Clinical and echocardiographic follow-up after aortic valve reconstruction with bovine or autologous pericardium

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Eighty-six patients, mean age 29 ± 15 years, underwent aortic valve reconstruction with bovine or autologous pericardial tissue. Mean clinical follow-up was 35 months. Echocardiographic data were assessed in 65 patients with follow-up ≥6 months. There were two in-hospital and three late deaths. Warfarin was not given, and no thromboembolic events occurred. Five (6%) patients needed reoperation because of severe aortic regurgitation. Peak aortic valve gradients remained low (26 ± 14 mm Hg for the bovine group and 16 ± 16 mm Hg for the autologous group). One patient is awaiting surgery for aortic stenosis after 76 months. Leaflet thickening at latest follow-up was marked in six (9%) patients. Left ventricular dimensions normalized postoperatively and showed only insignificant increase during follow-up. This technique is a promising alternative to valve prosthesis in selected patients; however, longer follow-up is necessary to assess long-term results. (Am Heart J 1996; 132:1173-78.)

Aortic valve replacement in the young patient represents a problem because of the well known limited durability of bioprosthetic valves and the need for permanent anticoagulation of mechanical valves. This problem is particularly important for patients in the developing world, where poor drug compliance and multiple pregnancies are the rule. In an attempt to palliate this situation, aortic cusp extension with glutaraldehyde-treated bovine pericardium has been introduced.1 Experiences with this technique and the realization that many valves were too fibrotic to conserve encouraged the development of a method to totally replace the diseased valve with free hand-sutured, glutaraldehyde-treated autologous pericardium.2 We report the clinical and echocardiographic short-term and intermediate results in 86 consecutive patients operated with these two techniques, most of them young patients with rheumatic valvular disease.

METHODS

Patients. Between August 1988 and December 1994, 86 patients at our institution underwent aortic valve reconstruction with pericardial tissue. Mean age was 29 ± 15 years (range 12 to 68 years). Fifty-nine (69%) patients were male and 27 (31%) were female. The cause of aortic valve disease was rheumatic in 74 (86%), degenerative in 9, congenital in 2, and infective endocarditis in 1 patient.

The aortic valve was predominantly regurgitant (AR) in 45 (52%) patients, stenotic (AS) in 15 (17%), and mixed in 26 (30%). Before surgery, 49 patients were in sinus rhythm at the time of surgery, and 6 (7%) had atrial fibrillation. Mitral valve lesions were present in 31 (36%) patients. Of these, 17 had isolated mitral regurgitation, 6 had mitral stenosis, and 8 patients had mixed disease. Mitral valve repair was attempted in all 31 cases and was successfully performed in 30 patients, although one patient needed mitral valve replacement after unsuccessful repair. Five (6%) patients had additional tricuspid valve repair because of significant tricuspid regurgitation.

Surgical technique. The surgical technique has been described in detail elsewhere,3 and is briefly reviewed here. All patients were operated on through a median sternotomy and placed on cardiopulmonary bypass with aortic and single or double caval cannulations. The aortic valve was exposed through a hockey stick incision, descending into the noncoronary sinus, and stopped a few millimeters from the aortic annulus. Two different techniques were used for aortic valve reconstruction during the study period. In the first 27 patients, the three aortic cusps were extended with a single strip of commercially available bovine pericardium (BOV group). In the remaining 59 patients, the aortic valve was completely resected and replaced with glutaraldehyde-treated autologous pericardium (AUT group). Initially only trileaflet aortic valves with thickened but otherwise mobile cusps were reconstructed with this technique; however, with the use of autologous pericardium, total excision of the valve allowed...
Fig. 1. Transthoracic echocardiographic long-axis view of aortic valve after reconstruction. Systole, illustrating complete opening of leaflets from their points of origin (arrows, left panel). Diastolic frame, showing central coaptation of leaflets (right panel).

Fig. 2. Transthoracic echocardiographic short-axis view of aortic valve after reconstruction. Central leaflet coaptation is visualized. Also seen is suture line of pericardial tissue at inner circumference of aortic annulus.

reconstruction of heavily calcified aortic valves with no cusp remnant left. Figs. 1 and 2 show an example of the appearance of the aortic valve after reconstruction as visualized with transthoracic echocardiography.

The competence of the valve was initially tested by visual inspection, by palpation once off bypass, and by observation of systemic pressures. With the evolving use of intraoperative transesophageal echocardiography, this technique was used to test valve competence in nine (35%) of the 26 patients with echocardiographic follow-up in the BOV group and in 32 (82%) of the 39 patients in the AUT group. All patients received antiplatelet aggregants (acetylsalicylate 100 mg/day); no other anticoagulation was given postoperatively, except for one patient who had a mechanical mitral prosthesis after a failed attempt at mitral valve repair.

