

# BENTALL OPERATION - A CLASICAL AORTIC ROOT RECONSTRUCTION WITH PROVED RESULT OVER YEARS

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## REZUMAT

**Introducere:** Operația Bentall este considerată tratamentul standard al anevrismului aortei ascendente, fiind caracterizată de mortalitate redusă și rezultate bune. Tehnici originale i-au fost aduse modificări referitoare la reimplantarea arterelor coronare. Scopul studiului a fost să se determine mortalitatea, morbiditatea și rezultatele pe termen lung ale protezării rădăcinii aortei și aortei ascendente și de a evalua riscurile asociate acestei proceduri

**Materiale și metodă:** Între 1986 și 2002, la Clinica de Chirurgie Cardiacă din Innsbruck s-a practicat protezarea aortei ascendente și/sau a arcului aortei la 67 de pacienți. Dintre aceștia, 57 erau bărbați, iar 30 (44,8%) au fost supuși unei operații în urgență. Douăzeci și opt (41,8%) au fost internați cu disecție acută tip A, 2 cu disecție cronică, 28 (41,8%) cu anevrism de aortă ascendentă combinat cu regurgitare aortică, iar 7 (10,5%) aveau o extensie a anevrismului către arcul aortic. Toate operațiile au fost realizate folosind metoda butanului coronarian. Stopul circulator în hipotermie profundă (SCHP) a fost necesar la 36 pacienți (53,7%).

**Rezultate:** Mortalitatea intraspitalicească a fost de 9 din 67 pacienți (13,4%). Factorii asociați cu mortalitatea imediată au fost: disecția de aortă, timpul de clampare a arcului aortic, timpul de bypass cardiopulmonar, SCHP, sindromul de debit cardiac scăzut postoperator, insuficiență renală postoperatorie necesitând hemofiltrare și insuficiență multiplă de organ. Supraviețuirea excluzând decesele intraspitalicești a fost de 96% la 1 an, 90% la 3 ani, 90% la 5 ani și 85% la 7 ani.

**Concluzii:** Protezarea rădăcinii aortei și aortei ascendente cu greafă mecanică compozită este o operație cu mortalitate redusă, mai ales în cazurile electivă, fără disecție. Supraviețuirea pe termen lung este bună, majoritatea pacienților prezentând o evoluție fără complicații.

**Cuvinte cheie:** operația Bentall, anevrism aortic, reconstrucție

## ABSTRACT

**Background:** The Bentall operation is considered the standard in the surgical treatment for aortic root aneurysm, with low mortality and very good long results. Technical modifications have been added to the original description, regarding the coronary arteries reimplantation. Our purpose was to determine the mortality, morbidity and long time events after composite graft replacement of the aortic root and to evaluate the risk factors associated with this procedure.

**Material and Method:** Between 1986 and 2002, at the University Cardiac Surgery Innsbruck, 67 patients underwent aortic root and/or the aortic arch replacement. From 67 patients, 57 were males and 30 patients (44.8%) underwent emergency procedures. Twenty eight patients (41.8%) presented with acute aortic dissection type A, 2 patients had chronic aortic dissection, 28 patients (41.8%) had an ascending aortic aneurysm combined with aortic regurgitation, and 7 (10.5%) had an extension of the aneurysm into the aortic arch. All operations were performed using the coronary-button-method. Deep hypothermic circulatory arrest (DHCA) was necessary in 36 patients (53.7%).

**Results:** Overall hospital mortality was 9/67 patients (13.4%). The factors associated with early mortality: aortic dissection, CPB time, aortic cross clamp time, DHCA, postoperative low cardiac output syndrome, postoperative renal failure requiring hemofiltration, multiorgan failure. Survival excluding hospital deaths was 96% at 1 year, 90% at 3 years, 90% at 5 years and 85% at 7 years.

**Conclusion:** Aortic root and ascending aorta replacement using a mechanically valved composite graft is an operation with low hospital mortality especially in elective, non-dissecting cases. The long-term survival rates are good and the majority of patients are event-free after the operation.

