Aortic root replacement with the Carboseal composite valve graft: analysis of risk factors

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Abstract

This retrospective analysis of a selected series of Bentall-De Bono procedures was carried out in order to evaluate the performance of the Carboseal composite valve graft (Sulzer Carbomedics Inc, Austin, TX, USA). Between October 1997 and April 2004, 120 patients underwent aortic root replacement with the Carboseal Composite Valve Graft. The mean age of patients was 59.7 ± 13.4 years (range, 21–83 years); 96 patients (80%) were male. Eighty-nine patients (74.2%) had annuloaortic ectasia, 10 patients (8.3%) post-stenotic dilatation, 3 (2.5%) post dissection aneurysm, 2 (1.7%) acute type A dissection and 1 (0.8%) endocarditis. The average follow-up duration was 29.2 months (range 2–82 months). Hospital mortality was 1.7% (2 of 120 patients). The actuarial survival rate (including hospital mortality) was 97.2 ± 1.5% at 1 year, 91.6 ± 3.5% at 3 years and 84.0 ± 8.0% at 5 years. Chronic renal failure was an independent risk factor for late mortality (P = 0.02). The actuarial freedom from pseudoaneurysms at 3 years was higher among patients without Marfan syndrome (94.7 ± 3.2% vs. 75.0 ± 21.6% at 3 years, P < 0.003). In our recent series, the Bentall-De Bono operation provided good results with low incidence of prosthetic related complications. Pseudoaneurysms requiring re-operation have a higher incidence among patients with Marfan syndrome.

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Keywords: Aortic root; Composite graft; Aneurysm

1. Introduction

In order to assess the performance of the Carboseal composite valve graft (Sulzer Carbomedics Inc, Austin, TX, USA) we retrospectively analysed a selected series of Bentall-De Bono procedures.

2. Materials and methods

2.1. Patients

Between October 1997 and April 2004, 120 patients underwent aortic root replacement with the Carboseal composite valve graft. Until November 2003 we have exclusively used this conduit regardless of patient’s age. After this date we also started implanting ‘home made’ biological conduits (pericardial valve, Mosaic® Medtronic Inc., Minneapolis, MN, USA and a tubular graft, Sulzer Vascutek, Renfrewshire, Scotland, UK) in patients aged >65 years. So far our experience with biological conduits is limited to 12 cases. Patients preoperative characteristics are listed in Table 1.

2.2. Operative technique

A median sternotomy was performed and hypothermic cardiopulmonary bypass (32 °C) was instituted with cannulation of the ascending aorta, aortic arch or femoral artery and right atrium. Myocardial protection was achieved with a combination of antegrade and retrograde cardioplegic solution and topical cooling with 4 °C saline solution. The ‘button technique’[1] was used in all cases and all patients received the Carboseal composite valve graft. If aortic dissection was present, continuity between the separated layers of the aorta was restored using gelatin-resorcinol formaldehyde biologic glue (GFR; F.I.I, Saint-Just Malmont, France) [2] and the distal anastomosis was further reinforced with an inner and outer Teflon felt strip. Concomitant procedures included planned coronary artery bypass grafting in 18 patients (15%), coronary artery bypass grafting due to periooperative technical problems in 4 patients (3%), mitral valve replacement in 4 patients (3%), mitral valve repair in 3 patients (2%) and left atrial ablation for atrial fibrillation in 3 patients (2%). The mean cardiopulmonary bypass time was 99 ± 30 min (range 61–213 min) and the mean aortic cross-clamp time was 82 ± 21 min (range 52–159 min).

2.3. Follow-up

Follow up was conducted between March and April 2004 and was 96% complete. The 5 patients, whose follow-up was incomplete, were censored at the time of their last follow-up. The average follow-up duration was 29.2 months (range 2–82 months).
Within 30 days after the operation or during initial hospitalisation was 1.7% (2 of 120 patients). Cause of death was acute prosthetic endocarditis complicated by acute myocardial infarction and sepsis in one patient and multiple organ failure (MOF) in the other patient. Because of the small number of the events (2 cases), univariate and multivariate analysis was not carried out.