Clinical and echocardiographic follow-up. All patients were clinically assessed before discharge (within 7 days of surgery), in a dedicated valve clinic 8 weeks and 6 months postoperatively, and at yearly intervals thereafter. If a patient did not attend the clinic, he or she was contacted by a social worker. This report includes follow-up until April 30, 1995. The preoperative, surgical, postoperative, and follow-up data were entered into a software program (PATs, Dendrite, Portland, Ore.). All events were noted according to the guidelines issued by the American Association for Thoracic Surgery and the Society of Thoracic Surgery.4

At follow-up, transthoracic echocardiographic examination was performed with standard ultrasound equipment. The following measurements were made. (1) AR was graded on a scale from 0 (no AR) to 4 (severe AR). The severity of the AR was assessed with a combination of several characteristics, including the extension of the AR jet into the left ventricle (LV), the width of the jet in left ventricular outflow tract (LVOT) and at the aortic valve in parasternal long- and short-axis views, pressure half-time of the AR signal recorded with continuous-wave Doppler, and the degree of flow reversal in the descending and abdominal aorta.5 (2) Peak transvalvular aortic gradients were used to assess valvular stenosis in this study because of the lack of software to calculate the mean gradient during the first part of the study. Gradients were measured with continuous-wave Doppler from the apical, right
parasternal, or suprasternal position. The recorded maximal transvalvular velocity was used for gradient calculation in patients with sinus rhythm, and the mean of three consecutive beats was used for patients with atrial fibrillation. (3) Thickening of the aortic leaflets at follow-up was assessed visually and graded as 0 (none), 1 (mild thickening), or 2 (marked thickening). (4) Left ventricular internal diameter in end diastole (LVED) and end systole (LVES) were measured in parasternal long-axis or short-axis view according to the recommendations of the American Society of Echocardiography. LVED >58 mm and/or LVES >40 mm was considered abnormal. Fractional shortening (FS) was calculated as the difference between LVED and LVES divided by LVED. FS was expressed as percentage and was considered abnormal if <30%. All echocardiographic studies were assessed by two independent observers, and the opinion of a third observer was sought in cases of disagreement.

Statistics. Continuous data, such as aortic valve peak gradient and LV dimensions, are presented as mean ± SD plus range in parentheses. Comparisons between groups and between preoperative and postoperative data were performed with two-tailed Student's t test. A p value <0.05 was considered statistically significant. Noncontinuous data (AR grade, leaflet thickening) are presented as percentages or frequency distributions.

RESULTS

Clinical follow-up. Mean clinical follow-up for the total study population was 35.2 months, or 254 patient-years—56.5 months for the BOV group and 25.5 months for the AUT group. Of the 86 patients, two (2.3%) died early in the hospital. One death was from extensive bleeding caused by a postoperative rupture of a coronary sinus diverticulum after retrograde cardioplegia. The other was caused by postoperative multiorgan failure. Three (3.5%) patients have died during the follow-up period. One death occurred as mor subita at home in the patient who also had a mechanical mitral prosthesis inserted after failed attempt at mitral valve repair. Another occurred in another hospital with an apparently competent aortic valve, and the last death was caused by a car accident.

Reoperation during the follow-up period was performed in 9 (10.5%) patients. Of these, 5 patients were reoperated on because of failure of the aortic valve reconstruction, and 4 reoperations were from failure of the mitral valve repair. Of the patients reoperated on for aortic valve failure, one was in the BOV group and was reoperated because of aortic valve regurgitation after 49 months. Four patients were in the AUT group. The reason for reoperation was infective endocarditis in 2 patients, occurring after 5 and 31 months, respectively. One patient had a tear of one of the reconstructed aortic cusps 8 months postoperatively, and one had progressive dilatation of the aortic ring and was reoperated before discharge. One patient from the BOV group is awaiting reoperation 76 months postoperatively because of severe cusp calcification and valvular stenosis. Of the four patients reoperated on because of failure of the mitral valve repair, one patient with grade 2 AR had the pericardial free edge of the aortic valve resuspended. Another patient did not need any corrective aortic valve surgery at the time of mitral valve reoperation, whereas the last two patients had their aortic valves replaced with mechanical prostheses as requested by the patients to avoid a third operation. These patients had AR grade 1 and 2, respectively. All patients not reoperated on belonged to New York Heart Association functional class 1 or 2 at last follow-up. No major or minor thromboembolic event has occurred during the follow-up period.