**Key Words:** Bentall operation, aortic aneurism, reconstruction

## INTRODUCTION

Ascending aortic aneurysms, associated with severe aortic valve pathology or aortic dissection involving the aortic valve, require replacement of both the ascending aorta and the aortic valve. Over the years,

modified Bentall operation remained the most commonly applied procedure for achievement of this surgical goal with very low mortality/morbidity and proved long-term results.

The Bentall-DeBono operation was considered the golden standard in the surgical treatment for a variety of aortic root pathologies, since the original description in 1968, over years.<sup>1</sup> This operation consists in replacement of aortic valve and ascending aorta, with reimplantation of the coronary arteries using a composite graft, association of a mechanical valve and a tube graft. It is easily reproducible in almost any cardiac surgical service, with low mortality and very good long results. However, from the original

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description, technical modifications regarding the coronaries arteries reimplantation have broadened the surgical strategies for aortic root substitute with composite graft, aortic allograft, porcine root or pulmonary autograft.<sup>18</sup>

The purpose of the study was to determine mortality, morbidity and long time events after composite graft replacement of the aortic root and to evaluate factors associated with this procedure.

## **MATERIAL AND METHODS**

At University Cardiac Surgery Innsbruck, between 1986 - 2002, 67 patients underwent aortic root replacement and replacement of the ascending aorta and/or the aortic arch with a mechanically valved composite graft using the modified “button” Bentall-DeBono surgical technique. From 67 patients, 57 were male and the median age was 50 (15-74 years). Thirty patients (44.8%) underwent emergency procedures. Twentyeight patients (41.8%) presented acute aortic dissection type A, 2 patients had chronic aortic dissection. Twentyeight patients (41.8%) had an ascending aortic aneurysm combined with aortic regurgitation, 7 (10.5%) had an extension of the aneurysm into the aortic arch. There were 9 patients with Marfan’s syndrome (13.4%). A bicuspid valve was found in 12/67 patients (17.9%), 5 patients (7.5%) had undergone previous cardiac or ascending aortic surgery. Associated surgical procedures were CABG in 3 cases and mitral valve replacement in 1 patient.

### **Surgical Technique:**

All the patients were operated by median sternotomy approach. Cardiopulmonary bypass (CPB) was established by arterial cannulation at the following sites: femoral artery (41 patients - 61,2%), ascending aorta (19 patients - 28,4%) and axillary artery place (7 patients - 10,4%) and single double-stage venous cannula in right atrium. Right axillary artery approach was our choice on the last two years in special in aortic dissection type A (Fig. 1).<sup>5</sup>



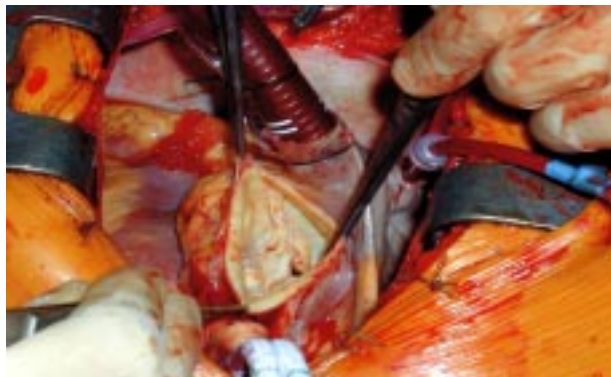
**Figure1.** Right axillary artery cannulation in case of ascending aortic aneurysm extended on aortic arch

The myocardium was protected by moderate hypothermia with antegrade and retrograde cardioplegia as well as local application of ice. In case of the aortic arch repair deep hypothermic circulatory arrest (DHCA) at 18°C nasopharyngeal temperature was used associated with retrograde cerebral perfusion via superior cava vena for brain protection.

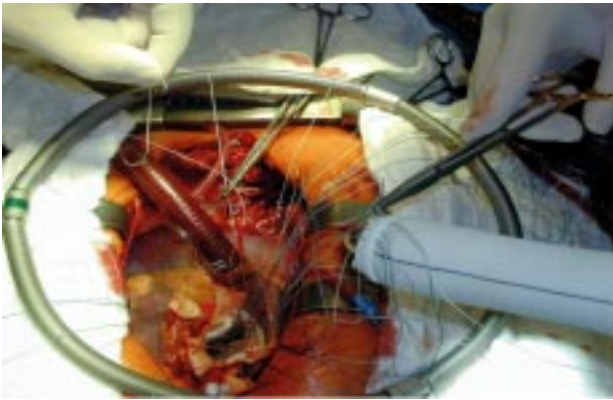
After clamping of the ascending aorta, the aneurysm was opened and the aortic valve inspected for a final decision regarding the replacement or repair. In very severe pathology of aortic valve like calcification (Fig. 2A) or congenital disease (bicuspid aortic valve) (Fig. 2B) replacement was preferred to repair.

