A total of 404 cases of aortic valve reconstruction with glutaraldehyde-treated autologous pericardium

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Objective: To determine the feasibility of original aortic valve reconstruction, 404 consecutive cases were reviewed. The early results are reported here.

Methods: Aortic valve reconstruction was performed for 404 patients from April 2007 through September 2011. The results for all 404 patients were reviewed retrospectively. There were 289 patients with aortic stenosis and 115 patients with aortic regurgitation. One hundred two patients had bicuspid aortic valves, 13 patients had unicuspid valves, and 2 patients had quadricuspid valves. There were 201 males and 203 females. Mean age was 69.0 ± 12.9 years. Preoperative echocardiography revealed an average peak pressure gradient of 79.6 ± 32.5 mm Hg with aortic stenosis. Surgical annular diameter was 20.3 ± 3.2 mm. The surgical procedure is based on the independent tricuspid replacement by autologous pericardium. First, the distance between the commissure is measured with an original sizing apparatus, then the pericardial cusp is trimmed using an original template, and it is sutured to the annulus.

Results: There were no conversions to prosthetic valve replacement. There were 7 in-hospital mortalities resulting from a noncardiac cause. Postoperative echocardiography revealed an average peak pressure gradient of 19.8 ± 10.2 mm Hg 1 week after surgery and 13.8 ± 3.7 mm Hg 3.5 years after surgery. Two patients needed reoperation because of infective endocarditis. The other 402 patients showed less than mild aortic regurgitation. No thromboembolic events were recorded. The mean follow-up period was 23.7 ± 13.1 months. Freedom from reoperation was 96.2% at 53 months of follow-up.

Conclusions: Original aortic valve reconstruction was feasible in patients with various aortic valve diseases. Long-term data will be disclosed in the future. (J Thorac Cardiovasc Surg 2014;147:301-6)

Atrioventricular valve repair has become more popular than valve replacement with its standardization and reproducibility. For aortic valve disease, bioprosthetic valves are being used increasingly for replacement because of the problems with anticoagulation of mechanical valves. However, despite the progress of the design and construction of prosthetic valves, hemodynamic performance is not yet comparable with that of native aortic valves. In recent years, much attention has been given to repairing aortic valve disease, with consequent improvement in postoperative results.

Many reports of aortic valve repair are limited to the treatment for aortic regurgitation (AR).^{2,3} Our new style of aortic valve reconstruction can be applied to a wide spectrum of aortic valve diseases, including aortic stenosis (AS), AR, infective endocarditis (IE), prosthetic valve endocarditis (PVE), and annulo-aortic ectasia.

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We basically replace all 3 aortic valve cusps by glutaraldehyde-treated autologous pericardium. We assume this technique is more like valve reconstruction than replacement because there is no use of foreign material and no need for postoperative anticoagulation. The main reason why we call this technique a reconstruction is that we can make new cusps, one by one, from the distance between each commissure in the operative field. There have been some reports of aortic valve reconstruction with autologous pericardium or stentless autologous pericardial aortic valve replacement. 4,5 These reports mentioned the advantage of direct suturing of the pericardium to the annulus. 6-9 With this method, surgeons can preserve the natural aortic root expansion in the systole with maximal effective orifice area, 10-12 but they still replace the aortic valve as 1 whole structure. The difference in our original aortic valve others is reconstruction from the independent replacement of 3 cusps by 3 native-size autologous pericardial cusps. We consider the size of the aortic cusp to be defined by the distance between the commissures. In addition, aortic valves may represent a collection of different-size cusps. We believe independent replacement of cusps is more effective in preserving the natural motion of the aortic valve annulus and the coordination of the left ventricle, aortic annulus, sinus of Valsalva, and aorta.

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Abbreviations and Acronyms

AR = aortic regurgitation

AS = aortic stenosis

IE = infective endocarditis

PVE = prosthetic valve endocarditis

To inspect the feasibility of original aortic valve reconstruction, 404 consecutive patient results were reviewed.

METHODS

Our new original aortic valve reconstruction and the clinical study of this procedure were approved by the institutional review board of Toho University Ohashi Medical Center. All patients underwent this operation after written informed consent was obtained.

Our original aortic valve reconstruction was performed on 404 patients from April 2007 through September 2011. We reviewed retrospectively all 404 patients and evaluated short-term and mid-term results.

The indication of our original aortic valve reconstruction was first by echocardiography for the patients with a small aortic annulus with a diameter ≤ 21.5 mm, and second for patients who rejected mechanical valve implantation. Among them, we performed this reconstruction for patients who were willing to have this operation.

