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Expanding indications for the Ross procedure

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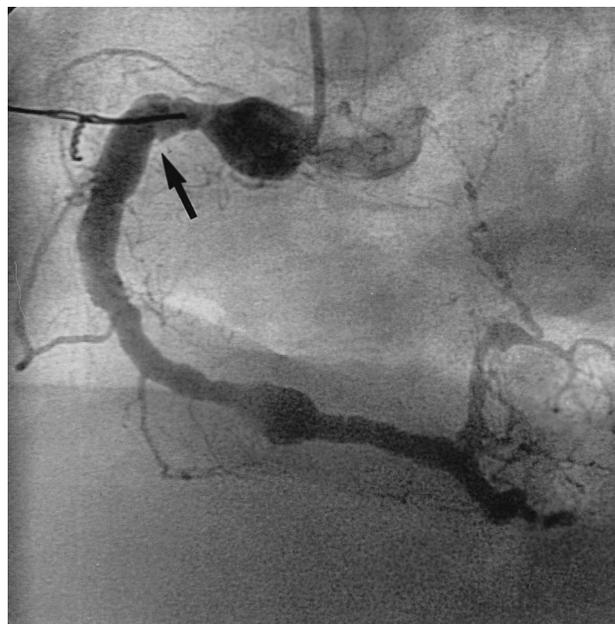


Fig 3. Postoperative angiogram in patient 1. The arrow indicates anastomosis.

Comment

This simple direct reconstruction of the right coronary proved remarkably effective. In each case the patient was left with a dominant native vessel that did not rely on a bypass graft.

Our previous approach to repair of coronary aneurysms has been tailored to their site and size. Kawasaki aneurysms have been ligated and distal coronary flow achieved with a pedicled graft of left or right internal thoracic artery. Previously, we have performed direct repair of a posttraumatic aneurysm of the proximal left anterior descending coronary artery and preserved continuity of the native vessel [3]. In this patient we grafted the left internal thoracic artery to the distal left anterior descending coronary artery as a safeguard. However, in the patients described, both the proximal and distal right coronary were 4 mm in diameter and had a satisfactory runoff. Under these circumstances a bypass graft would have provided competitive flow.

Although simple and effective this technique should be reserved for those patients where the distal coronary artery has been seen to be without disease. The method is only useful when direct anastomosis can be performed without tension. Otherwise ligation of the artery and coronary bypass should be used, as is conventional.

The etiology of massive thin-walled right coronary aneurysm is presumably atheroma, although possibly congenital [1, 4]. In both patients histology of the aneurysm wall excluded the possibility of a false aneurysm. Both patients had atherosclerotic abdominal aortic aneurysms and were lifelong smokers with chronic obstructive airway disease. Both aneurysms were clearly chronic in nature because the right atrium was deformed.

Spontaneous rupture of a coronary aneurysm is un-

usual but given the size and consequent wall tension rupture was a likely event [1, 2, 5].

In summary, we presented 2 patients with giant right coronary aneurysms managed by direct repair. The etiology of a giant right coronary aneurysm is obscure but operation is advisable to prevent rupture [6].

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Expanding Indications for the Ross Procedure

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The pulmonary autograft procedure has been shown to provide excellent hemodynamic results in young patients with aortic pathology. However, the use of this procedure in those with more complex aortic disease has not been extensively evaluated. The purpose of this report is to present the application of the Ross procedure in a 21-year-old man with extensive acquired aortic root pathology, both subannular and supraannular, and prosthetic valve dysfunction after two previous procedures.

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The pulmonary autograft procedure has been shown to provide excellent hemodynamic results in young patients with aortic root pathology. The efficacy of this procedure has been documented in several series of patients with relatively straightforward aortic root pathology [1-3].

The Ross procedure has also been expanded to neonates and infants with complex aortic root pathology with excellent results in both the immediate and midterm

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periods [4]. However, its application in complicated acquired adult aortic root conditions has had less appreciation and evaluation.

It is the purpose of this report to present the application of the Ross procedure in a patient with extensive aortic root pathology, both subannular and supraannular extending to the transverse arch. The patient had undergone two previous aortic root procedures and presented for his third procedure at age 21.