The conduit was first sewn into the annulus with interrupted 2/0 Ethibond pledged sutures (Fig. 3). Then the left and right coronary buttons were implanted end to side into the composite graft using a 5/0 Prolene running suture. Selectively albumine-glutaraldehyde glue (Bioglue) was applied onto the anastomoses. The conduit was tailored and sewn to the distal portion of the transected aorta using a 4/0 Prolene running suture reinforced by a strip of Teflon felt placed outside of the aorta. The anastomosis was sealed with Bioglue.

In operations requiring DHCA the distal anastomosis was performed first using an adequate aortic prosthesis. The prosthesis was cannulated via a sidearm and clamped to reinstall CPB. After proximal implantation of the composite graft and coronary reimplantation (as described above) the two prostheses were connected using a 4/0 Prolene running suture.



**Figure 2.** Very severe aortic valve stenosis and calcification associate with ascending aortic aneurysm (A) and bicuspid aortic valve combine with AAA and high risk of aortic dissection (B)



**Figure 3.** Composite graft implantation in Bentall-DeBono technique

**Definitions of outcome parameters:**

Postoperative low cardiac output syndrome (LCOS) was defined as a cardiac index lower than 2.0 l/min/m<sup>2</sup> and the need for inotropes. Tracheostomy was indicated if weaning from ventilation was impossible until the fifth postoperative day. Multi-organ failure (MOF) was defined as severe dysfunction of two or more organ systems. Neurologic complications were diagnosed clinically and confirmed by cerebral computed tomography.

**Follow up:**

All patients were followed-up by our outpatients' department. Clinical exams, CT scans and TTE or TEE were performed. Monitoring of oral anticoagulation was performed by family physicians or by the patients' internist. When necessary, patients or their physicians were interviewed by telephone to get actualized information. Mean follow up of 58 hospital survivors was 53 months (1-196).

**Statistical analysis:**

The SPSS software (SPSS 10.0) for Windows was used for statistical analysis. Categorical variables are given as percentages; continuous variables are presented as median and range. In univariate analysis qualitative variables were analyzed using chi-square tests. For survival rates Lifetable was used. Factors associated with survival rates were calculated using Kaplan-Meier curves and the Log Rank test. Results were considered statistically significant at p values of less than 0.05.

**RESULTS**

All operations were performed using the coronary-button-method. Björk-Shiley composite grafts were used in 8 patients (11.9%), Carbomedics conduits in 12 (17.9%) and St. Jude Medical conduits in 47 (70.2%). CPB time was 226 (106-671) minutes, aortic cross clamp time 135 (74-321) minutes. DHCA was necessary in 36 patients (53.7%) with durations ranging from 11-

67 (median 30) minutes. Arterial cannulation was performed at the following sites: femoral artery n = 41 (61.2%), aorta n = 19 (28.4%), axillary artery n = 7 (10.4%).

The postoperative complications are shown in Table 1. Low cardiac output syndrome occurred in 15/67 patients (22.4%). Revision due to bleeding was necessary in 12/67 patients (17.9%). 3/12 bleedings were localized at the coronary buttons, 3/12 localized to the distal anastomosis, 1/12 to the prosthesis-prosthesis anastomosis. In the other cases bleeding was of diffuse nature. Renal failure requiring hemofiltration occurred in 8 patients (11.9%), sepsis occurred in 4/67 patients (6%), multi organ failure was present in 10/67 patients (14.9%) and tracheostomy was necessary in 5/67 patients (7.5%). A new postoperative stroke was found in 1 patient (1.5%). In 2 patients (3.0%) third degree heart block, requiring pacemaker implantation, occurred. As shown in Table 1 the complication rate was higher in case of aortic dissection.