3.2. Early morbidity

Early (<24 h) re-intervention for excessive bleeding was necessary in 11 patients (9.2%). Perioperative myocardial damage (serum creatinine kinase level 300 IU/l, with a creatinine kinase MB isoenzyme fraction 3%) occurred in 4 patients (3.3%). Haemodialysis for renal insufficiency was necessary in 3 patients (2.5%). Permanent neurological deficits developed in 2 patients (1.7%). Transient neurological deficits involving left or right side weakness were observed in 2 patients (1.7%) and in both cases the deficit was fully recovered. One patient (0.8%) developed prosthetic endocarditis and died from sepsis 15 days after the operation.

3.3. Late mortality

There were 7 (6.4%) late deaths. Causes of death were cerebral haemorrhage in 3 patients, ischemic heart disease in 1 patient, uncontrollable bleeding during reoperation in 2 patients and cholecystic cancer in 1 patient. Overall actuarial survival is shown in Fig. 1. The survival rate was 97.2±1.5% at 1 year, 91.6±3.5% at 3 years and 84.0±8.0% at 5 years. The difference in survival between Marfan and non-Marfan patients was not significant (P=0.584). Univariate analysis showed a significant association between late death chronic renal insufficiency (P<0.001), left ventricle ejection fraction (LVEF) <40% (P=0.04) and re-operation on the aortic root (P=0.04). In the Cox multivariate analysis chronic renal insufficiency (creatinine levels greater than 1.9 mg/dl) was found to be the only independent risk factor for late mortality (P=0.02; OR=11.5). The results

![Survival Curve](image)

**Fig. 1.** Overall actuarial survival.

### Table 1

Preoperative patients characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n=120</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>59.7±13.4</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>96 (80)</td>
</tr>
<tr>
<td>NYHA functional class</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>24 (20)</td>
</tr>
<tr>
<td>II</td>
<td>57 (48)</td>
</tr>
<tr>
<td>III</td>
<td>39 (32)</td>
</tr>
<tr>
<td>IV</td>
<td></td>
</tr>
<tr>
<td>Left ventricular ejection fraction</td>
<td></td>
</tr>
<tr>
<td>≥60%</td>
<td>66 (55)</td>
</tr>
<tr>
<td>40–59%</td>
<td>44 (37)</td>
</tr>
<tr>
<td>&lt;39%</td>
<td>10 (8)</td>
</tr>
<tr>
<td>Marfan syndrome</td>
<td>4 (3)</td>
</tr>
<tr>
<td>Indications for operation</td>
<td></td>
</tr>
<tr>
<td>Primary operation</td>
<td>105 (87)</td>
</tr>
<tr>
<td>Anuloaortic ectasia</td>
<td>89</td>
</tr>
<tr>
<td>Poststenotic dilatation</td>
<td>10</td>
</tr>
<tr>
<td>Acute aortic dissection</td>
<td>2</td>
</tr>
<tr>
<td>Chronic aortic dissection</td>
<td>3</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>1</td>
</tr>
<tr>
<td>Reoperation</td>
<td>15 (13)</td>
</tr>
<tr>
<td>Aortic valve prosthesis</td>
<td>1</td>
</tr>
<tr>
<td>Valsalva sinus aneurysm after AVR or AAR</td>
<td>11</td>
</tr>
<tr>
<td>Valsalva sinus aneurysm after CABG</td>
<td>3</td>
</tr>
</tbody>
</table>

Values are mean±1 SD.
Numbers in parentheses are percent.
NYHA = New York Heart Association.
AAR = ascending aorta replacement.
AVR = aortic valve replacement.

