Aortic valve reconstruction using self-developed aortic valve plasty system in aortic valve disease

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Abstract

Aortic valve disease is usually treated by prosthetic valve replacement. We have performed aortic valve plasty (AVP) using glutaraldehyde-treated autologous pericardium. AVP was performed for 88 patients from April 2007 through August 2009. Sixty-five patients had aortic stenosis, and 23 patients had aortic regurgitation (AR). Twenty-one patients showed bicuspid aortic valves, and one patient showed quadriseptum valve. There were 43 males and 45 females. Their mean age was 70.6 ± 10.5 years old. First, diseased leaflets excised. Then, the distance between each commissure was measured. The new leaflet were trimmed with an original template from a glutaraldehyde-treated autologous pericardium sample. Finally, the annular margin of the pericardial leaflet was running sutured to each annulus. There was no operative mortality or embolic event. Postoperative echocardiography revealed a mean peak pressure gradient (PG) of 19.0 ± 9.1 mmHg one week after surgery. Thirty-two patients had echocardiography one year after surgery. The peak PG became 12.9 ± 5.8 mmHg. Ten patients showed no AR, 20 patients showed trivial AR, and two patients showed mild AR. Freedom from reoperation is 100% at three years follow-up.

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Keywords: Aortic valve repair; Reconstructive valve surgery; Autologous pericardium

1. Introduction

Mitral and tricuspid valve repair have become more popular than valve replacement due to their standardization and reproducibility. However, for aortic valve disease (AVD), aortic valve replacement (AVR) is still the gold standard treatment. Bioprosthetic implantation is the preferred choice for AVR in the elderly as a result of the shorter life expectancy and reduced need of anticoagulation. However, despite the progress of the design and construction of prosthetic valves, hemodynamic performance is not yet comparable to that of native aortic valves.

Aortic valve repair is performed occasionally only by some surgeons. Moreover, many reports of aortic valve repair are limited to the treatment of aortic regurgitation (AR) [1, 2]. Our new style of aortic valve reconstruction can be applied to wide spectrum of AVDs including aortic stenosis (AS), AR, infective endocarditis (IE), prosthetic valve endocarditis (PVE), and annulo-aortic ectasia (AAE). Since the number of patients with AS is dramatically increasing in a society composed largely of elderly people, our technique becomes important especially for the treatment of AS.

We basically replaced all three aortic valve leaflets using glutaraldehyde-treated autologous pericardium. We assume this technique is more like valve repair than replacement because there is no use of foreign material and no need for postoperative anticoagulation.

2. Materials and methods

Our original aortic valve plasty (AVP) has been performed for 88 patients from April 2007 through August 2009. We retrospectively reviewed these 88 cases and evaluated short-term and mid-term results.

There were 43 males and 45 females. Their mean age was 70.6 ± 10.5 years old. Preoperative echocardiography revealed a mean peak pressure gradient (PG) through the aortic valve of 81.6 ± 31.1 mmHg and surgical annular diameter of 20.7 ± 2.8 mm. Sixty-five patients had AS, 23 patients had AR. Twenty-one patients showed bicuspid aortic valves, and one patient showed a quadriseptum valve. AAE were recorded in two patients. The other two patients had IE.

Among patients with AS, 27 were male, 38 were female. Bicuspid aortic valves were recorded in 16 patients. The mean age of patients with AS was 72.8 ± 8.8 years old. The mean surgical aortic annular diameter was 20.0 ± 2.5 mm. Isolated AVP was performed for 36 patients. Concomitant procedures included nine hemi-arch aortic graft replacements, six MAZE procedures, five coronary artery bypass...
graft operations (CABG), four other valve repairs, three septal myectomies, and two complex combinations.

Among patients with AR, 15 were male, eight were female. Bicuspid aortic valves were noticed in five patients, and a quadricuspid aortic valve was noticed with one patient. Two patients had AR due to IE, and another two patients had AR due to AAE. The mean age of patients with AR was 66.0 ± 12.4 years old. The mean surgical aortic annular diameter was 21.0 ± 3.3 mm. Isolated AVPs were performed for nine patients. Concomitant procedures included two David’s procedures, four hemi-arch aortic graft replacements, four mitral valve repair with MAZE procedure, two mitral valve repairs, one CABG with MAZE procedure, and one MAZE procedure.

