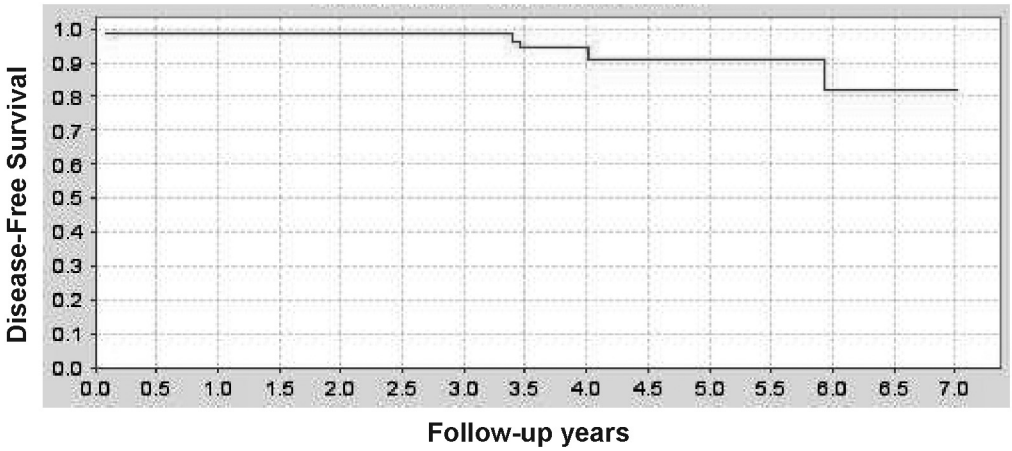

Figure 2. Kaplan-Meier actuarial survival of the study patients.

RESULTS

No patient left the operating room with a tricuspid regurgitation grade ≥2. Forty-one patients (70.6%) and 18 patients (31%) had a grade of zero or 1, respectively. One patient required reinstitution of cardiopulmonary bypass for an unsatisfactory repair.

Mortality

Only 1 patient (1.6%) suffered early death (30-day mortality), a 71-year-old man with a diagnosis of severe aortic stenosis, mitral regurgitation grade 3+, and coronary artery disease. On postoperative day 3 this patient underwent reoperation because of bleeding. The patient died from renal failure and lactic acidosis, most likely related to low cardiac output. Late death occurred in 4 patients. All of these deaths occurred in the home setting, and no further information was obtained on these deaths. One patient suffered a stroke. The actuarial survival rate was 98.4% at 7 years after surgery (Figure 2).

Reoperation

None of the patients required reoperation for the tricuspid valve. There were 2 non–valve-related reoperations (3.4%) at a mean of 2.4 ± 1.9 months (range, 0 to 4.3 months) after the initial surgery. One patient underwent reexploration due to bleeding and the other patient for placement of a permanent pacemaker.

Morbidity

Postoperative complications consisted of atrial fibrillation in 15 patients (25.4%), acute renal failure in 3 patients (5%), pneumonia in 1 patient (1.7%), and atrioventricular heart block grade 3 in 1 patient (1.7%). Any other postoperative complications (endocarditis, hemolysis, and so forth) did not occur during the follow-up period.

Clinical Follow-up

Follow-up was complete in 58 patients (100%), 27 (46.5%) of the patients were in New York Heart Association (NYHA) functional class I, 29 (50%) were in class II, and 2 (3.4%) were in class III. There were no patients in NHYA functional class IV.

Echocardiographic Follow-up

Transthoracic echocardiography was performed in 58 of the 58 surviving patients (100%); 39 (67.2%) had grade 0, 18 (31%) had grade 1+, 1 (1.8%) had grade 2+, and none had grade 3+ or 4+ tricuspid regurgitation. Left ventricular function was good in 44 patients; moderate in 9, and poor in 2. There were no patients in whom left ventricular function had deteriorated during the follow-up period. A comparison of preoperative and postoperative echocardiographic data is shown in Table 2.

DISCUSSION

Tricuspid valve regurgitation was secondary to left-heart pathology in the patients presented in this study. Valve pathology consisted mainly of progressive annular dilation and decreased leaflet coaptation, findings similar to those reported for other studies [Tang 2006]. Repair of the diseased tricuspid valve as a concomitant procedure during surgical correction of left-sided lesions is becoming a common procedure because the regression of tricuspid regurgitation is unpredictable after surgical treatment of mitral and/or aortic valve diseases [Filsoufi 2006]. Untreated tricuspid regurgitation

Table 2. Comparison of Preoperative and Postoperative Echocardiographic Data*

Variable	Preoperative (N = 58)	Follow-up Echocardiogram (N = 58)
Grade 0+ TR	0	39 (67.2%)
Grade 1+ TR	0	18 (31%)
Grade 2+ TR	2 (3.4%)	1 (1.8%)
Grade 3+ TR	18 (32%)	0
Grade 4+ TR	38 (65.5%)	0

*TR indicates tricuspid regurgitation.

will increase mortality and morbidity due to congestive heart failure [King 1984; Nath 2004; Filsoufi 2005].

Evidence indicates that patients with tricuspid regurgitation >2+ should undergo repair in combination with other surgical procedures [King 1984; Tang 2006]. Furthermore, Dreyfus et al [2005] concluded that tricuspid annular dilatation will progress to severe tricuspid regurgitation over time and recommend that surgical correction of the tricuspid valve be performed regardless of the severity of tricuspid regurgitation.

