

A Versatile Technique for Aortic Root Replacement Without Pre-Manufactured Composite Graft: A 12-year experience

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Background and aim of the study: Replacement of the aortic root is the treatment of choice for aneurysmal dilatation. Many modifications of the Bentall technique have been described, as have valve-sparing procedures. The study aim was to determine the outcome of a versatile modification of composite replacement that has been adopted over the past 12 years. Separate graft and prosthetic valve components were used to allow freedom of valve choice and the use of an appropriately sized graft for the distal aortic anastomosis.

Methods: Between January 1990 and March 2002, 59 patients (45 males, 14 females; mean age 56 ± 14 years) underwent aortic root replacement using this technique. Indications for surgery were elective in 35 patients and emergent (usually type A aortic dissection) in 24. The range of valve prostheses used, their size, and the size of aortic graft used in each case was assessed. Durations of ischemia and cardiopulmonary bypass were recorded, as was postoperative

blood loss and subsequent patient progress, including valve-related events, perioperative mortality and actuarial survival.

Results: A wide range of aortic graft sizes was combined with both mechanical and tissue valves (from 1-7 mm larger in diameter). Median postoperative blood loss was 550 ml (IQR 400-800 ml). Perioperative mortality was 5.1%. There were no valve- or technique-related deaths, and the median actuarial survival was 13.17 years. During a 12-year follow up there were no proximal aortic reoperations.

Conclusions: This technique had favorable perioperative mortality, produced a secure proximal suture line, and allowed the surgeon free choice of both valve type and size of aortic graft. This minimized tension at the distal suture line, and produced good hemostasis, especially in those patients with fragile dissected tissues.

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Aortic root replacement remains the treatment of choice in aneurysmal disease of the aortic root with annular dilatation and aortic dissection with valve disruption. The original technique described by Bentall and De Bono (1) involved the placement of a valved conduit into the aortic root and closure of the native aorta around the graft - the 'inclusion' technique. This approach controlled blood loss, but led to the formation of false mediastinal aneurysms in a significant proportion of patients (2).

More recently, the development of pre-clotted Dacron tube grafts, tissues glues (3) and the widespread adoption of the open or exclusion technique (excision of all aneurysmal aortic tissue) have further

reduced perioperative bleeding (4). However, discrepancy between the aortic graft diameter and aorta size at the desired site for distal anastomosis causes mismatch when utilizing pre-sutured composite valve conduits, where the tube graft diameter is a fixed increment larger than the valve (typically 2 mm). This mismatch can lead to bleeding as a result of distortion at the distal anastomosis. The technique reported herein involves the selection of a separate tube graft and prosthetic valve, with sizes based solely on the distal aortic and annular diameters, respectively. This aortic root replacement technique produces excellent hemostasis and provides the flexibility to deal with the range of pathological processes leading to dilatation, as the annular and distal aortic enlargements are often disproportionate.

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Materials and methods

Data abstraction

A review of the present authors' prospective aortic surgery database was undertaken for all aortic root replacements performed at their institution between 1990 and 2002. Patients were identified from computerized records to enable the retrieval of hospital case notes, histopathology and necropsy reports. The only exclusion was of patients requiring aortic root replacement for acute excavating aortic root sepsis, as this group received a cryopreserved aortic homograft implanted using a different technique. Moreover, these patients required aortic root replacement for abscess formation rather than for true aneurysmal disease, hence their exclusion. The following parameters were identified and documented: age, sex, indication for surgery, urgency of operation, operating time, use of deep hypothermic circulatory arrest, size, make and model of valve used, size and make of corresponding aortic graft. The pathological diagnosis for all specimens were reported and documented for the study.

Emergency surgery was defined as surgery proceeding immediately following diagnosis. Total blood loss was defined as the amount of blood loss at the time of removal of the surgical drains. Perioperative mortality was defined as death occurring within 30 days of the procedure, or before hospital discharge, and was reported.

Surgical technique

The technique described was utilized consistently between 1990 and 2002 for aortic root replacement procedures performed by the present authors. The choice of either a mechanical or biological prosthesis for aortic valve replacement was surgeon-dependent, and correlated with patient age.

The operative technique for aortic root replacement involved the institution of hypothermic cardiopulmonary bypass (CPB) using central or femoral arterial cannulation (depending on pathology), and right cavoatrial two-stage drainage. Where necessary, deep hypothermic circulatory arrest (DHCA) was utilized and conducted at 20°C, without retrograde cerebral perfusion. Following cross-clamp application, antegrade cold St. Thomas' crystalloid cardioplegia was delivered into the coronary ostia, and cold saline was administered topically. The aortic valve leaflets were excised and all aneurysmal aortic tissue was excised, including the aortic sinuses, down to the level of the aortic annulus. The coronary arteries were mobilized with limited (~1 cm diameter) buttons of pericoronary aortic wall (Fig. 1).