**Table 1.** Postoperative complications of patients after modified Bentall operations with mechanically valved composite graft.

Complication	No. of patients	Rate of aortic dissections
Low cardiac output syndrome	15/67 (22.4%)	12/15 (80%)
Revision due to bleeding	12/67 (17.9%)	6/12 (50%)
Renal failure requiring hemofiltration	8/67 (11.9%)	6/8 (75%)
Sepsis	4/67 (6%)	4/4 (100%)
Multi organ failure	10/67 (14.9%)	7/10 (70%)
Respiratory failure requiring tracheostomy	5/67 (7.5%)	5/5 (100%)
New postoperative stroke	1/67 (1.5%)	1/1 (100%)
Hospital death	9/67 (13.4%)	6/9 (66.6%)

Postoperative length of stay in the intensive care unit was 2 (1-72) days, median postoperative stay in our department of cardiac surgery was 13 (7-40) days. Overall hospital mortality was 9/67 patients (13.4%). 28/67 patients had an acute aortic dissection type A, and the hospital mortality in this group was 6/28 (21.4%).

Univariate analysis revealed the following factors were significantly associated with early mortality: aortic dissection (hospital mortality was 27.6% if aortic dissection was present vs. 2.7% if aortic dissection was not present (p=0.003), CPB time (hospital mortality was 30.8% if CPB time was more than 4hours vs. 2.6% if CPB time was less than 4 hours; p=0.01), aortic cross clamp time (hospital mortality was 37.5% if aortic clamp time was > 150 minutes vs. 7.1% if aortic clamp time was < 150 minutes; p=0.02), DHCA (hospital mortality was 23.7% if operation was performed under DHCA vs. 0% if operation was performed without DHCA; p=0.006), postoperative low cardiac

output syndrome (hospital mortality was 33.3% if LCOS was present vs. 2.2% if LCOS was not present;  $p=0.01$ ), postoperative renal failure requiring hemofiltration (hospital mortality was 50 % if postoperative renal failure requiring hemofiltration was present vs. 4 % if renal failure requiring hemofiltration was not present;  $p=0.002$ ), multi organ failure (hospital mortality was 50% if MOF was present vs. 2% if MOF was not present;  $p<0.001$ ).

The following factors showed no significant association with hospital mortality: sex, age, previous cardiac surgery, bicuspid aortic valve, Marfan's syndrome, emergency operation, concurrent CABG, postoperative revision due to bleeding, postoperative sepsis, prolonged tracheostomy.

Overall survival including hospital deaths was 85% at one year, 78% at 3 years, 75% at 5 years, and 71% at 7 years. Survival excluding hospital deaths was 96% at one year, 90% at 3 years, 90% at 5 years, and 85% at 7 years. None of the factors investigated for prediction of hospital mortality showed an influence on long-term survival.

Pseudo-aneurysm at the CG occurred in 2/67 patients (3.0%). In 1 patient the leak was at the coronary button, in the other one it was at the proximal anastomosis of the CG. Both patients were successfully treated by re-intervention and surgical closure of the leak. One patient (1.5%) acquired infection of the prosthesis which had to be treated with replacement of the conduit. Three patients were re-operated on the descending aorta for aneurysm progression after deBakey Type I aortic dissection. Thrombosis of the mechanical valve did not occur in any of the patients. No patient experienced bleedings and/or thromboembolic events related to anticoagulation.

## DISCUSSIONS

In 1968, Bentall and de Bono described a replacement technique for the aortic root using mechanical aortic valves and ascending aortic vascular prosthesis constructed as so called conduits. In this original technique the coronary ostium was sewn into holes in the conduit and the prosthesis was covered with the remaining aortic wall. In the following years a modified technique has been increasingly used. The coronary ostium was excised from the aortic wall and reimplanted into the conduit as so called "buttons".<sup>9-11</sup> In our department we have started using the modified Bentall procedure in 1986.