A 21-year-old man presented with extensive aortic root pathology after two previous procedures at ages 5 and 15 years. He had originally undergone aortic valvuloplasty and supraannular patch reconstruction for congenital aortic valvular and supravulvar stenosis. At age 15 years he underwent reoperation at which time his aortic valve was replaced with a 23-mm St. Jude mechanical valve (St. Jude Medical, St. Paul, MN). To deal with the supravulvar problem, a graft was placed "... at the level of the commissures and somewhat below the coronary ostia, which were large." Because of significant intraoperative bleeding through the graft material, the previous operative note stated that it was necessary to place a Teflon felt band over the majority of the ascending aortic Dacron graft.

The patient's postoperative course after this second operation was uncomplicated. However, while on anticoagulant therapy he experienced a spontaneous intraspinal bleed leading to a transient paraplegia that required emergency incision and drainage to restore normal neurologic function. At that time, his warfarin was discontinued. He had remained on aspirin until the time of the present procedure.

Symptoms of exercise-induced fatigability had also developed. Transthoracic echocardiography demonstrated a 55-mm Hg mean resting gradient across the mechanical prosthesis and the subaortic area, with the suggestion of a subannular narrowing or membrane by echocardiography. These findings prompted surgical consultation and operation.

At operation, dense adhesions were encountered between the entire ascending aorta with the external Teflon felt wrap and surrounding structures. Standard bicaval cannulation technique was used together with femoral artery cannulation for cardiopulmonary bypass. Systemic hypothermia to 26°C was used, with both antegrade and retrograde blood cardioplegia for myocardial protection. An insulating pad was placed between the heart and the posterior mediastinal structures. With satisfactory exposure obtained, the aorta was cross-clamped and alternating antegrade and retrograde myocardial protection was begun. Topical iced saline and continuous monitoring of the myocardial temperature were used with the goal of maintaining myocardial temperatures below 10°C. Cold blood cardioplegia was administered every 20 minutes, antegrade or retrograde or by direct coronary cannulation.

The existing ascending aortic graft was first removed along with the anterior portion of the right pulmonary artery, which was imbedded in the Teflon felt posteriorly.

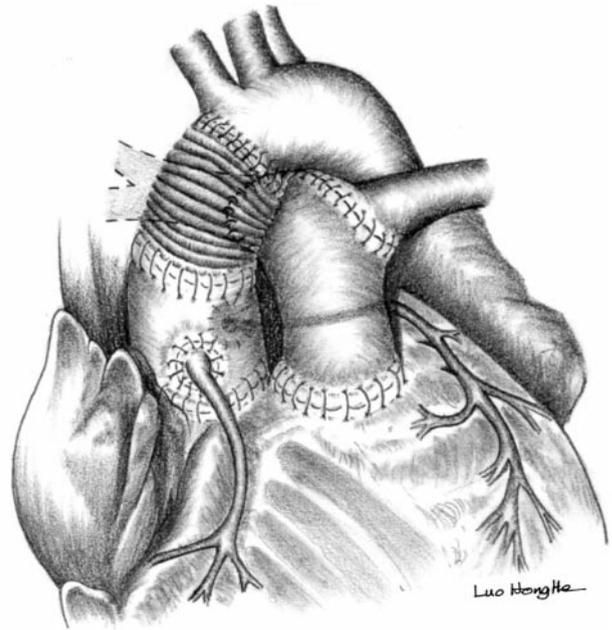


Fig 1. The completed extended Ross procedure, including Dacron graft extensions of the pulmonary autograft and homograft to reconstruct the pulmonary artery bifurcation and the right pulmonary artery.

The pulmonary autograft root was next harvested in the manner originally described by Ross [1]. As its length was not sufficient to reach the distal ascending aorta/transverse arch, it was necessary to extend the pulmonary autograft using a 24-mm Dacron conduit (Hemashield, Meadox Medical, Oakland, NJ), (Fig 1). The patient was cooled to 17°C and under a 17-minute period of circulatory arrest, an open distal anastomosis was constructed between the distal aorta and the Dacron graft.