Various techniques are used for repairing the tricuspid annulus. The optimal annuloplasty technique remains uncertain. The Cosgrove-Edwards Annuloplasty System [Crosgrove 1995] consists of a polyester velour band that is held in place by flame sutures in the posterior annulus, beginning at the fibrous trigone and proceeding along the posterior annulus to the opposite fibrous trigone. Short-term data showed good results. However, later published studies showed that 25% of patients had 3+ or 4+ mitral regurgitation in the first 6 months after surgery in patients with ischemic mitral valve regurgitation [McGee 2004]. Both the Crosgrove-Edwards system and tricuspid annuloplasty with autologous pericardium preserved annular dynamics. With the Crosgrove-Edwards system the annulus is partially repaired (posterior annuluplasty), whereas we describe a complete annuloplasty, although McGee et al [2004] showed that the absence of an annuloplasty along the anterior mitral annulus did not influence midterm-repair durability in their patients. No long-term studies have investigated this issue, however, and therefore the risk of anterior segment dilatation after several years remains uncertain. Nakano et al [1988] described the plication of the posterior leaflet (bicuspidalization), and although they showed acceptable results patients with rheumatic valve disease, this technique is now rarely performed because it was associated with fibrotic transformation of the posterior leaflet and continued dilatation of the anterior segment of the annulus. Another annuloplasty technique [De Vega 1973; Rivera 1985] consists of the placement of 2 semicircular purse-string sutures from the anteroseptal to the posteroseptal commissure to achieve annular narrowing. High recurrence rates were reported with this technique, attributable to suture migration leading to dilatation of the tricuspid orifice [Rivera 1985; McCarthy 2004]. Better outcome was reported with the use of pledgets between every suture (modified De Vega [Antunes 1983]), although the long-term durability remains unknown.

Another surgical approach to repair tricuspid regurgitation, introduced by Carpentier [1983], is the use of prosthetic rings. Better results have been reported with the use of remodeling annuloplasty for tricuspid regurgitation than with the techniques described above [De Vega 1973; Yada 1990; McCarthy 2004].

Rivera et al [1985] investigated the differences between the De-Vega suture and the Carpentier ring annuloplasty and observed a higher recurrence of moderate and severe tricuspid regurgitation in the De-Vega group at 45 months of follow-up (Carpentier 4 of 40, De Vega 14 of 41; $P < .01$). Matsuyama et al [2001] reported similar findings in 45 patients, with 45% recurrence of 2+ to 3+ tricuspid regurgitation in the De-Vega group compared with 6% in the Carpentier repair group ($P = .027$). Despite these results, there are reports of ring dehiscence, mainly due to a mismatch in configuration between the prosthetic ring and the tricuspid annulus [Filsoufi 2006]. In 2002 a new type of tridimensional prosthetic ring, the Edward MC3, was introduced to avoid the possibility of dehiscence and to increase the stabilization of the annulus [Filsoufi 2006].

Combination of the advantages of both the prosthetic ring and the suture techniques might improve surgical outcomes. In our study patients, tricuspid valve repair was performed with autologous pericardium annuloplasty; this material is extensively used in cardiac surgery because of its ready availability, ease of handling, and pliability. Treatment with gluteraldehyde solution endows the pericardium with more resistance to retraction and degeneration and also offers better long-term durability and low thrombogenicity [Chachques 1988; Odim 2005; De La Zerda 2007]. The use of autologous pericardium can delay and sometimes avoid limitations of other surgical techniques in situations such as those involving biological constraints of growing children, tissue antigenicity, calcium metabolism, bleeding and thromboembolic complications caused by synthetic valve substitutes, mismatch in configuration between the prosthetic ring and the tricuspid annulus, complications related to the use of anticoagulation therapy [Robbins 1988; Sade 1988; Bradley 1997], and further dilatation of the tricuspid annulus.

Limited data are available regarding the use of tricuspid valve annuloplasty with pericardium. McCarthy et al [2004] compared different tricuspid valve repair techniques in 790 patients. Bovine pericardium (Peri-Guard or Bio-Vascular, Inc, St Paul, MN, USA) and De-Vega suture repairs demonstrated earlier recurrence and progressive increase of moderate and severe tricuspid regurgitation compared with the Carpentier ring ($P = .002$ and $P = .06$, respectively).

The surgery results in our patients may be related to the use of the modified stitch technique. By the use of intercalated sutures rather than a De-Vega stitch, the method we describe aims to prevent further dilatation of the annulus, and the use of reinforcement of the annulus with a pericardial strip resembling a prosthetic ring aims to prevent late dilatation of the annulus as it is fixed to the stretched pericardial strip.

In this study both echocardiographic and clinical follow-up showed improvement in tricuspid valve function. None of the patients required reoperation related to tricuspid regurgitation or stenosis. Follow-up echocardiogram demonstrated trace regurgitation in 67.2% of patients, mild in 31%, and moderate in 1.8%, with no severe regurgitation.

Study Limitations

Because our institute functions as a referral center and the patients were followed up only by the primary physician, we were not able to identify all the etiologies of late mortality. The mechanisms for tricuspid regurgitation were heterogeneous, previous surgical interventions, or percutaneous interventions. The surgical repair of the tricuspid valve with autologous pericardial annuloplasty was the common denominator in all patients. Thus, the relatively small

numbers and confounders make subgroup analysis inherently difficult in this study compared with other published series. A control group could not be used with our study because since 2000 our institution has performed tricuspid valve repair only with autologous pericardium annuloplasty.

CONCLUSIONS

Tricuspid valve annuloplasty as a concomitant procedure during tricuspid valve repair is associated with a decreased recurrence of tricuspid valve regurgitation and with improved long-term survival. Glutaraldehyde-treated autologous pericardium tricuspid annuloplasty is an effective technique that improves tricuspid valve function and conserves the normal anatomy of the heart. The technique described in this study provides a durable, reproducible, and repeatable repair of the tricuspid valve.

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