Preparation of autologous pericardium was initiated by cleansing fat and other redundant tissue on the outer surface of the pericardium with the harmonic scarpe. Pericardium was excised (at least 7 × 8 cm; Fig. 1). Then, a excised pericardium was treated with 0.6% glutaraldehyde solution for 10 min. The treated pericardium was rinsed for 6 min three times using physiological saline solution.

All the aortic valve reconstructive procedures were performed during cardioplegic arrest on cardiopulmonary bypass.

Firstly, diseased leaflets are excised meticulously. In case of severe calcification along the aortic annulus, a Cavitron Ultrasonic Surgical Aspirator (CUSA) is very helpful to remove calcium without damaging annular tissue. Then, the distance between each commissures is measured with an originally invented sizing apparatus (Fig. 2). Two horns of our original AVP sizer should be correctly placed at the commissures. The new leaflet of the size corresponding to the measured value is trimmed with an original template from glutaraldehyde-treated autologous pericardium (Fig. 3). Finally, the annular margin of the pericardial leaflet was running sutured with 4-0 monofilament running sutures to each annulus. Commissural coaptation was secured with additional 4-0 monofilament sutures. The coaptation of three new leaflets was always insured with direct vision under negative pressure made by a left ventricular vent before closure of the aortotomy (Fig. 4).

3. Results

No operations converted to prosthetic valve replacement. AVD with IE and PVE could be operated in the same fashion. For AR with AAE, our original aortic valve plastic procedure could be used successfully with David’s procedure. The mean aortic cross-clamp time was 110.2 ± 24.3 min for patients with AS, and it was 98.5 ± 7.3 min for the patients with AR. The mean cardiopulmonary bypass time was 147.8 ± 224.4 min in AS group, and 142.5 ± 3.4 min in AR group. There was one in-hospital death with non-cardiac cause among patients with AS. No medium term mortality was recorded. No embolic event or reoperation were recorded in both the AS and AR group only who received a small dose of daily aspirin. Basically, we do not provide anticoagulation postoperatively. Anticoagulation was employed for five patients in the AS group and six patients in the AR group mainly because of atrial fibrillation.

The preoperative mean PG through the aortic valve with echocardiography was 81.6 ± 31.1 mmHg. It decreased to
treated autologous pericardium with glutaraldehyde solution. The treated pericardium is used to increase the height of native aortic valve leaflets and commissures resulting in the increase of coaptation zone. Glutaraldehyde treatment can provide more resistance against retraction and degeneration and maintain the intrinsic tissue pliability of the pericardium.

Halees et al. reported an overall reoperation free survival of 47% at 16 years after aortic valve reconstruction with pericardium [12]. It was their contention that cusp extension or replacement of the three aortic cusps with a single strip of pericardium is technically more reliable. Odim et al. reported that aortic valve repair with autologous pericardial leaflet extension was a good alternative for a congenitally diseased aortic valve [13].

Our original aortic valve reconstruction technique does not focus on the total repair with a single strip of pericardium. On the contrary, we emphasize that aortic valve represents a collection of different cusps. Therefore, we considered the size of the aortic cusp to be defined independently by the distance between the commissures. As a result, we make up pericardial leaflets separately for each coronary cusp. Also, each cusp may become different sizes from each other. With our technique of total resection of all three diseased leaflets, our procedure can be applied any type of AVD. In fact, we could operate AS, AR, IE, PVE basically in a similar fashion. Even for AAE, this technique could be applied with David’s operation. This wide applicability can be attributed also to the independent reconstruction of three leaflets. In the situation with intact aortic annulus, this new reconstruction technique can be applied to all AVD. To secure the intact aortic annulus, CUSA play an important roll in removing calcium without damaging annular tissue.

AVP provides good short- and mid-term results with good hemodynamics and good quality-of-life without anticoagulation. This procedure is effective especially for calcified AS with small aortic annulus in elderly patients. Assessment of long-term data especially regarding valve durability will be examined in the future.