Standard root replacement techniques were used to seat the pulmonary autograft. However, because of the small aortic annulus and subannular stenosis, a Konno procedure was also necessary. The intraventricular septum was incised and the pulmonary autograft with its extended segment of attached anterior right ventricular wall was placed using interrupted 4-0 Prolene sutures (Ethicon, Somerville, NJ) tied over an external reinforcing strip of Teflon felt. Left and right coronary buttons were then attached to the autograft in the usual fashion with running 6-0 Prolene suture.

Reconstruction of the right ventricular outflow tract (RVOT) and the right pulmonary artery was then accomplished using a pulmonary homograft (Cyrolife, Inc, Kennesaw, GA) with attached branch pulmonary arteries. The distal portion of the homograft pulmonary artery was used as a patch to reconstruct the excised anterior portion of the native right pulmonary artery. With the distal pulmonary homograft and pulmonary artery reconstruction secure, the end-to-end anastomosis between the pulmonary autograft and the distal Dacron graft was performed. The proximal pulmonary homograft was then anastomosed to the RVOT in the usual fashion.

Aortic cross-clamp time was 263 minutes. Sinus rhythm returned within 5 minutes after removal of the aortic cross-clamp. After 30 minutes of rewarming and stabilization, the patient was easily weaned from cardiopulmonary bypass. After bypass transesophageal echocardiogram demonstrated a competent pulmonary autograft from the left ventricular outflow tract (LVOT) to the ascending aorta with a physiologic gradient (< 5 mm Hg). Normal left ventricular function was also documented by transesophageal echocardiogram.

The patient's postoperative course was uneventful. He was extubated within 12 hours, moved from the intensive care unit within 18 hours, and discharged on his fifth postoperative day.

Comment

Valid concern exists regarding the use of the Ross procedure for complex aortic root pathology. The operation is complex and involves a two-valve procedure for single valve pathology. It is unarguably apparent, however, that when performed properly, it offers the ideal solution for aortic root pathology [5].

The expansion of this procedure for the neonate and infant born with complex aortic root pathology has evolved in the past decade beginning with the report of Drs Dewan and Oswalt submitted in 1994 to the Ross registry of a 1-day-old infant undergoing the Ross procedure (J. D. Oswalt and S. J. Dewan, personal communication). Hanley's group [6] in San Francisco has reported excellent early and mid-term results in this age group, adding significantly to the surgeon's repertoire when dealing with complex aortic root pathology by using the Ross procedure or additional LVOT widening procedures, formerly amenable only to the standard Konno procedure. With the Ross/Konno operation, they have reported complete relief of outflow tract obstruction, with excellent short- and midterm results.

When dealing with the adult patient, however, whose original pathology involved complex aortic root reconstruction in infancy or childhood, the basic components of this operation leading to a successful outcome using the Ross procedure have been less well-appreciated and applied.

Principles leading to a successful outcome in these acquired or iatrogenic forms of aortic root pathology, are summarized as follows: (1) optimum exposure and uniform meticulous myocardial protection anticipating a prolonged period of ischemic arrest; (2) placement of an architecturally perfect pulmonary homograft, which also, because of the marked distortion of the aortic root encountered in these situations, requires root replacement; and (3) accurate reconstruction of the RVOT and pulmonary artery using a pulmonary homograft. The operative sequence followed in this case emphasized these basic principles and allowed excellent exposure, good myocardial protection, and secure hemostasis of all suture lines. All the techniques used in this procedure are part of current standard cardiovascular teaching [7]. However, the sequence involved in these techniques is

worth noting as it allows a methodical and unhurried approach to this complex problem and achievement of an optimal outcome.

The perioperative risks of this procedure must be weighed against other suitable alternatives including aortic homograft root replacement, unstented porcine xenograft root replacement, and composite mechanical valve conduit alternatives. In this setting, however, each of the alternatives requires a fairly similar approach in terms of myocardial protection and prolonged ischemic time owing to the complexity of the aortic root pathology encountered and the necessity of removing the entire aortic root and prosthetic valve. They also individually do not address the LVOT obstruction that was a component of the clinical presentation of this patient. As demonstrated with the Ross/Konno procedure, this last problem is easily solved by use of the pulmonary graft with attached right ventricular free wall muscle, allowing widening of the LVOT as necessary.

