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# Redo Aortic Root Surgery: Clinical Validation of Prosthetic Valve Preservation and Coronary Graft Interposition Technique

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Redo aortic root replacement is technically challenging. We review our redo aortic root surgical results following composite valve graft replacement. Between January 1997 and July 2007, 10 patients (mean age 38.7 ± 15.5 years, 70.0% men) underwent redo aortic root replacement. The coronary reconstruction techniques in the previous operation were the inclusion technique in 7 (70.0%), graft interposition in 2 (20.0%), and the coronary button technique in one (10.0%). The indications for reoperation were pseudoaneurysm formation in 8 patients (80.0%) and prosthetic valve endocarditis in 2 (20.0%). We could preserve the previous mechanical valve in 5 patients. There were no operative deaths. The mean follow-up was 28.4 months. There were 2 late deaths, one due to sepsis and the other due to thoracoabdominal aortic aneurysm rupture. During follow-up period, there were no thromboembolic events, reoperations, coronary events, or coronary pseudoaneurysms. The actuarial survival rate at 5 years was 75.0 ± 15.8%. Redo aortic root replacement can be performed with good early and late results. In cases of redo aortic root replacement, we consider coronary reconstruction using the separately interposition technique to be feasible as one of many modifications when the button technique is not able to performed.

**Key words**: aortic root, reoperation, endocarditis

## Introduction

Composite valve graft replacement of the aortic root is the most radical mode of treating a variety of proximal aortic conditions, including aortic dissection and ascending aortic aneurysm. Bentall and De Bono introduced a surgical technique for aortic root operation with a composite valve graft in 1968[1]. This original Bentall procedure employed an in situ circumferential suture line around the coronary ostia with subsequent complete aortic wrap around to control bleeding. Tension within the perigraft space conveyed a significant risk of coronary separation, false aneurysm formation and the need for reoperation[2]. To avoid this tension, Cabrol and colleagues used an interposition graft to the coronary ostium, resulting in graft thrombosis[3)4)]. Kouchoukos and colleagues showed that the modified, "open button technique", for the reconstruction of the coronary arteries was safer in terms of a lower incidence of late false aneurysms at the site of anastomosis[5].

The frequency of reoperations on the aortic root has been increasing[6)~13)]. The indications for redo aortic root surgery after composite valve graft replacement are mainly pseudoaneurysm formation, biologic valve failure and prosthetic endocarditis[6)~8)]. In this report, we review our experience with redo aortic root surgery which was selected based on the etiology due to reoperation following composite valve graft replacement.

## Patients and Methods

Between January 1997 and July 2007, 142 patients underwent composite valve graft replacement for aortic root disease at Tokyo Women's Medical University. There were 100 men and 42 women with a mean age of 45.9 ± 14.1 years. There were 65 patients with Marfan's syndrome and 5 with Aortitis syndrome. Ten of these patients had undergone

**Table 1** Preoperative EuroSCORE

| Variables | Number (%) |
|---|---|
| Patient-related factors | |
| Mean age (range) | 48.7 ± 15.5 (16-60) |
| Male/Female | 8/2 (80.0/20.0) |
| Chronic pulmonary disease | 2 (20.0) |
| Extracardiac arteriopathy | 5 (50.0) |
| Active endocarditis | 2 (20.0) |
| Cardiac-related factors | |
| Moderate LV dysfunction (EF 30-50%) | 3 (30.0) |
| Operation-related factors | |
| Emergency | 1 (10.0) |
| EuroSCORE | |
| Mean (range) | 10.7 ± 1.25 (8-12) |
| Predicted mortality (range) | 25.6 ± 8.28% (11.05-36.84) |

LV: left ventricular, EF: ejection fraction.

previous composite valve graft replacement. We reviewed the records of these 10 patients who underwent redo aortic root replacement. There were 7 men and 3 women. The patient's age at the time of reoperation ranged from 16 to 60 years (mean ± SD; 38.7 ± 15.5 years). There were 8 patients (80.0%) with Marfan's syndrome and 1 (10.0%) with Aortitis syndrome. Previous root replacement had been performed with a composite mechanical valved graft in all patients. The techniques of coronary reconstruction of the previous procedures were the original Bentall technique (inclusion method) in 7 (70.0%), the graft-interposition technique in 2 (20.0%), and the coronary-button technique in 1 (10.0%). The indications for reoperation were pseudoaneurysm formation in 8 patients (80.0%) and prosthetic valve endocarditis in 2 (20.0%). The mean interval between previous root replacement and redo aortic root replacement was 13.2 (range, 0.75 to 24) years. Patient-, cardiac-, and operation-related factors relevant to the EuroSCORE[14] are presented in Table 1.