At this stage, the aortic annulus was sized and a valve selected. The choice of prosthesis was made on

normal clinical grounds according to the preferences of the surgeon and patient. St. Jude Medical mechanical, Carpentier-Edwards porcine, Edwards Perimount and Björk-Shiley monostrut valves have all been incorporated into the repair, without difficulty.

All aortic grafts used were woven Dacron hemoshield (Meadox Medicals Inc., Oakland, NJ, USA), with the appropriate size chosen following inspection of the aortic diameter at the desired site of distal anastomosis. The choice of graft diameter was solely dependent on the caliber of the aorta at the distal anastomosis. The root replacement was constructed using 12 to 18 interrupted 2-0 braided horizontal mattress sutures placed initially through the aortic annulus using either an everting or non-everting technique, depending on annular diameter (no pledgets were used). These sutures were then passed through the valve sewing ring and finally the separate aortic graft (Fig. 2). After careful seating of the prosthetic valve and conduit, the sutures were ligated on the external aspect of the graft, thereby ensuring a smooth internal profile and a hemostatic suture line. Tissue glues were not used in any of the procedures. Next, a suitable site on the aortic graft for anastomosis with the left coronary button was chosen, to ensure no tension or distortion to the left coronary artery. An 8-10 mm circular

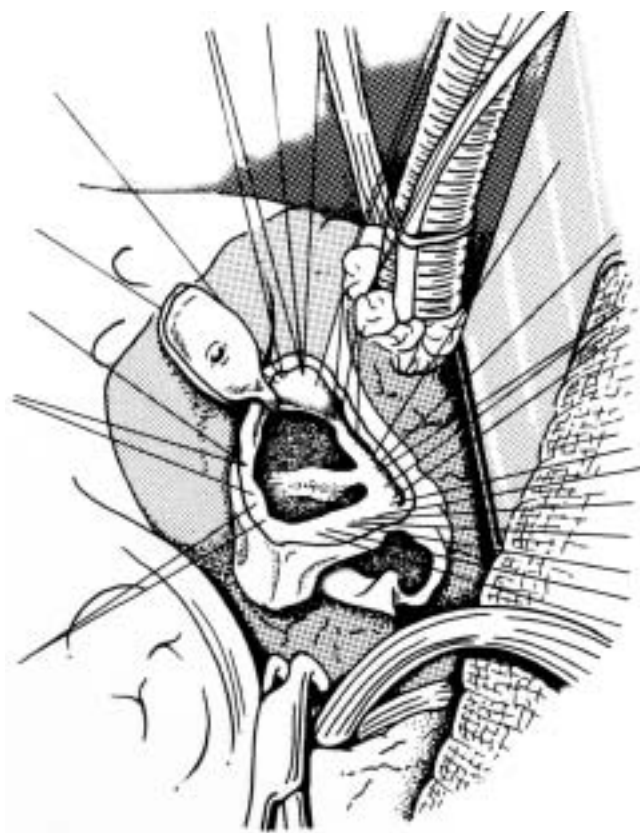


Figure 1: The exposed aortic root with all aneurysmal tissue and valve excised.

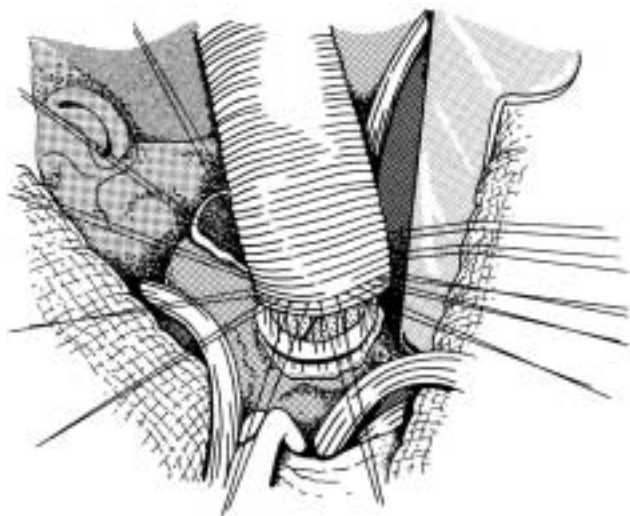


Figure 2: The technique of replacement with sutures passing through separate valve and graft components.

window was fashioned at this site using a hot wire loop, and the left coronary button was anastomosed to the aortic graft with a single continuous 5-0 polypropylene suture. The right coronary button was then anastomosed to the anterior aspect of the aortic graft in a similar manner. Finally, the distal aortic anastomosis was constructed either below the cross-clamp, or open using DHCA, depending on the extent of aneurysmal dilatation and aortic wall pathology.

