Left ventricular outflow tract reconstruction and translocation of the aortic valve for annular erosion: Early and midterm outcomes

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Objective: Aortic annular erosion is a serious complication of aortic valve endocarditis or previous aortic valve replacement without endocarditis, and its surgical management is challenging. We present the early and midterm results of a technique for left ventricular outflow tract and aortic root reconstruction with a polyester tube graft and translocation of the aortic valve and coronary arteries.

Methods: A polyester tube graft is placed into the left ventricle and sutured to the left ventricular outflow tract below the area of erosion. The graft is then everted and sutured to a composite graft. Interposition polyester grafts from the coronary arteries are attached to the composite graft above the valve. This technique has been used in 12 cases. All but 1 patient had previously undergone aortic root or aortic valve replacement, and 4 had endocarditis of prosthetic (n = 2) or aortic allograft (n = 2) valves.

Results: There were no in-hospital deaths. There was 1 early death from pulmonary embolism at 1 postoperative month and 2 late deaths at 15 and 64 postoperative months, both resulting from heart failure. The remaining 9 patients are alive at 3 to 132 postoperative months. Actuarial 5-year survival is 75%.

Conclusions: Left ventricular outflow tract reconstruction with translocation of the aortic valve and coronary arteries for annular erosion is a useful technique that safely excludes the area of annular erosion and eliminates left ventricular outflow tract obstruction. The procedure can be safely performed with satisfactory early outcomes and 5-year survival. (J Thorac Cardiovasc Surg 2011;142:292-7)

Aortic annular erosion is a serious complication after aortic valve or root replacement, often associated with annular abscess secondary to aortic valve endocarditis. Other conditions that may lead to annular erosion include multiple operations on the aortic valve or aortic root, chronic hemodialysis therapy, and long-term therapy with corticosteroids.¹ The process can result in discontinuity between the ascending aorta and the mitral valve and adjacent ventricular myocardium.

Several techniques have been described to address this condition. These include suturing a patch of synthetic graft or pericardium over the eroded area with subsequent valve or root replacement^{2,3} and insertion of an aortic root allograft, pulmonary autograft, or xenograft.⁴⁻⁶ Alternatively, the left ventricular outflow tract (LVOT) can be reconstructed with a polyester tube graft with translocation of the aortic valve prosthesis to a more cephalad position. A composite graft containing an aortic valve prosthesis is sutured to the tube graft and to the distal aorta. Continuity with the coronary arteries is established with saphenous vein bypass grafts⁷⁻⁹ or

polyester interposition grafts.¹ We present the early and midterm outcomes with the latter technique with polyester interposition grafts to the coronary arteries.

MATERIALS AND METHODS

Patients

The technique has been used in 12 cases. The median patient age was 49 years (range, 29–61 years), and 6 patients were male. Eleven of the patients had undergone previous aortic valve or aortic root replacement. The indications for reoperation are shown in Table 1. Four patients had active endocarditis (2 cases involving a prosthetic valve and 2 an aortic root allograft valve), and were receiving antibiotic therapy. Three patients had large false aneurysms of the annulus after aortic valve or aortic root replacement, and 2 patients had substantial erosion (greater than half the circumference) of the annulus after removal of a prosthetic valve. Two patients had dense calcification of the aortic root that precluded safe attachment of a mechanical prosthesis, and 1 patient had a small (<19 mm) annulus with severe calcification of the aortic root.

The study was reviewed by the institutional review board of the Missouri Baptist Medical Center and was exempted from board approval. Follow-up was 100% complete. Survival data were obtained from the social security death index (<http://ssdi.rootsweb.ancestry.com/cgi-bin/ssdi.cgi>).

Operative Technique

Our operative technique has been previously reported.¹ Standard cardiopulmonary bypass is used. After aortic clamping and administration of cold blood cardioplegia (antegrade and retrograde), the native aortic valve and root tissue or the previously inserted aortic valve or composite graft are excised. The eroded area is extensively debrided to remove all necrotic or infected tissue. The coronary arteries are mobilized if technically feasible, and the diameter of the LVOT is determined with a valve sizer. A 4- to 5-cm tubular segment of collagen-impregnated, woven polyester aortic graft (Hemashield Gold; Boston Scientific Corp, Natick, Mass) of comparable or slightly larger size than the measured aortic annulus is positioned