**1. Operative technique**

A median sternotomy incision was performed in all patients. Cardiopulmonary bypass was instituted through the femoral artery in 7 patients because of a large false aneurysm or hemodynamic instability. In the others, cardiopulmonary bypass was established through the distal ascending aorta. Venous cannulation was performed through either the femoral vein, right atrium (bicaval or two-stage), or both. In 2 patients, deep hypothermic circulatory arrest before reopening was planned because the pseudoaneurysm had eroded the backside of the sternum. Continuous antegrade or retrograde cold blood cardioplegia was applied for myocardial protection during aortic cross-clamp. Deep hypothermic circulatory arrest with retrograde cerebral perfusion (16℃) was applied in patients that required concomitant transverse arch replacement. After cross-clamping the ascending aorta, we performed aortic root reconstruction. The redo technique was selected in part based on the procedure used for the first replacement and the etiology of reoperation.

In cases with pseudoaneurysm formation at the coronary reconstruction site, the inclusion method was the major cause of reoperation (6/8 patients; 75.0%). When subvalvular stenosis such as punnus formation or massive thrombus was not found, we preserved the previous aortic prosthetic valve. In these cases, a new tube graft was anastomosed to the previous graft between the coronary reconstruction site and then anastomosed to the previous prosthetic valve. We were able to preserve the previous valve in 5 (62.5%) of 8 reoperations due to pseudoaneurysm formation. In 3 patients, we could not preserve the previous valve, because 2 tilting disc valves were covered with red thrombus and valves were replaced with a bileaflet valve. In the other patient, pannus formation was found beneath the previous valve.

In cases of reoperation due to prosthetic valve endocarditis, the surgical strategy was to excise all previous material and aggressively debride all suspicious infected tissue. We performed replacement using Homograft when could obtain it.

In coronary re-replacement, we performed separately interposed graft using the exclusion technique[15] (sewing all three layers of the aortic wall) or AC bypass using a saphenous vein graft when button technique was not able to be performed (Fig. 1). The redo aortic root procedures are presented in Table 2.

The total aortic arch was concomitantly replaced in 3 patients (30.0%). The mean duration of circulatory arrest with retrograde cerebral perfusion time was 60 ± 2.7 minutes. The mean cardiopulmonary

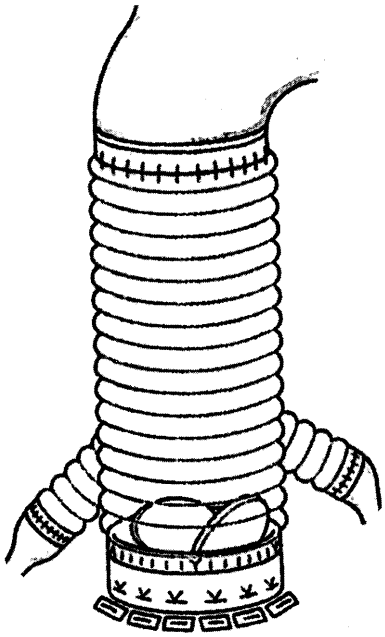

**Fig. 1** Composite valve graft replacement using separately interposed grafts
Coronary buttons were made. The interposed grafts were anastomosed with the exclusion technique.

bypass time was 308 ± 80 minutes, and the mean aortic cross-clamp time was 200 ± 57 minutes.

**2. Follow-up and data analysis**

The clinical status of patients was determined by hospital records and telephone interviews. The mean follow-up was 28.4 (range, 6 to 77) months. The results are presented as mean ± standard deviation. A Student's paired t-test was used to compare the data. A p-value of less than 0.05 was considered statistically significant. Long-term survival was evaluated by the Kaplan-Meier method.