Statistical analysis

The statistical analysis was conducted in accordance with previously published guidelines (5). Background data and procedural details were presented as mean \pm SD, or medians with interquartile ranges (IQR). Frequencies were expressed as percentage with 95% confidence limits (95% CL). Actuarial survival was calculated using the method of Kaplan-Meier. A statistical software package (S plus version 6.0, Insightful, Washington, USA) was used for the analysis.

Results

Between January 1990 and March 2002, 86 patients underwent aortic valve and root replacement at the authors' institution. A total of 27 patients was excluded due to the use of a homograft root for endocarditis; hence 59 patients (45 males, 14 females; mean age 56 ± 14 years) were included. Indications for surgery are listed in Table I. During this period, other proximal aortic operations included approximately 900 isolated aortic valve replacements (AVR), 70 AVR with supra-coronary tube graft replacement of the root and ascending aorta, and 200 isolated replacements of the

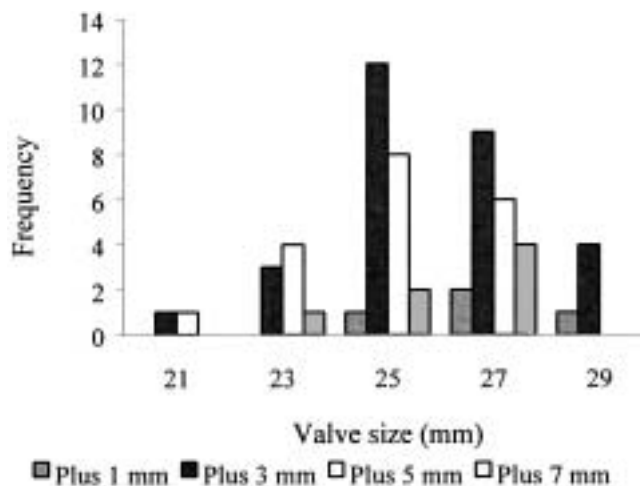


Figure 3: Frequency of aortic graft diameters used with each prosthetic valve size.

ascending aorta (mostly for acute dissections).

The urgency of operation was elective in 35 patients (59%) and emergent in 24 (41%). All of the spontaneous and the two postoperative, acute type A dissections were treated as emergencies. In addition, two patients with annuloaortic ectasia and one patient with Marfan's syndrome underwent emergency procedures due to fulminating left ventricular failure secondary to central aortic regurgitation.

The range of prostheses incorporated into this technique of aortic root replacement is shown in Table II. In essence, any mechanical or stented tissue valve would be applicable for incorporation in this root replacement strategy. The range of aortic graft diameters was 24 to 34 mm, and the range of valve prostheses 21 to 29 mm. All aortic grafts were at least 1 mm larger than the accompanying valve. The largest differential was 7 mm, showing the versatility of the technique. The aortic graft and valve sizes used, and

Table I: Pathological diagnoses in patients.

Pathological diagnosis	No. of patients
Annuloaortic ectasia	21 (36)
Acute type A dissection	19 (32)
Marfan's syndrome	7 (12)
Atherosclerotic aneurysm	5 (8)
Chronic dissection	2 (3)
Postoperative type A dissection	2 (3)
Post-stenotic dilatation	2 (3)
Aortitis	1 (2)

Values in parentheses are percentages.

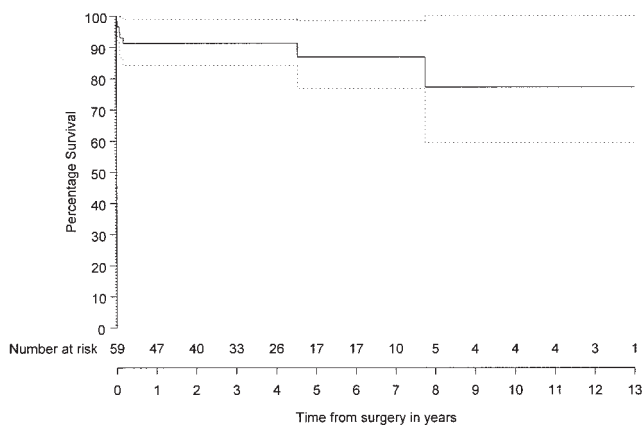


Figure 4: Kaplan-Meier survival (with confidence intervals).

specifically the range of grafts used with each valve size, is shown in Figure 3.