There were 201 males and 203 females. Mean age was 69.0 ± 12.9 years. Preoperative echocardiography revealed an average peak pressure gradient through the aortic valve of 79.6 ± 32.5 mm Hg for patients with AS and a surgical annular diameter of 20.8 ± 3.2 mm for all patients. Two hundred eighty-nine patients had AS and 115 patients had AR. One hundred two patients had bicuspid aortic valves, 13 patients had unicuspid valves, and 2 patients had quadricuspid valves. Annulo-aortic ectasia was recorded in 8 patients. The other 13 patients had IE.

Surgical Technique

The surgical technique for our original aortic valve reconstruction has been reported previously. 13 Preparation of autologous pericardium was started by cleaning fat and other redundant tissue on the outer surface of pericardium with the Harmonic scalpel (Ethicon Endo-Surgery, Inc, Cincinnati, Ohio). Pericardium was excised at least 7×8 cm. The excised pericardium was then treated with 0.6% glutaraldehyde solution with a buffer for 10 minutes. The treated pericardium was rinsed 3 times using physiologic saline solution for 6 minutes.

Human pericardium is usually thin near the cranial end and thick caudally near the diaphragm. We use the thinner part of pericardium for small cusps to make the movement smoother, and the thicker part for large cusps to make them able to tolerate more stress (Figure 1). All aortic valve reconstructive procedures were performed during cardioplegic arrest on cardiopulmonary bypass.

Briefly, diseased cusps are excised meticulously. In case there is severe calcification along the aortic annulus, the Cavitron Ultrasonic Surgical Aspirator (SonoSurg, Olympus, Tokyo, Japan) is very helpful in removing calcium without damaging annular tissue. Then, the distance between each commissure is measured with an originally invented sizing apparatus. The intercommissural distance is measured using the original sizing apparatus by giving the appropriate tension, similar to reproducing the annulus during diastole. Correct measurement is vital to complete this operation. The new cusp with the size corresponding to the measured value is trimmed with an original template from glutaraldehyde-treated autologous pericardium. Last, the annular margin of the pericardial cusp is sutured with running 4-0 monofilament stitches to each annulus. The smooth (inner) surface of pericardium is placed on the left ventricular side. A running suture should be used to produce the natural, 3-dimensional bulge of the cusps effectively (Figure 2). The pericardial cusp is sewn thoroughly up to the top

of commissure, and it is designed to have a deep coaptation that reaches up to the same horizontal plane as the commissure (Figure 3, A). The commissural coaptation is secured with additional 4-0 monofilament sutures. Recently, we added the small wing at the commissural part of pericardial cusps to get more tolerance to shear stress and even better coaptation (Figure 3, B and C). The coaptation of 3 new cusps is ensured with a visual check under negative pressure made by the left ventricular vent before closure of the aortotomy (Figure 3, D).

Follow-up

All the patients were monitored at the outpatient clinic of our hospital or at the referral hospital. Echocardiographic evaluation has been done 1 week, 1 month, 3 months, and every 6 months after surgery.

Statistical Analysis

Data are presented as mean \pm standard deviation. Survival rate and freedom from reoperation rate were calculated by Kaplan-Meier method.

RESULTS

No operation to convert to a prosthetic valve replacement was required. Aortic valve disease with IE and PVE could be operated in the same fashion. For AR with annuloaortic ectasia, our original aortic valve reconstruction could be combined effectively with the aortic root reimplantation technique. Mean aortic crossclamp time was 110.1 ± 26.8 minutes, and mean cardiopulmonary bypass time was 149.4 ± 29.9 minutes for isolated aortic valve reconstructions. Mean ischemic time was reduced to 96.7 ± 26.9 minutes among patients operated from January 2011 through September 2011. We have never resumed cardiopulmonary bypass to place additional sutures or to readjust the heights of the commissure or redundancy of the cusps.

Mean follow-up was 23.7 ± 13.1 months. Survival rate was 87.7% at 53 months (Figure 4, A). The freedom from reoperation rate was 96.2% (Figure 4, B). Reoperations were recorded for 2 patients, both because of IE. One was 10 months after the first operation and was induced by pacemaker implantation; the other was for a patient on hemodialysis 3.5 years after the first operation. These two

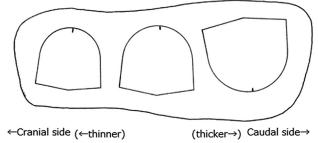


FIGURE 1. Management of pericardium. Generally speaking, pericardium becomes thicker as it approaches the diaphragm. On the other hand, it becomes thinner as it reaches the aorta. A larger cusp tends to have the more shear stress, and its opening/closing movement can be smooth regardless of its stiffness. Therefore, we always make the larger cusp from the diaphragm side and the smaller cusps from the aortic side.

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