## Results

Between January 1997 and July 2007, 142 patients underwent composite valve graft replacement for aortic root disease in our hospital. The actuarial survival rate at 5 and 10 years was 96.8 ± 1.6% and 90.6 ± 5.1%, respectively (Fig. 2).

A total of 16 (11.3%) patients required reoperation. Seven patients required abdominal aortic replacement, 5 required replacement of the descending thoracic aorta, 2 required total arch replacement, one required replacement of the thoracoabdominal aorta and only one patient required redo composite valve graft replacement due to infection. The actuarial freedom from reoperation at 5 and 10

**Table 2** Redo operation

| Cases | Age (years) | Etiology | Cause of reoperation | Site of pseudoaneurysm | Extent of graft replacement | Previous prosthetic valve | Coronary reconstruction: RCA/LCA | Concomitant operation | ECC time (min) | ACC time (min) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 37 | MFS | Pseudoaneurysm | BCA | Repair of leakage + Ascending + TAR + RSCA | Bileaflet/Left | SIG/SIG | TAR + RSCA | 319 | 205 |
| 2 | 44 | MFS | PVE | BCA | Valved conduit | Bileaflet/Excised | SIG/SIG | MVR + TAP | 387 | 275 |
| 3 | 32 | MFS | Pseudoaneurysm | LCA/Distal anastomosis of the CVG | Valved conduit + TAR | Tilting disc/Excised | SIG/SIG | TAR | 302 | 223 |
| 4 | 39 | MFS | Pseudoaneurysm | BCA | Repair of leakage + Ascending + TAR | Bileaflet/Left | SIG/SIG | TAR | 353 | 212 |
| 5 | 60 | MFS | Pseudoaneurysm | RCA/Distal anastomosis of the CVG | Repair of leakage + Ascending | Bileaflet/Left | SIG/Left | none | 206 | 124 |
| 6 | 59 | MFS | Pseudoaneurysm | BCA | Valved conduit | Tilting disc/Excised | SIG/SIG | none | 289 | 242 |
| 7 | 16 | MFS | Pseudoaneurysm | RCA | Ascending | Bileaflet/Left | ACB with SVG/Left | none | 336 | 273 |
| 8 | 53 | Aortitis | Pseudoaneurysm | RCA | Valved conduit | Bileaflet/Excised | SIG/ACB with SVG | none | 278 | 145 |
| 9 | 28 | unknown | PVE | NONE | Homograft | Bileaflet/Excised | Homograft/Homograft | none | 439 | 178 |
| 10 | 19 | MFS | Pseudoaneurysm | BCA | Repair of leakage + Ascending | Bileaflet/Left | Button/Button | none | 166 | 122 |

MFS: Marfan syndrome, PVE: prosthetic valve endocarditis, BCA: both coronary artery, LCA: left coronary artery, CVG: composite valve graft, RCA: right coronary artery, TAR: total arch replacement, RSCA: right subclavian artery, SIG: separately interposed graft, ACB: aorto-coronary bypass, SVG: saphenous vein graft, MVR: mitral valve replacement, TAP: tricuspid valve annuloplasty.