4. Discussion

AVR is the treatment of choice for acquired AVD, although there is an apparent limitation of durability with bioprosthetic valves and an apparent disadvantage of anticoagulation with mechanical prostheses. Under these circumstances, the current standardization and popularity of mitral and tricuspid valve repair technique have induced interest in aortic valve repair. The origin of aortic valve repair can be traced back to the early era of cardiac surgery [3]. Aortic valve repair has been performed using native valve leaflets by various techniques that included commissurotomy [4], annuloplasty, free edge unrolling, cusp resuspension, supra-aortic crest enhancement, free edge reinforcement, wedge resection, and so on [5]. This type of conservative repair is not always possible especially for calcified AS of increasing elderly patients. Simple decalcification or slicing of leaflets has not shown good results. Attempts to replace aortic valve cusp tissue with biological material have already been made since the late 1960s [6–8]. Fascia lata, dura mater, bovine pericardium have been used in small number of patients, but the results have not been favorable in the majority of cases. On the contrary, autologous pericardium is readily available for immediate aortic valve repair in every patient.

Aortic valve repair using autologous pericardium leaflet extension was described by Duran et al. [5, 9–11]. They

Fig. 4. Evaluating the coaptation of three new leaflets under left ventricular negative pressure made by a left ventricular vent.

$19.0\pm 9.1$ mmHg one week after surgery and to $12.9\pm 5.8$ mmHg one year later. The degree of AR with echocardiography had always been less than mild postoperatively. Among 32 patients underwent one year follow-up echocardiography, 10 patients showed no AR, 20 patients showed trivial AR, and two patients showed mild AR.

References

leaflet functionality worsened after the postoperative monitoring period. If they did not we removed them completely. But in some patients, the removal of the residual calcification with CUSA, we preserved the leaflets; really to be congratulated for your excellent results.

main problem. I would see with it is not reproducible unless you commercialize your sizes, and this is probably the biggest pitfall. Otherwise you are really to be congratulated for your excellent results.

Dr. Ozaki: Initially, if the valve leaflets resumed normal function after removal of the residual calcification with CUSA, we preserved the leaflets; if they did not we removed them completely. But in some patients, the leaflet functionality worsened after the postoperative monitoring period. Consequently, these days we replace and repair all three leaflets.

Dr. A. Carlo (Milan, Italy): Congratulations for your work. It is a very difficult thing, but I have some doubt about autologous pericardium. I also use autologous pericardium, treated or untreated, to repair the valve. But to build a complete valve, sometimes we have a problem with quality and thickness of pericardium, inflammatory problems, et cetera. What do you do to resolve this problem, because you build a complete valve?

Dr. Ozaki: Usually we harvest 8 x 7 cm of pericardium. Of course, as you know, thickness varies. Pericardium near the diaphragm is thick but near the aortic root is thin. We measure the intercommissural distance. The smaller one is taken from the aortic side and the bigger one is taken from near the diaphragm, because the movement of the leaflet is different.

Dr. El Khoury (Brussels, Belgium): Do you sometimes perform some kind of cusp extension, by which I mean not replace all the cusps but only a part of the cusp, what we call a cusp restoration, taking the leaflet itself, the rest of the leaflet, as a reference? And my second question, in the case of aneurysm of the ascending aorta and normal leaflet, do you replace the leaflets or do you perform a sparing surgery in these cases?

Dr. Ozaki: I did not understand the first question.

Dr. El Khoury: Do you sometimes perform cusp extension? I mean, leaving a part of the native cusp.

Dr. Ozaki: No, I do not do cusp extension.

Dr. El Khoury: Otherwise radical excision?

Dr. Ozaki: Yes.

Dr. El Khoury: And the second question, if you have an aneurysm in the ascending aorta and a normal leaflet, do you replace the leaflet or do you perform a sparing surgery?

Dr. Ozaki: Normal leaflet, just replace the ascending aorta. I will do valve-sparing surgery.

Dr. El Khoury: And you leave the aneurysm of the root?

Dr. Ozaki: No.

Dr. G. Dreyfus (Monte Carlo, Monaco): I would like to answer our Italian colleague about his concerns regarding autologous pericardium treated with glutaraldehyde. As I mentioned, we have had an experience with patients who are now at nearly 10 years of follow-up, young patients. We had a very precise tool, a cutting die, to cut the pericardium in order to have a precise tool, a cutting die, to cut the pericardium in order to have a complete valve? Sometimes we have a problem with quality and thickness of pericardium, inflammatory problems, et cetera. What do you do to resolve this problem, because you build a complete valve?