The median CPB and aortic cross-clamp times were 110 min (IQR 90-135 min) and 79 min (IQR 70-90 min), respectively. DHCA was used in 13 patients for construction of distal anastomoses to the proximal aortic arch, with a median arrest duration of 14 min (IQR 12-19 min).

Postoperatively, four patients required re-exploration for bleeding. Sternal bleeding was seen in two of these patients, whilst in the other two no bleeding point was found. Specifically, no blood loss was observed from the aortic root or distal anastomosis. The median mediastinal blood loss was 550 ml at the time of chest drain removal (IQR 400-800 ml). All patients survived the procedure and were returned to the intensive care area in a stable condition. The perioperative mortality for this series was 5.1%. There were no deaths among patients undergoing elective surgery (median EuroSCORE elective group 6 (IQR 5-8), emergency cases 8 (IQR 7-11)). The perioperative deaths were due to progressive multiorgan failure. A post-mortem examination was undertaken in the three patients who died. Their valves and root replacements were inspected and found to be unremarkable. Specifically, there was no evidence of thrombosis, valve dehiscence or periaortic hematoma. Perioperative morbidity among survivors included a need for temporary hemofiltration (n = 2) and pro-

longed ventilatory support due to pneumonia (n = 2). Minor sternal wound infection (n = 3) and major sternal infection requiring operative debridement (n = 1) were also encountered.

The median stay in the intensive care area was 21 h (IQR 19-37.5 h), and the median hospital stay was 8 days (IQR 7-11 days). The Kaplan-Meier survival for the series as a whole was excellent (Fig. 4). Actuarial freedom from prosthetic-related mortality was 100% at 10 years. At present, the authors are unaware of any proximal pseudoaneurysm formation in these patients; nor have there been any reoperations on the proximal aorta in this series.

Discussion

Despite the prevalent short- and long-term complications of separate valve and ascending aortic replacement, there was an initial reluctance among surgeons to accept Bentall's technique for complete replacement of the aortic root. The operation of aortic root replacement has now become widely accepted, and the advantages remain those outlined in Bentall's initial report (1). The patient with true Marfan's syndrome probably benefits most from this procedure as it avoids premature death from aortic rupture, dissection or heart failure due to aortic incompetence. Improved surgical results have followed the innovations in graft and suture materials, the use of aprotinin and tissue glues, and an ever-growing body of experience. However, the principal difficulties in the technique remain the need to ensure hemostasis and avoid coronary distortion. Various techniques have been described to overcome these problems (3,4,6-9). In addition, the valve manufacturers have produced composite valve conduits in an attempt to reduce the need for additional suture lines. Nonetheless, hemostasis may still be difficult to achieve as the composite valve conduit imposes constraint upon the surgeon in the choice of prosthesis, and the sizing of both valve and graft components. Moreover, avoiding using these products could produce economic savings, as the individual components may be cheaper, especially when issues of stock control and low-volume purchasing apply.

The present technique benefits from a single proximal suture line, which incorporates both valve and graft material. As the valve sutures must be hemostatic, it follows that the same sutures secure the graft hemostasis. As the postoperative blood loss in the present series indicated, this results in acceptable hemostasis, which in turn has a central role in the final mortality statistics. The technique is simple, and the median cross-clamp time of 79 min compared favorably with that of published series (10), especially given

Table II: Types of valve implanted.

Valve type	No. implanted
St. Jude Medical mechanical	43
Carpentier-Edwards porcine	12
Carpentier-Edwards Perimount	3
Björk-Shiley monostrut	1

the high percentage of emergency cases. In addition, a wide range of graft diameters has been utilized, ranging from 1 to 7 mm larger than the valve-sewing ring. This allowed the selection of a conduit for which the diameter matched the distal aortic diameter, thus avoiding size mismatch. Hence, tension at this distal suture line was reduced, and this may have contributed to improved hemostasis, especially in fragile dissected tissues. Clearly, this flexibility is not possible with commercially available composite valve conduits.

The present authors believe that this technique is applicable to both aortic root aneurysms, irrespective of any underlying pathology, and acute aortic dissections with aortic valve disruption. In their experience, there have been low rates of postoperative hemorrhage considering the patient population. Moreover, this approach affords the surgeon greater flexibility in the choice of valve prosthesis and graft size, allows normal clinical practice in selecting appropriate valve prostheses, may be cheaper, and is associated with an excellent long-term outcome.

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