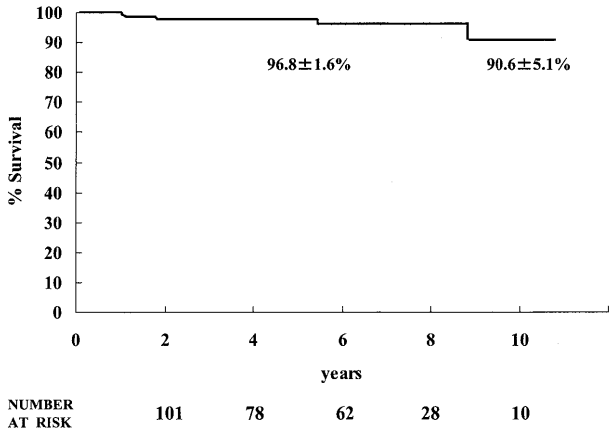


**Fig. 2** The actuarial survival rate

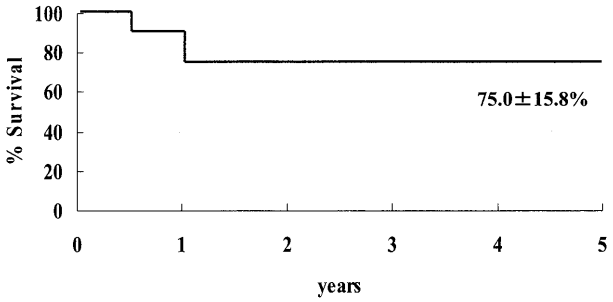


**Fig. 3** The actuarial survival rate (Redo aortic root surgery)

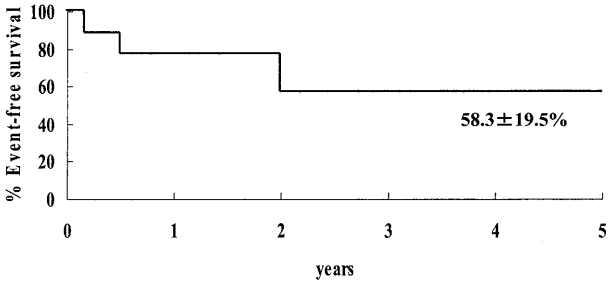


**Fig. 4** Actuarial event-free survival (Redo aortic root surgery)

years was 90.9 ± 2.8% and 77.9 ± 6.4%, respectively. For coronary reconstruction, we used the button technique in 40 (28.2%), separate interposition technique in 77 (54.2%), the modified Piehler's technique (left coronary artery reconstruction using the interposition technique and right coronary artery reconstruction using the button technique) in 24 (16.9%) and the Cabrol[3] technique in 1 (0.7%). During the follow-up period, pseudoaneurysm formation at the site of coronary reconstruction was not found.

In redo aortic root study, there were no operative deaths. Two patients (20.0%), including one patient who underwent concomitant total aortic arch replacement, required additional exploration of the mediastinum for bleeding. One patient (10.0%) had an intracranial hemorrhage 2 weeks postoperatively. The cause of intracranial hemorrhage was mycotic aneurysm rupture. Although left upper extremity paresis was noticed, it improved after rehabilitation. No patient had a perioperative myocardial infarction.

Postoperative echocardiography at pre-discharge demonstrated keeping good left ventricle function. The mean postoperative fractional shortening of left ventricle was 0.28 ± 0.05, which was not significantly different from the preoperative value of 0.32 ± 0.09 (p=0.20). The mean postoperative maximum creatine kinase (CK) was 980.1 (IU/*l*) and the mean maximum creatine kinase isoenzyme MB (CKMB) was 13.36 (ng/ml).

There were 2 late deaths because of sepsis of unknown origin at 6 months after reoperation in one patient and thoracoabdominal aortic aneurysm rupture of chronic aortic dissection at 24 months after reoperation in another. During follow-up, there were no thromboembolic events, reoperations, coronary events, or coronary pseudoaneurysms. The actuarial survival rate at 5 years was 75.0 ± 15.8% (Fig. 3).

Event-free survival rate (defined as freedom from death, reoperation, thromboembolism, and anticoagulation-related hemorrhage) at 5 years was 58.3 ± 19.5% (Fig. 4).

## Discussion

The number of patients who undergo reoperation on the aortic root, ascending aorta and aortic valve is increasing[6)7)10)12)]. However, comparing the outcomes of previous studies is difficult because of the wide spectrum of interventions performed on the aortic root. Our study included a very small number of patients since we included only patients that had previous composite valve graft replacement. Moreover, we reviewed our surgical strategy based on the indications for reoperation since this type of information is not available in previous reports.

Fundamentally, redo aortic root replacement re-

quires excision of all previously implanted materials[6)7)12)13)]. However, we believe that previously implanted materials, especially prosthetic valves can be preserved in some cases. The main indications for redo aortic root replacement are pseudoaneurysm formation and prosthetic endocarditis[6)~8)]. In cases of prosthetic endocarditis, the surgical strategy is to remove all previously implanted material and aggressively debride all suspicious infected tissue. In cases of pseudoaneurysm formation at the site of anastomosis, all previously implanted materials are not necessarily removed. Our strategy is to remove only the previously implanted valve when there is pannus formation with or without valve malfunction, or when there is a tilting disc valve that may lead to thrombus formation in the future. Redo aortic root replacement is technically complex and challenging; however, preserving the previous valve has the following advantages: ① it requires less suture sites and there is less bleeding from the aortic root, ② it avoids A-V block, and ③ it reduces aortic cross-clamp time and CPB pump time and the overall cost of the operation.