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Abbreviation and Acronym

LVOT = left ventricular outflow tract

in the LVOT, and the superior edge is sutured to the intervalvular fibrous body of the mitral valve and the adjacent myocardium below the eroded area with a continuous 3-0 polypropylene suture. After completion of this suture line, segments of 8-mm or 10-mm collagen-impregnated, woven polyester graft (Hemashield; Boston Scientific) are sutured end-to-end to the aortic tissue surrounding the right and left main coronary arteries with 4-0 or 5-0 polypropylene sutures. The polyester tube is then everted from the LVOT and cut to an appropriate length. A composite graft containing a mechanical, stentless bioprosthetic or stented bioprosthetic valve that is attached to a coated polyester graft is sutured to the rim of the tube graft with a continuous 4-0 polypropylene suture (Figure 1). The coronary artery grafts are then sutured to openings in the aortic graft above the aortic valve or to a bioprosthetic root graft with 5-0 polypropylene sutures. The distal end of the composite or stentless graft is sutured to the distal ascending aorta or to a previously inserted polyester graft.

RESULTS

The operative procedures and outcomes are summarized in Table 1. The size of the tubular graft placed into the LVOT ranged between 22 and 30 mm. A composite graft containing a St Jude (St Jude Medical Inc, St Paul, Minn) or CarboMedics (CarboMedics Inc, Austin, Tex) valved conduit (21–27 mm) was used in 10 patients and a stentless aortic root valve graft (Medtronic Freestyle; Medtronic Inc, Minneapolis, Minn) was used in 2 patients (23 mm and 27 mm). All patients survived the operative procedure. Two patients (17%) required the insertion of a permanent pacemaker for complete heart block. Three patients required open packing of the sternal wound because of significant intraoperative bleeding and had delayed sternal wound closure 48 hours later; these patients had significant coagulopathy, and no specific surgical source of bleeding could be identified. None of our patients required hemorrhage-related reexploration or had pericardial tamponade after the procedure. Postoperative echocardiograms, obtained in 4 cases, demonstrated no significant gradient through the LVOT and aortic valve prosthesis (peak gradients 3.8 mm Hg, 7.4 mm Hg, 10.8 mm Hg, and 30.7 mm Hg). No patients had mitral insufficiency during the follow-up echocardiogram. There was 1 early death resulting from pulmonary embolism at 1 month and 2 late deaths resulting from heart failure at 15 and 64 postoperative months. The remaining 9 patients are alive at 3 to 132 postoperative months. Actuarial (Kaplan–Meier) 5-year survival is 75%. Postoperative patency of the coronary interposition grafts was confirmed with computed tomographic evaluation during the initial hospital stay in all cases. Computed tomography of the chest at 1 year demonstrated patency of the coronary interposition grafts in 9 patients.

DISCUSSION

Aortic annular erosion is a serious complication, and its surgical management may be formidable. We describe here a technique of aortic valve translocation and reconstruction of the aortic valve annulus that is of particular value when destruction or severe distortion of the aortic annulus precludes safe placement of a rigid mechanical or bioprosthetic valve into the aortic annulus, and when insertion of a prosthesis would result in significant LVOT obstruction or impingement on the coronary ostia.

Prosthetic valve endocarditis is the principal cause of annular erosion. Surgical management consists of aggressive and complete débridement of infected and necrotic tissue with subsequent reconstruction of the LVOT and the aortic annulus. Aortic root allografts have been used to treat this condition because of their resistance to infection.¹⁰ Persistent infection, however, has been observed after allograft placement.¹¹

Although a major indication for use of the described technique is endocarditis causing annular erosion, other indications include significant noninfective erosion and calcification of the annulus, particularly in the reoperative setting. In these situations, severe calcification may preclude safe insertion of a prosthetic valve in the annular position. Furthermore, insertion of a valve prosthesis into a small LVOT could result in significant obstruction.

Our technique allows surgical repair of ventriculoaortic discontinuity and aortic root destruction without creating LVOT obstruction. Alternative techniques involving aortic valve translocation in combination with occlusion of the coronary ostia and placement of venous bypass grafts to the coronary arteries have been previously described.^{10,12–14} Reitz and colleagues¹⁴ recommended the use of 3 bypass grafts because of concern that the circumflex coronary arterial system might be inadequately perfused from only a left anterior descending coronary artery graft. Disadvantages of this technique include the need to dissect the heart away from the pericardium to construct the distal coronary arterial anastomoses, which could be challenging in the reoperative setting, and also the potential for development of occlusive disease in the vein grafts.¹⁰ Lack of suitable venous conduit could preclude use of this technique. Danielson and colleagues¹² have reported aneurysmal dilatation of the aortic root when it is preserved beneath the translocated aortic valve and coronary arteries. Our technique avoids this complication by replacing the root with a polyester graft and suturing it within the LVOT. It also excludes the eroded annular tissue from systemic pressure, an important principle of surgical management of endocarditis.¹⁵ Avoidance of repeated infections with our technique was accomplished with (1) débridement of the eroded annulus and the annular abscess, (2) exclusion of the infected area from the systemic circulation by sewing the polyester graft into

