Bentall procedure using cryopreserved valved aortic homografts: mid-to long-term results

CHRISTENSON, Jan, et al.

Abstract

The Bentall procedure is the standard operation for patients who have lesions of the ascending aorta associated with aortic valve disease. In many cases, however, mechanical prosthetic conduits are not suitable. There are few reports in the English-language medical literature concerning the mid- to long-term outcome of Bentall operations with cryopreserved homografts. Therefore, we reviewed our experience with this procedure and valved homografts. From January 1997 through December 2002, 21 patients underwent a Bentall operation with cryopreserved homografts at our institution. There were 14 males and 7 females; the mean age was 36 +/- 21 years (range, 15-74 years). Eleven patients had undergone previous aortic valve surgery. All patients had aortic dilatation or aneurysms involving the ascending aorta. Indications for surgery included aortic valve stenosis or insufficiency, and aortic valve endocarditis (native valve or prosthetic). One patient had Takayasu's arteritis and 3 had Marfan syndrome. There was 1 hospital death (due to sepsis), but no other major postoperative complications. The mean hospital stay was 14 +/- 7 [...]
Clinical Investigation

Bentall Procedure Using Cryopreserved Valved Aortic Homografts
Mid- to Long-Term Results

The Bentall procedure is the standard operation for patients who have lesions of the ascending aorta associated with aortic valve disease. In many cases, however, mechanical prosthetic conduits are not suitable. There are few reports in the English-language medical literature concerning the mid- to long-term outcome of Bentall operations with cryopreserved homografts. Therefore, we reviewed our experience with this procedure and valved homografts.

From January 1997 through December 2002, 21 patients underwent a Bentall operation with cryopreserved homografts at our institution. There were 14 males and 7 females; the mean age was 36 ± 21 years (range, 15–74 years). Eleven patients had undergone previous aortic valve surgery. All patients had aortic dilatation or aneurysms involving the ascending aorta. Indications for surgery included aortic valve stenosis or insufficiency, and aortic valve endocarditis (native valve or prosthetic). One patient had Takayasu’s arteritis and 3 had Marfan syndrome.

There was 1 hospital death (due to sepsis), but no other major postoperative complications. The mean hospital stay was 14 ± 7 days. Follow-up echocardiographic and computed tomographic scans were performed yearly. The mean follow-up was 34 months (6–72 months). Follow-up imaging revealed no calcifications or degenerative processes related to the homograft. Four patients had minimal valve regurgitation. Two patients died during follow-up. The 3-year actuarial survival rate was 85.7%.

Our data suggest that the Bentall procedure with a valved homograft conduit is a safe procedure with excellent mid- to long-term results, comparable to results reported with aortic valve replacement with a homograft. (Tex Heart Inst J 2004;31:387-91)

Aortic valve replacement with homografts has shown excellent long-term results, with flow profiles better than those reported with other biological or mechanical valve prostheses.1-5 The advantages of homografts are several: they have excellent physiologic flow profiles, a low incidence of thromboembolic complications without need for long-term anticoagulation therapy, and a very low incidence of endocarditis.1,2,6,7 The use of homografts for treatment of various clinical conditions (for example, Marfan syndrome) and for native and prosthetic valvular endocarditis, in both adults and children, has been reported.8-10

Lesions of the ascending aorta associated with aortic heart valve disease are usually treated by implantation of a mechanical valved conduit (Bentall procedure). Use of the Bentall procedure and valved homografts for aortic root replacement including the ascending aorta has been reported by several authors.1,7,11,12 However, only a few reports are available in the English-language medical literature on mid- to long-term outcome of Bentall operations using cryopreserved homografts.6,13,14 Therefore, we retrospectively reviewed our experience with the Bentall procedure combined with the use of valved cryopreserved homografts.