In coronary artery reconstruction, the coronary button technique has better long-term survival results and there is a reduce rate of reoperation[5)16)]; however, in the aortic root reoperation there are cases that coronary button mobilization and direct reimplantation is not suitable due to severe adhesion or calcifications around the coronary ostia. Raanani and colleagues reported 16 (51.5%) cases of 31 redo aortic root replacements that required extension of one or both coronary arteries[7)]. Girardi and colleagues reported that 45 patients had redo composite replacement of the aortic root utilizing the exclusion technique while 11 (24.4%) required a modification of the Cabrol procedure[10)]. Kirsch and colleagues reported that unplanned CABG was performed either because coronary ostium reimplantation was deemed impossible or because of suspected coronary malperfusion after aortic unclamping as a consequence of technical error in coronary button anastomosis or unrecognized coronary artery disease or both. The need for unplanned CABG occurred with an incidence of 25% in their experience. The need to perform unplanned CABG during reoperative aortic root replacement is a major risk factor for hospital death[12)]. In our series, coronary reconstruction using the button technique was performed in only one patient; coronary reconstruction using the interposition technique and coronary artery bypass grafting was performed in the others (9/10 patients; 90%). The reasons are: ① mobilization of the coronary ostium is limited because of tight adhesion to the surrounding tissue or widely separate because of pseudoaneurysm (5/9 patients; 55.6%), ② direct suturing is not feasible because of severe calcification of the coronary ostium (2/9 patients; 22.2%), and ③ the coronary ostium is destroyed due to endocarditis or pseudoaneurysm (2/9 patients; 22.2%). The disadvantage of the interposition technique is the long-term patency of these grafts and the increased number of coronary events. However, with appropriate myocardial protection during the procedure, there was no perioperative myocardial infarction and no coronary events during follow-up in our series.

The limitations of our study are that it was retrospective and included only a small number of patients. However, it provided information on our surgical strategy for the redo aortic root replacement following composite valve graft replacement.

## Conclusion

Redo aortic root replacement is technically complex and challenging but can be performed with good early and late results. An intact previous mechanical valve can be preserved during the reoperation due to false aneurysm formation. In cases of redo aortic root replacement, we consider coronary reconstruction using the separate interposition technique to be feasible as one of many modifications when the button technique is cannot be performed.

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## Bentall 術後の大動脈基部再置換術症例の検討と術式の工夫

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大動脈基部再置換術は手技的にも複雑であり困難である．今回我々は弁付き人工血管置換術後における大動脈基部再置換術の手術成績と手技的工夫について検討した．対象は1997年1月～2007年7月までに当院で施行した大動脈基部再置換術10例である．平均年齢は38.7±15.5歳で7例が男性であった．初回手術で使用した人工弁は全て機械弁であった．初回手術時の冠動脈再建法は，Inclusion法が7例（70.0%），Graft Interposition法が2例（20.0%），Button法が1例（10.0%）であった．再手術の原因は仮性動脈瘤形成が8例（80.0%），人工弁感染が2例（20.0%）であった．また初回手術時に使用した機械弁を再手術時に5例温存可能であった．再手術の成績については，手術死亡を認めなかった．平均観察期間は28.4（6～77）ヵ月で，遠隔期死亡を2例に認め，原因は敗血症と胸腹部大動脈瘤破裂であった．観察期間中に血栓塞栓症，再手術，冠動脈イベント，冠動脈吻合部瘤は認めなかった．再手術後の5年生存率は75.0±15.8%であった．大動脈基部再置換術の早期遠隔成績は満足のいくものであった．冠動脈吻合部瘤で再手術となったものに関しては初回手術時の人工弁を温存することが可能であった．また，大動脈基部再置換術に関して，Button法が施行できない場合，Separate Interposition法は選択肢の一つとなりえると考えられた．