The long-term durability of the pulmonary autograft in the aortic position has been documented both experimentally and clinically [8, 9]. The hemodynamic performance of the pulmonary autograft is also identical to its normal counterpart and certainly superior to other mechanical or biologic alternatives [10]. The freedom from complications related to anticoagulation is also of obvious importance in this particular case as the patient had previously documented warfarin-related complications. The issue of long-term durability of the pulmonary autograft has been raised in terms of its use in young adults. Data compiled by the Ross registry document a greater than 80% 25-year survival with the pulmonary autograft in the aortic position and similar statistics for the pulmonary homograft used to reconstruct the RVOT [11].

In conclusion, the Ross procedure as performed in a patient with complex aortic valve pathology provided an optimally suited solution for this problem. The pulmonary autograft was easily adapted to this complex LVOT and aortic root pathology and provided a satisfactory clinical result. The perioperative risk of this procedure, primarily the prolonged cross-clamp time, must be weighed against the long-term performance of other alternatives.

Consideration must be tempered by the realization that an individual approach to the patient is dependent on the experience of the surgeon performing such repairs. However, in experienced hands, the Ross procedure is feasible and provides significant immediate and long-term advantages in selected patients with complex aortic root pathology.

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Unusual Origin and Fistulization of an Aortic Pseudoaneurysm: “Off-Pump” Surgical Repair

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Aortic pseudoaneurysm is an unusual complication of cardiac operations. The origin depends on the site of arterial wall disruption. Rupture into the right side of the bronchial tree is an exceedingly rare evolution. Repair is commonly performed using cardiopulmonary bypass. In our report a male patient underwent two procedures for aortic dissection, and 6 months after the second operation massive hemoptysis appeared abruptly. A false aneurysm rose from a graft-to-graft anastomotic site and ruptured into a segmental bronchus of the right upper lobe. Repair was performed without cardiopulmonary bypass.

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Pseudoaneurysm of the ascending aorta is an unusual complication after cardiovascular operations. Rupture into the right side of the bronchial tree is an exceptional cause of hemoptysis because of the distance from the ascending aorta. Blood flooding into the airways is a potentially fatal evolution and requires prompt

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Fig 1. Computed tomogram of the chest showing the pseudoaneurysm compressing both the superior vena cava (thin arrow) and the aortic graft (large arrow). Hemorrhage in the right lung is also visible.

surgical treatment. Cardiopulmonary bypass is commonly used to excise the aneurysm and repair the bronchial tear.

In our report the mass rose from a graft-to-graft anastomotic site as the patient underwent two procedures for aortic dissection 4 years and 6 months previously. Massive hemoptysis was caused by rupture into a segmental bronchus of the right upper lobe. Successful surgical treatment was performed without cardiopulmonary bypass.

A 58-year-old man was first admitted to our hospital in July 1993, because of type I aortic dissection. Operation involved replacement of the ascending aorta and the inner curvature of the aortic arch with a 30-mm Dacron-Hemashield prosthesis (Meadox Medicals, Oakland, NJ), using profound hypothermia and circulatory arrest. He remained asymptomatic for 3 years.

In December 1996 he underwent a Bentall procedure because of dissection of the residual proximal aortic root with aortic valve incompetence. A 26-mm Dacron-Hemashield composite tubular graft containing a size 23 St. Jude Medical valve (St. Jude Medical, St. Paul, MN) was inserted. The graft-to-graft anastomosis was performed using a running 4-0 Prolene suture (Ethicon, Somerville, NJ). He was discharged on the ninth postoperative day.

The patient was readmitted after 6 months because of a sudden onset of massive hemoptysis. Chest roentgenogram showed a widened mediastinum and abnormal radiopacities on the right side. Transesophageal echocardiography revealed a compressive mass along the entire aortic graft. On computed tomographic scan, the mass was recognized as an anterior mediastinal hematoma compressing the proximal aortic arch and the superior vena cava; hemorrhage within the right lung was evident (Fig 1). The patient was taken to the operating theater for the third time, in a desperate condition. The right femoral artery was prepared for cardiopulmonary bypass before the sternum was opened. After median sternotomy was performed, a wide false aneurysm of 10 by 10 cm in diameter appeared lying between the right lung and the prosthetic aorta, compressing the superior vena cava.

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