2.4. Statistical analysis

Univariate and multivariate analysis to determine whether any single factor influenced hospital mortality was not carried out due to the low incidence (2 cases). Preoperative, intraoperative and postoperative variables were analysed for their influence on mortality during follow-up. Variables considered were: sex, age, NYHA class, chronic renal insufficiency (creatinine levels greater than or less than 1.9 mg/dl), left ventricle ejection fraction (<40% or >40%), coronary artery disease, Marfan syndrome, bicuspid aortic valve, indication for operation (anuloaortic ectasia, post-stenotic dilatation, dissection, endocarditis) previous aortic valve or aortic operation, cross clamping time, cardiopulmonary bypass time, concomitant procedures and postoperative complications (myocardial infarction, respiratory insufficiency, bleeding, neurologic deficit, hemodialysis). Variables achieving a P-value of less than 0.2 in the univariate analysis were examined using Cox proportional hazard regression. Estimates for long term survival and freedom from morbid events were made with the Kaplan–Meier method. Differences between survival curves were evaluated with the log-rank statistic.

3. Results

3.1. Early mortality

Hospital mortality rate, defined as all patients who died within 30 days after the operation or during initial hospitalisation was 1.7% (2 of 120 patients). Cause of death was acute prosthetic endocarditis complicated by acute myocardial infarction and sepsis in one patient and multiple organ failure (MOF) in the other patient. Because of the small number of the events (2 cases), univariate and multivariate analysis was not carried out.

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of univariate and multivariate analysis are reported in Table 2.

### 3.4. Re-operations

Re-operation as a result of complications in the composite valve graft procedure was necessary in 6 (5.5%) patients, 3 to 65 months after primary operation. Pseudoaneurysm at the aortic or coronary ostial suture lines occurred in 4 (3.5%) patients, 2 of which had Marfan syndrome. All patients with pseudoaneurysm except one were re-operated at our institute and survived the operation. The other patient underwent re-operation in another hospital and died from uncontrollable bleeding during the procedure.

Two more patients required re-operation for prosthetic valve endocarditis, where the composite valve graft was replaced with an aortic homograft root. One of them died during the operation from uncontrollable bleeding. Freedom from re-operation due to complications of the composite valve graft procedure was 97.9 ± 1.4% at 1 year, 93.8 ± 3.2% at 3 years and 78.1 ± 10.4% at 5 years (Fig. 2). The rate of freedom from re-operation for patients with Marfan syndrome was lower than that of the remaining patients (75.0 ± 21.6% vs. 94.7 ± 3.2% at 3 years), and the difference was significant (P=0.003).

### 3.5. Operations on the remaining aorta

Three patients (2.7%) underwent subsequent operations for aneurismal disease of the abdominal aorta respectively 3, 7 and 15 months after the initial operations. None of them had Marfan syndrome. The freedom from operation on the remaining aorta was 98.5 ± 1.4% at 2 years, 95.9 ± 2.9% at 3 years and 91.5 ± 5.1% at 5 years.

### 3.6. Prosthetic endocarditis

Two patients (1.8%) developed prosthetic valve endocarditis respectively 3 and 19 months after the operation. The infected valve conduit was replaced in both cases by a homograft aortic root. The first patient, as previously mentioned, died during the re-operation from uncontrollable bleeding; the second made a complete recovery and, at the time of the last follow-up, was in NYHA class I. The freedom from prosthetic endocarditis was 99.1 ± 0.8% at 1 year, and 90 ± 7.9% at 5 years.

### 3.7. Thromboembolism

Thromboembolic events occurred in 2 patients (1.8%). Both of them had a stroke and survived the event, but with a permanent neurological deficit. The freedom from thromboembolism at 5 years was 98 ± 1.4%.

### 3.8. Anticoagulant-related complications

Three patients (2.7%) suffered cerebral haemorrhage respectively 31, 35 and 37 months after the initial operation. All of them died. The freedom from anticoagulant-related complications was 97 ± 2.0% after 2 years, and 94.4 ± 3.2% after 5 years.