TABLE 1. Patient characteristics

Case	Age at operation (y)	Previous operation	Indication for surgery	Operative interval (mo)	Procedure	Outcome
1	32	Composite graft replacement of aortic root (Marfan syndrome)	False aneurysm at annulus, chronic type A dissection	60	30-mm outflow graft, composite graft (27-mm SJM), 12-mm graft LMCA, 10-mm RCA, ascending aortic replacement, arch descending aorta, MVR	Alive at 132 mo
2	44	Composite graft replacement of aortic root (bicuspid aortic valve, ascending aortic aneurysm)	Thrombotic obstruction of aortic valve prosthesis	16	26-mm outflow graft, composite graft (25-mm SJM), 10-mm graft LMCA, 8-mm graft RCA	Alive at 90 mo
3	54	AVR, CABG	Prosthetic valve endocarditis, false aneurysm at annulus, coronary artery disease	48	30-mm outflow graft, 27-mm porcine Freestyle aortic root heart valve, 10-mm graft LMCA, 10-mm graft RCA, SVG to LAD, SVG to RCA	Died at 15 mo of heart failure
4	29	Aortic root allograft (bicuspid aortic valve, type A dissection)	Severe aortic regurgitation, allograft degeneration	132	24-mm outflow graft, composite graft (23-mm SJM), 10-mm graft LMCA, 10 mm graft RCA, ascending aorta and arch replacement	Alive at 10 years
5	25	Aortic root allograft (bicuspid aortic valve, ascending aortic aneurysm)	Allograft endocarditis, severe aortic and mitral regurgitation	81	26-mm outflow graft, composite graft (25-mm SJM), 10-mm graft LMCA, 10-mm graft RCA, MVR	Alive at 48 mo
6	57	None	Dense calcification of aortic root, severe coronary ostial stenosis of LMCA and RCA	NA	30-mm outflow graft, composite graft (27-mm SJM), SVG to RCA, SVG to LAD, SVG to obtuse marginal, replacement of ascending aorta and arch	Died at 64 mo of heart failure
7	55	AVR, replacement of ascending aorta, arch and descending thoracic aorta	False aneurysm at annulus	37	22-mm outflow graft, composite graft (21-mm SJM), 8-mm graft LMCA, 8-mm graft RCA, ascending aorta replacement	Alive at 7 mo
8	61	AVR ×2, aortic root allograft (paravalvular leak of previous aortic valve prosthesis)	Endocarditis, severe aortic regurgitation	132	22 mm outflow graft, composite graft (21-mm CarboMedics), 10-mm graft LMCA, 10-mm graft RCA, ascending aorta replacement	Alive at 22 mo
9	57	Composite graft replacement of aortic root (annuloaortic ectasia and aortic regurgitation)	False aneurysm of annulus	144	24-mm outflow graft, composite graft (21-mm CarboMedics), 10-mm graft LMCA, 8-mm graft RCA, ascending aorta replacement	Alive at 5 mo

(Continued)

TABLE 1. Continued

Case	Age at operation (y)	Previous operation	Indication for surgery	Operative interval (mo)	Procedure	Outcome
10	40	Aortic root homograft (endocarditis)	Aortic stenosis, calcification of aortic root, homograft	72	22-mm outflow graft, composite graft (21-mm SJM), 8-mm graft LMCA, 8 mm-graft RCA, ascending aorta replacement	Alive at 5 mo
11	70	Aortic root homograft (aortic regurgitation, aneurysm of ascending aorta)	Aortic regurgitation	108	24-mm outflow graft, 23-mm porcine Freestyle aortic root heart valve, 10-mm graft LMCA, 8-mm graft RCA, ascending aorta replacement	Alive at 3 mo
12	34	Composite graft replacement of aortic root (Marfan syndrome)	Endocarditis, false aneurysm of annulus	156	24-mm outflow graft, composite graft (23-mm CarboMedics), 10-mm graft LMCA, 8-mm graft RCA, ascending aorta replacement	Died at 1 mo of pulmonary embolism

SJM, St Jude Medical; LMCA, left main coronary artery; RCA, right coronary artery; MVR, mitral valve replacement; AVR, aortic valve replacement; CABG, coronary artery bypass grafting; SVG, saphenous vein graft; LAD, left anterior descending coronary artery; NA, not applicable.

the LVOT, and (3) careful timing of the operation after blood cultures become negative or (if that was not feasible) after intravenous antibiotics were administered for a few days.