Echocardiographic follow-up. Sixty-five (76%) of the 86 patients had a follow-up of ≥6 months, including echocardiographic assessment. Of these, 26 were in the BOV group and 39 in the AUT group. Mean follow-up was 48 ± 22 months for the BOV group and 27 ± 16 months for the AUT group. Table I shows assessment of AR grade, peak gradients, leaflet thickening, and left ventricular dimensions at baseline, at discharge, and at last follow-up, and Figs. 3 and 4 show the AR grade.

Aortic regurgitation. Transesophageal echocardiography at the termination of the reconstruction procedure showed, for both groups combined, none or trivial AR in 28 patients, grade 1 in 11, and grade 2 in 2 patient (both in the AUT group). At discharge, the number of patients with AR grade 0, 1, or 2 were 30, 29, and 4, respectively. The four patients with AR grade 2 were all in the AUT group. In the BOV group, 23 (88%) patients had AR grade 0 or 1 at last follow-up, and 1 patient had grade 3 and was reoperated on. In the AUT group, 30 (77%) patients had none or mild AR at last follow-up, whereas 4 (10.2%) patients had grade 3 or 4; all of them were reoperated on.

Peak transvalvular gradient. For the BOV group, peak gradients were 36 ± 21, 20 ± 10, and 26 ± 14 mm Hg preoperatively, at discharge, and at last follow-up, respectively. Peak systolic gradients preoperatively for the AUT group were 45 ± 32 mm Hg, 17 ± 13 mm Hg at discharge, and 16 ± 16 mm Hg at last follow-up. Hence postoperative gradients were significantly lower than preoperative values in both groups and showed only mild or no increase, respectively, during the follow-up period. None of the patients has been reoperated on because of progressive stenosis; however, one patient from the BOV
Table I. Echocardiographic data preoperatively, at discharge, and at last follow-up

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<tr>
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<th>AUT group: n = 39</th>
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<td>Preop.</td>
<td>Discharge</td>
<td>Follow-up</td>
<td>Preop.</td>
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<tr>
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<tr>
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<td>Gradient (peak):</td>
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<tr>
<td>mm Hg</td>
<td>36 ± 21</td>
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<td>LV dimensions:</td>
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<td>50 ± 8</td>
<td>62 ± 13</td>
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<td>LVES, mm</td>
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<td>FS, %</td>
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<td>31 ± 8</td>
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<td>Grade 2</td>
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AR, Aortic regurgitation.

group is awaiting surgery for aortic stenosis 76 months after surgery.

Leaflet thickening. Twenty-two (85%) of 26 patients in the BOV group had none (12 patients) or mild (10 patients) leaflet thickening at last follow-up. One of the 4 patients with marked thickening was reoperated on during the follow-up period because of AR grade 3, and 1 patient is awaiting surgery for stenotic valve. In the AUT group, leaflet thickening at last follow-up was graded as none (33 patients) or mild (4 patients) in 37 (95%) of the 39 patients. Of the 2 patients with marked thickening, 1 patient had aortic valve endocarditis and was reoperated on.

Left ventricular dimensions. Because of the increased preload associated with severe AR, LVED and LVES values were enlarged preoperatively, with values being 63 ± 11 mm and 42 ± 9 mm (BOV group) and 62 ± 13 mm and 41 ± 11 mm (AUT group), respectively. Mean LV dimensions were significantly reduced at discharge from the hospital and did not tend to increase during the follow-up period. Eighteen patients had preoperative LVED ≥70 mm. Among these patients, 13 had normal LVED at follow-up, 3 had mildly dilated LVED (59 to 63 mm), and 2 had severely dilated LVED; both were reoperated on because of failure of the aortic valve reconstruction (1 patient), or to failure of the mitral valve repair (1 patient).

FS was normal at baseline (33% ± 5% for the BOV group and 35% ± 6% for the AUT group), and showed no significant changes at discharge (31% ± 8% and 28% ± 9%, respectively) or at last follow-up (35% ± 6% and 32% ± 6%, respectively) compared with preoperative values. Twelve patients had abnormal preoperative FS (<30%); 9 (75%) of these had normalized FS at last follow-up, and the remaining 3 patients all had FS ≥24%.