Patients and Methods

Patient Characteristics

From January 1997 through December 2002, 21 patients (14 males and 7 females; mean age, 36 ± 21 years; range, 15–74 years) underwent the Bentall operation with a valved cryopreserved homograft at our institution. There were 7 children (33%), aged 15 years or younger, and 14 adults. Aortic valve disease with an additional area of dilatation or aneurysm of the ascending aorta was present in all cases,
according to angiographic findings. Indications for the Bentall procedure are listed in Table I. Eleven patients (52%) had undergone previous aortic valve surgery: 7 of these operations were aortic valve replacements (3 biological and 4 mechanical valves), 3 were aortic valve repairs, and 1 was balloon dilation for aortic valve stenosis in a child. The underlying diseases are listed in Table II. One or more concomitant diseases were present in 15 patients (71%) at the time of surgery: arterial hypertension in 8 patients, pulmonary artery hypertension in 3, insulin-dependent diabetes in 2, renal insufficiency in 2, previous cerebrovascular accident (septic emboli) in 2, symptomatic coronary artery disease in 1, previous liver transplantation in 1, and septic shock at presentation in 1. The mean preoperative left ventricular ejection fraction was 0.44 ± 0.11 (range, 0.25–0.60). Five patients (24%) underwent additional surgery at the same time as the Bentall operation: mitral valve repair (2), myocardial revascularization (1), hemi-arch replacement (1), and a Konno procedure (1).

**Surgical Technique**

After systemic heparinization, femoral and venous cannulas were used in all patients. Median sternotomy was performed, and moderate hypothermic cardiopulmonary bypass (28–30 °C) was begun. After aortic cross-clamping and longitudinal aortotomy, myocardial protection was achieved with antegrade blood cardioplegia, which was repeated every 30 minutes. In patients undergoing reoperation, the previously implanted aortic valve was removed, and the aortic valve annulus and the adjacent part of the ascending aorta were carefully debrided. The native aortic leaflets were excised, and both coronary ostia were detached from the aortic root.

Cryopreserved aortic homografts were obtained from 2 sources: the European Homograft Bank (Military Hospital; Brussels, Belgium) and CryoLife, Inc. (Marietta, Ga). An appropriately sized homograft conduit was selected for each patient. The mean homograft size was 21 ± 2 mm (range, 18–26 mm). Thirteen patients (62%) received homografts that were blood-group compatible. All children in this series received blood-group compatible homografts.

The homograft was sutured proximal to the aortic annulus with a standard continuous suture. There was no 2nd suture line, and no additional materials such as pericardial or Dacron strips were used to buttress the suture line. After resection of the coronary ostia of the homograft, two 7- to 10-mm openings were created, and the 2 native coronary arteries were implanted into the homograft. A distal anastomosis was then performed, end-to-end between the homograft and the ascending aorta, proximal to the origin of the brachiocephalic artery. The native aortic wall was wrapped around the homograft. Surgical biological fibrin glue (Tissucol Duo S™, Baxter AG; Vienna, Austria) was used in all patients; the glue did not contain formaldehyde or glutaraldehyde. Upon completion of the procedure, intraoperative transesophageal echocardiography was performed to evaluate homograft function.

**Follow-Up.** Transthoracic echocardiography was performed in all patients before discharge to evaluate the position and function of the implanted homograft. All surviving patients underwent computed tomographic (CT) scanning, transthoracic echocardiography, or both, 6 months after the Bentall procedure and once every year thereafter.

**Statistics.** Actuarial survival and freedom from reoperation rates were calculated by the Kaplan-Meier actuarial method using a 70% confidence limit. Parametric data were analyzed with the Student’s unpaired 2-tailed t-test. Data are expressed as mean ± standard deviation. A P value less than 0.05 was considered statistically significant.

**Results**

Relevant surgical data are as follows: the mean aortic cross-clamping time was 95 ± 37 minutes (range, 388 Bentall with Valved Homograft
There was a significant difference in aortic cross-clamping time ($P < 0.001$) between patients undergoing reoperation (113 ± 34 minutes; range, 76–195 minutes) and those undergoing primary operations (74 ± 30 minutes; range, 39–150 minutes).

One patient (4.8%) died in the hospital: a 74-year-old woman with arterial hypertension and insulin-dependent diabetes who underwent a Bentall procedure combined with mitral valve repair due to bacterial endocarditis. She died of sepsis and multiple-organ failure on the 2nd postoperative day. With the exception of sepsis, postoperative complications were few and easily managed. One patient had postoperative bleeding from the femoral cannulation site but required only a direct arterial suture; another patient required drainage after developing a retroperitoneal hematoma due to bleeding from the cannulation site. One patient developed deep venous thrombosis on the same side as the femoral cannulation site, and 1 patient required implantation of a permanent pacemaker for complete atrioventricular block.

Transcatheter echocardiography before discharge from the hospital revealed an overall mean gradient of 8 ± 6 mmHg over the aortic homograft valve; 6 patients (29%) had minimal valve regurgitation. The mean stay in the intensive care unit for hospital survivors was 3 ± 2 days (range, 1–12 days), and the mean total hospital stay was 14 ± 7 days (range, 8–30 days).