A similar technique has been reported by Krasopoulos and others.¹⁶ In their technique, a polyester graft was tailored to correct the defect in the LVOT and sutured with continuous polypropylene sutures directly to the interventricular septum and the intervalvular fibrous body or sewing ring of a prosthetic mitral valve. The coronary arteries were reimplanted as high as anatomically possible, and a mechan-

ical or bioprosthetic valve was implanted into the graft below the coronary arteries. A disadvantage of their technique is that it requires mobilization of the coronary arteries. In 3 cases, there was practically no remaining sinus wall around the coronary artery orifices, and a patch of saphenous vein was sutured around to create a button suitable for reimplantation.¹⁶ Our technique avoids this problem by suturing segments of 8-mm or 10-mm collagen-impregnated, woven polyester graft end-to-end to the aortic tissue surrounding the right and left main coronary arteries with 4-0 or 5-0 polypropylene sutures. That obviates the need for mobilization of the coronary arteries.

Sewing a compliant polyester graft to the LVOT results in a secure suture line, which in turn reduces the risk of serious bleeding. Other advantages of our technique include

FIGURE 1. Aortic valve transposition and left ventricular outflow tract reconstruction with porcine root and attachment of coronary arteries by interposition grafts. Arrows depict interposition grafts to left main coronary artery (L MAIN) and right coronary artery (RCA).

FIGURE 2. Follow-up computed tomographic angiogram demonstrates patency of coronary artery interposition grafts. Arrows depict interposition grafts to left main coronary artery and right coronary artery (RCA).

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FIGURE 3. Follow-up coronary angiogram demonstrates patency of both coronary artery interposition grafts. A, View of left main interposition graft. B, View of right coronary artery interposition graft. Arrows depict interposition grafts to left main and right coronary arteries.

avoidance of dissection of the left side of the heart for construction of distal coronary arterial anastomoses. Patency of the interposition prosthetic coronary grafts can be assessed with computed tomographic angiography (Figure 2) or coronary angiography (Figure 3). Late patency of the coronary interposition grafts was confirmed with computed tomography in 9 of our patients. Nakahira and associates¹⁷ reported a patency rate of 92% among patients who underwent the modified Bentall technique with reimplantation of the left coronary ostium with a long interposed graft wrapping behind the composite graft and direct attachment of right coronary artery as a button. In their study, patency of the left main interposition graft was confirmed with multislice computed tomography or coronary angiography as late as 4.7 postoperative years.¹⁷

The excellent patency rate obtained with this technique is in contrast to the study by Knight and associates,¹⁸ who reported lower patency rates with the classic Cabrol technique, particularly with the right coronary artery graft. Specifically, Knight and associates¹⁸ reported graft occlusion to 1 of 7 left main coronary grafts (14%) and 2 of 5 right coronary grafts (40%). Similar findings have been reported by other authors.¹⁹ There are situations in which the classic Cabrol technique cannot be used. If the annulus is small or severely eroded, it would be extremely difficult to suture a very short cuff of graft to the annulus without creating obstruction or the potential for severe bleeding that could not be controlled. Our technique provides a way to avoid these problems by allowing secure suture of the cuff with clear visibility. In contrast to the classic Cabrol technique, our technique uses separate interposition grafts to the left and right coronary arterial systems and results in a smooth configuration and course of the grafts.

The destructive disease process of the aortic annulus is often associated with injury to the conduction system. In our study, 2 patients required a permanent pacemaker. Heart block may complicate the early postoperative period, and cardiac rhythm surveillance is therefore important. The incidence of recurrent endocarditis was 0%.

Limitations of our study include the relatively small sample size and the absence of late echocardiographic and angiographic follow-up in all cases.

In conclusion, LVOT reconstruction with a tube graft and translocation of the aortic valve and coronary arteries for annular erosion is a useful technique that eliminates LVOT obstruction, excludes the area of annular erosion, avoids the need for distal coronary artery anastomoses, and reduces the risk of serious bleeding from the proximal suture line. It can be safely performed with satisfactory early outcomes and late survival.

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