DISCUSSION

This study evaluated the short- and intermediate-term results of aortic valve reconstruction with pericardium in a population comprising predominantly young patients (mean age 29 years) with rheumatic valve disease. Theoretically, this approach has important advantages compared with other surgical alternatives. Bioprosthetic valves in young patients have a documented short durability, with rapid degeneration and fibrosis. Mechanical aortic prostheses necessitate lifelong anticoagulation therapy. This therapy is often difficult to achieve in the developing part of the world, and the rate of complications is high because of poor drug compliance. In a young population like our study group, anticoagulation is additionally unwanted because of the likelihood of pregnancies. The aortic valve reconstruction technique preserves the size of the aortic annulus, and the transvalvular gradient increase associated with prosthetic valves is avoided. In young patients with small aortic annular size, this feature of the technique may be hemodynamically important. Compared with prosthetic valves, the use of autologous pericardium also offers an inexpensive alternative of treatment. The procedure of Ross et al. of implantation of the pulmonary valve as autograft in the aortic position may be a useful alternative; the results
Fig. 3. Bar plot of AR grade for BOV group assessed intraoperatively with transesophageal echocardiography (TEE) (upper panel, n = 9); at discharge (middle panel, n = 26); and at last follow-up (lower panel, n = 26). Latter two assessments were performed with transthoracic echocardiography (TTE). Asterisk denotes reoperated patient.

of these two techniques have so far not been compared.

The incidence of reoperations in our study is significant; however, a distinction must be made between those patients requiring surgery because of failure of the aortic valve reconstruction (five patients) and those because of failure of the concomitant mitral valve repair (four patients). In this last group, two retained their initial aortic reconstruction, and the other two had their valve replaced at the patients’ request to avoid a possible future operation. The real incidence of failure of the procedure is thus 6%. Late endocarditis was the reason for reoperation in two patients. The incidence of endocarditis in a population with rheumatic valvular disease is high, and our results do not imply that patients are more susceptible to develop endocarditis after valve reconstruction. The causes of reoperation in the other three patients are truly procedure related. One patient had a rapid progression of annular dilatation with a large annulus; this situation probably constitutes a contraindication for the procedure. One patient had a late tear at the commissure where the two ends of the pericardial flap are joined. This failure can be attributed to a technical error. The last failure was caused by calcification of the bovine pericardium after more than 4 years of implantation. This expected problem, well described in bovine pericardial bioprosthesis particularly in the young population, was the main reason for the change from xenogeneic to autologous pericardium. The lack of antigenicity and reduced amount of glutaraldehyde present in the autologous tissue should significantly delay calcification. The positive long-term experience with this tissue used for mitral cusp extension corroborates this approach.9

In our study, the different length of follow-up for the bovine and autologous pericardium does not al-
low a direct comparison between the two. However, the serial echocardiographic follow-up indicates that cusp thickening may be more pronounced with bovine tissue, in which 50% of the patients had mild or marked thickening versus 15% with autologous tissue. The peak gradient across the aortic valve showed mild increase for the BOV group during follow-up, whereas the gradient did not tend to increase during follow-up for the AUT group. Longer follow-up is needed to evaluate the leaflet thickening and gradient increase associated with the use of bovine or autologous pericardium. It is however encouraging that in the two patients in the AUT group that required reoperation because of mitral valve repair dysfunction, the excised pericardium was pliable and the histologic analysis showed an acellular but conserved collagen structure. Most importantly, no thromboembolic episodes have occurred among the patients during the follow-up, confirming that warfarin treatment is not needed in patients after aortic valve reconstruction with this technique.

Preoperative LV systolic function, as expressed by FS, was preserved or only mildly impaired in the majority of our study patients despite increased LV dimensions. LV dimensions normalized quickly after operation with no further significant changes during follow-up. Marked preoperative LV dilatation tended to regress toward normal after successful repair of the valve, and even when LV function was mildly impaired before surgery, postoperative deterioration in LV systolic function was not seen.

This study shows that both surgical techniques, namely cusp extension and total reconstruction with pericardium, achieve good valve competence with insignificant transvalvular gradients in the absence of a rigid stent. Cusp extension would be indicated in patients with regurgitation in the presence of thin cusps, whereas total replacement would be necessary in stenotic lesions with thickened or even calcified leaflets. From a surgical point of view, both require a learning curve that was reflected in the need to replace the valve within the same surgery in several of the early patients not included in this series. We believe that the more anatomic shape and measures obtained with the autologous pericardium is important; although, again, the differences in the follow-up do not allow us to substantiate it.

We conclude that these techniques offer a valid alternative to standard valve replacement in patients with problems of anticoagulation and particularly in the presence of a small aortic root. Although a longer follow-up is needed, the lack of antigenicity of the autologous pericardium, correct anatomical design and absence of a rigid stent should significantly increase its durability.

REFERENCES