During follow-up, 2 patients died. One was a 51-year-old woman who had undergone surgery because of mechanical aortic valve endocarditis. She was in septic shock before the operation and had a left ventricular ejection fraction of 0.25. The patient recovered from the sepsis but was readmitted 4 months later due to cardiac failure and died. Her relatives refused autopsy. The 2nd patient was a 50-year-old man who had also undergone the Bentall operation because of prosthetic valve endocarditis. He was discharged in excellent clinical condition on the 15th postoperative day; however, he died 2.5 months later (reason unknown).

We observed no late complication related to valved homograft implantation. One patient with Marfan syndrome underwent successful replacement of the descending thoracic aorta 1 year postoperatively.

Follow-up was complete for the 18 surviving patients until June 2003, with an average follow-up of 34 months (range, 6–72 months). Computed tomographic scans and transthoracic echocardiographic examinations during follow-up revealed no calcifications or degenerative processes related to the homograft. There were no signs of annular or homograft tube dilatation. Figure 1 shows transthoracic echocardiograms in a patient before and after the Bentall op-

---

**Fig. 1** A) Preoperative transthoracic echocardiography of a 28-year-old man (parasternal long-axis view). Note the severely dilated aortic root (filled arrow) and doming of the anterior aortic valve leaflet (dotted arrow), suggesting a bicuspid valve, which was confirmed at surgery. Postoperative transthoracic echocardiography in the same patient illustrates the normal aortic valve and aortic root homograft after the Bentall procedure: B) parasternal long-axis view and C) parasternal short-axis view.
Fig. 2 A computed tomographic scan 5 years after a Bentall procedure with a cryopreserved aortic homograft reveals no graft dilatation or degenerative changes.

operation with a homograft. Figure 2 shows a CT scan in another patient 5 years after the procedure. 

At last follow-up, the mean gradient over the valve was 6 ± 2 mmHg (range, 2–35 mmHg). Only 2 patients had a valvular gradient greater than 20 mmHg. Nine patients (9/18, 50%) had no pathologic valvular gradient. Four patients (22%) had minimal valvular regurgitation, and the remaining 14 patients had no measurable regurgitation. None of the patients were given postoperative anticoagulation therapy, and no thromboembolic events were reported. The actuarial survival was 85.7% at 3 years (70% CL 78.0%–93.4%, 11 patients at risk).

Discussion

The Bentall operation has become a standard procedure for treating lesions of the ascending aorta with associated aortic valve disease. Typically, mechanical valved conduits have been used for this surgery, but they require anticoagulation therapy and carry an increased risk of infective endocarditis. The use of cryopreserved homografts as an alternative with the Bentall operation is still controversial. Although some groups have reported good results, others have expressed doubts about the suitability of homografts. The main concern has been the possibility of postoperative failure of the homograft due to progressive anular dilatation; however, clinical reports have shown no such dilatation with the use of homografts.

In our series, we observed no deterioration of valvular function up to the maximum follow-up of 72 months. The clinical results and durability of aortic homografts depend on several factors, including quality of the homograft, valve sizing, and implantation techniques. Results of a study by Yankah and associates emphasized the importance of using oversized homografts; oversizing showed a 92% freedom from homograft explantation at 15 years, compared with only 48% if the homograft was undersized. In our series, oversized homografts were routinely used. As a consequence, no paravalvular leaks, only minimal central regurgitation, and no instances of pseudoaneurysm formation or cusp rupture were observed.

In contrast to a method reported earlier by Chouthary and colleagues, we excised the coronary ostia from the homograft and created 7- to 10-mm openings to which the native coronary arteries were anastomosed; in this way, our homograft provided more secure implantation of the arteries. In addition, the homograft aortic valve is resistant to infection. This resistance was confirmed by our series, in which no homograft conduit infection occurred during follow-up. Other postoperative benefits of the use of homografts include normal hemodynamic function and no anticoagulation requirement.

Our data suggest that the Bentall operation with a valved homograft conduit is a safe procedure with excellent mid- to long-term results, comparable to those reported for aortic valve homograft replacement. Reinforcement of the proximal anastomosis and routine use of surgical glue might have contributed to the absence of late annular dilatation in our series. Longer follow-up is required to determine whether later degenerative processes in the homograft itself will lead to a need for homograft explantation.

References

2. Prager RL, Fischer CR, Kong B, Byrne JP, Jones DJ, Hance ML, Gago O. The aortic homograft: evolution of indica-