![Fig. 2. Freedom from re-operation due to complications of the composite valve graft procedure.](image)

![Fig. 3. Event free survival.](image)
When including death, re-operation, endocarditis, thromboembolism and anticoagulant-related complications as events, the event free survival was 95.3±2.0% at 1 year, 79.5±5.5% at 3 years and 61.8±10.3% at 5 years (Fig. 3).

4. Discussion

Composite valve graft replacement is the most radical mode of treating the combined disease of the aortic valve and aortic root. Although our experience began in 1997, from October 2002 onwards we have only used this approach in cases of gross structural defects of the aortic valve, preferring the aortic valve sparing operations [3] when the anatomy is suitable for repair.

Four patients underwent unscheduled bypass grafting because of electrocardiogram’s ischemia soon after the weaning from CPB. Intra-operative transesophageal echocardiogram documented a hypokinetic left ventricular anterior wall in two cases and hypokinetic left ventricular posterior wall in the other two. The treatment consisted of safenous vein grafting of either left anterior descending artery or right coronary artery, depending on the area involved. A kinking at the coronary ostium site was supposed to be the cause in all four cases.

Two patients (1.8%) experienced an early stroke. Both of them had risk factors for adverse cerebral outcome. The first was an 80-year-old patient with previous cerebral events; the second, because of ischemia after the weaning from the cardiopulmonary bypass (CPB) requiring a venous graft on the right coronary, had a long cross-clamping time (158 min) and CPB time (187 min).

The most frightening late complication within our group of patients was the anticoagulant-related cerebral haemorrhage that occurred in 3 cases and caused death in all of them. The reasons were patient related: the uncontrolled usage of anticoagulation and postponement of routine controls. It is well known that antithrombotic therapy with coumarin derivates carries a substantial risk of bleeding complications. It is well known that antithrombotic therapy with coumarin derivates carries a substantial risk of bleeding complications. It is well known that antithrombotic therapy with coumarin derivates carries a substantial risk of bleeding complications. It is well known that antithrombotic therapy with coumarin derivates carries a substantial risk of bleeding complications.

Pseudoaneurysms occurred in 4 patients; the leak was localised at the proximal suture line in 2 cases and at the coronary ostial suture line in the other 2 cases. Hilgenberg and associates [9] reported no re-operation for coronary ostial pseudoaneurysm. However, the incidence of this complication with the button technique in other series varies from 3.1% to 9% [1,4,10]. Miller and Mitchell [11] describe the use of a ‘life saver’ or doughnut of Teflon felt or autologus pericardium (tanned in 0.625% glutaraldehyde solution for 10 to 15 min) placed around the coronary ostium on the adventitious aspect to prevent tearing of tissues. We did not use any reinforcement of the coronary ostial suture lines in any of the patients. It must be said that both patients with pseudoaneurysms at the coronary ostial suture line had Marfan syndrome, which is well known to be associated with severe medial cystic necrosis of the ascending aorta (grade 4). In concurrence with other experiences [4,5], our study suggests that suture line reinforcement in patients with connective disorders must probably be taken into consideration.

The GFR glue was used in case of acute aortic dissection (2 patients) to obliterate the false lumen and reinforce the aortic layers. The use of tissue glue in the treatment of this pathology has been reported to reduce significantly the mortality [12]. Nevertheless, recent reports [13,14] have documented the necrosis of the arterial wall after application of glue and this is supposed to be one of the causes of subsequent formation of pseudoaneurysms. Considering that we still do not have a perfect glue, we think we may pay the small price of occasional pseudoaneurysm formation for the greater benefit of improving survival in acute type A dissection.

In conclusion we assume that composite graft aortic root replacement is the treatment of choice in many pathologic conditions affecting the aortic root and the aortic valve. In our recent series (mean follow-up time is 29.2 months), the Bentall-De Bono operation provided good results with low incidence of prosthetic related complications. Given that longer follow-up is needed to draw definitive conclusions, we thus believe that aggressive use of the Bentall-De Bono operation is appropriate if aortic valve surgery is necessary in patients with even moderate ascending aorta dilatation.

References