### Hospital mortality:

Our hospital mortality was 13.4% which is fitting into results of other institutions especially in the light

of our relatively high rate of acute aortic dissections type A. Predictors for hospital mortality were evaluated using univariate methods because for multivariate analysis the patient number was too small. Interestingly age was not significantly associated with hospital mortality. Prifti et al. and Niederhäuser et al. However, found age significantly associated with hospital mortality. Other authors did not find any significance either.<sup>1,4</sup>

Aortic dissection was significantly related to hospital mortality in our study. Mehta et al. recently described a hospital mortality of 32.5% in a multicenter study with 547 patients sustaining acute aortic dissection type A and undergoing various operations.<sup>12</sup> The mortality for Bentall procedures in acute aortic dissection type A was remarkably lower in our hospital. We had a proportion of 41.8% acute aortic dissections type A in our study and two thirds of hospital deaths occurred in this group. Two patients with chronic aortic dissection type A died in hospital. Acute dissection was not significantly associated with early death, but aortic dissection type A (including chronic dissections) was significantly related to hospital death. This is also the explanation for emergency operation not to be significantly related to hospital mortality. So, in our experience chronic type A dissections seem to represent a risk in Bentall operations but our number of patients in this group was too small to prove this fact.

In our patient cohort previous cardiac surgery was not significantly associated with hospital mortality which is consistent with the findings of Svensson et al.<sup>1</sup> However Prifti et al. found significant association in this factor.<sup>2</sup>

Increased CPB time and aortic clamp time are associated factors for early mortality in our series which confirms other authors' findings.<sup>1,4,6</sup> According to our data DHCA was highly significant associated with early mortality as well, a fact which was not described previously.

Out of the postoperative complications we found low cardiac output syndrome, and renal failure requiring hemofiltration, significantly associated with hospital mortality. This is in accordance with findings published by Svensson et al.<sup>1</sup>

Marfan syndrome was not related to hospital mortality in our study. Gott et al. found non-Marfan status as a predictor for early and late death.<sup>13</sup> This is probably due to the much lower age of Marfan patients and the absence of comorbidity such as coronary artery disease at the time of operation.

### Long-term survival and long-term events:

The long term survival rate of our patients lies within the rates given in literature. After 5 years  $\frac{3}{4}$  of the patients are alive (including hospital deaths). By

comparison Svensson et al. report a 5-year-survival rate of 71%, Lewis et al. report a 5-year-survival rate of 76%.

We found that none of our tested pre-, intra-, and postoperative variables are associated with long-time-survival. In contrast Lewis et al. and Prifti et al. found aortic dissection as a predictor for reduced long-time survival.<sup>2,4</sup> In our series the majority of patients underwent close follow up in a special thoracic aortic clinic, and patients with chronic aortic dissection underwent successful reoperations if progression of the disease was noted. This may have prevented some deaths during the long-term postoperative course. From our experience we can state that all hospital survivors have a good long-term-prognosis with survival rates of 90% after 5 years.

A lower rate of pseudoaneurysms using the "button" Bentall technique is reported versus the classical Bentall technique.<sup>5,10,11</sup> With the "button" technique the rate of late reinterventions due to pseudoaneurysm formation is reported in the literature with a frequency of 2.1%,<sup>4</sup> 3.5%<sup>1</sup> and 11.7%.<sup>8</sup> Confirming these results two of our patients developed a pseudoaneurysm and were submitted to reinterventions without major problems. Reinterventions due to aortic valve thrombosis are described in literature in the range between 0.8%<sup>4</sup> and 3.4%.<sup>8</sup> So far there were no aortic valve thromboses in our series. Late thromboembolic neurologic complications are reported in literature with frequencies of 2.5%<sup>4</sup> 3.4%<sup>8</sup> and 4.4%.<sup>1</sup> We found no bleeding or thromboembolic events related to anticoagulation in our follow up. We regard these satisfying results mainly as an expression of proper anticoagulation management in our referral area. In addition composite graft replacement of the aortic root has also been described, by others, to exhibit a very low rate of long-term thromboembolic and bleeding events.<sup>14</sup>

## **CONCLUSION**

We can conclude that aortic root replacement and replacement of the ascending aorta / aortic arch using a mechanically valved composite graft and the modified

Bentall technique is an operation with acceptable hospital mortality especially in elective, non-dissecting cases. The long-term survival rates are good and the majority of patients are event-free after the operation.

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