

AORTIC IMPLANTATION OF ANOMALOUS LEFT CORONARY ARTERY

An improved surgical approach

Anomalous origin of the left coronary artery from the pulmonary artery may present a technical challenge. Direct implantation of the anomalous left coronary artery into the aorta to provide a two coronary artery system is the preferred surgical approach. We describe a modification of this technique to allow anastomosis of the anomalous left coronary artery with the excised button of pulmonary artery from within the lumen of the aorta. We have used this procedure in six children and one adult with anomalous left coronary artery with favorable outcome. The potential benefits of this modified technique are (1) improved operative exposure, (2) ability to implant the anomalous left coronary artery in the appropriate sinus, (3) avoidance of aortic valve damage or distortion because of improved exposure, and (4) applicability to patients of all ages. (J THORAC CARDIOVASC SURG 1995;109:519-23)

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Anomalous origin of the left coronary artery from the pulmonary artery is a rare congenital malformation. It is estimated to occur in 1 of every 300,000 live births.¹ Most infants with anomalous left coronary artery die of myocardial infarction and sudden death in early life, if treated medically.^{2,3} Because of the high mortality of nonoperative management, urgent surgical intervention is deemed appropriate on diagnosis. Several surgical approaches have been proposed for the management of anomalous left coronary artery. The establishment of a two coronary artery system by direct implantation, which provides anatomic correction, has distinct advantages.⁴ When direct implantation of the anomalous left coronary artery into the aorta is not technically feasible, creation of an aortopulmonary window with an intrapulmonary baffle⁵ or anastomosis of the anomalous left coronary artery to an extracardiac arterial blood source has been used as an alternative technique to establish a two coronary artery system.^{6,7}

Direct implantation has been performed by mobilization of the anomalous left coronary artery and

anastomosis of the excised button of pulmonary artery to the left posterolateral aortic wall with the aid of cardiopulmonary bypass.^{8,9} Recently, we have modified our technique of direct aortic implantation by anastomosing the excised button of pulmonary artery from within the lumen of the aorta. This technique of implantation of the anomalous left coronary artery has been used by Sir Magdi Yacoub and was described to us in 1990 (personal communication). This article describes the technique and reviews our experience with seven patients undergoing implantation of an anomalous left coronary artery under direct visualization from within the aorta.

Methods

Patients. Since April of 1990, six consecutive children and one adult patient with anomalous left coronary artery arising from the pulmonary artery have undergone surgical treatment by means of the modified technique. The clinical characteristics of the patients are shown in Table I. The patient population consisted of six children with a mean age of 8 months at operation (range 7 weeks to 17 months) and one 23-year-old adult. All children had cardiomegaly on chest roentgenograms and displayed electrocardiographic evidence of myocardial ischemia/infarction. All children had clinical evidence of congestive heart failure at the time of initial evaluation except for one child who had an asymptomatic murmur of mitral regurgitation. Preoperative echocardiography revealed a dilated left ventricle with poor systolic function in all pediatric patients except one child. All children had moderate to severe mitral regurgitation. Patients 4, 5, and 7 underwent preoperative positron emission tomographic scans, which revealed significant myocardial ischemia in the left coronary artery distribution. The adult patient was first seen at age 2 months with myocardial infarction and

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Table I. Clinical characteristics of the seven patients with anomalous left coronary artery who underwent intraaortic direct implantation

Patient	Age	Presenting symptom	Electrocardiogram	Preoperative echocardiogram	Postoperative echocardiogram
1	11 mo	CHF	q Wave in anterolateral leads	EF 34%; moderate MR	EF 36%; mild MR
2	7 wk	CHF	q Wave in anterolateral leads	EF 17%; severe MR	EF 50%; moderate MR
3	17 mo	CHF	q Wave in inferolateral leads	EF 21%; moderate MR	EF 25%; mild MR
4	5 mo	CHF	q Wave in inferolateral leads	EF 32%; moderate MR	EF 40%; mild MR
5	8 mo	Asymptomatic murmur	ST depression in anterolateral leads	EF 60%; severe MR	EF 60%; moderate MR
6	6 mo	CHF	ST depression in inferolateral leads	EF 16%; moderate MR	EF 25%; mild MR
7	23 yr	angina	q Wave in anterior leads	EF 60%; mild MR	EF 60%; mild MR

CHF, Congestive heart failure; EF, ejection fraction; MR, mitral regurgitation.

congestive heart failure. The parents refused operative intervention, and she was managed medically. She gave birth to two children uneventfully. At 23 years of age, she began having exertional angina and evidence of significant myocardial ischemia on provocative tests. All patients underwent direct implantation of the anomalous left coronary artery into the aorta by means of the modified technique.

Technique. The heart was cannulated with a distal aortic cannula and bicaval venous cannulas. Cardiopulmonary bypass was instituted and the blood was cooled to 22° to 24° C. The aorta was crossclamped and cold blood cardioplegic solution was infused at a pressure of 80 mm Hg for 3 minutes to achieve cardiac arrest. At the same time the pulmonary artery was also clamped distal to the anomalous left coronary artery. This technique is important to maintain a high pressure within the proximal pulmonary artery, which avoids runoff from the orifice of the anomalous left coronary artery. The right atrium was opened and cardioplegic solution was given retrogradely via the coronary sinus for an additional 2 minutes at a pressure of 30 to 40 mm Hg. The pulmonary artery was opened anteriorly (Fig. 1, A and B) and the orifice of the left coronary artery identified. Cold blood cardioplegic solution was given in antegrade fashion via the left coronary artery ostium. The orifice of the anomalous left coronary artery was excised with a wide button of pulmonary artery. The left main coronary artery was then carefully mobilized. When the origin of the anomalous left coronary artery was in the posterior sinus or even the nonfacing sinus, the coronary artery button could be mobilized to reach the aorta. The ascending aorta was opened obliquely anteriorly. A vertical incision was made in the middle of the left coronary sinus adjacent to the pulmonary artery. A 2 mm punch may be used to enlarge the opening in the aorta. The cuff of pulmonary artery with the anomalous left coronary artery was pulled through this opening into the lumen of the aorta (Fig. 1, C). The anastomosis was performed with a running suture of 7-0 PDS polydioxanone (Ethicon, Inc., Somerville, N.J.) absorbable suture material (Fig. 1, D). The aortic incision was closed and cardioplegic solution was given via the aortic root. The defect in the pulmonary artery where the button had been removed was closed with a pericardial patch, and the pulmonary artery incision was then

closed. Warm blood cardioplegic solution was given retrogradely for 1 minute and antegradely for 1 minute while the right atrium was being closed.

Results

Five patients had an uncomplicated postoperative course necessitating minimal inotropic support. In patient 1, the sternum had to be kept open for 3 days and high doses of inotropic support were required. This patient recovered well. A follow-up cardiac catheterization in this patient showed normal coronary arteries and no evidence of coronary ostial lesions. Patient 6 could not be weaned from cardiopulmonary bypass and required a left ventricular assist device for 3 days. Postoperatively, he had mild neurologic impairment with hyperreflexia and hypertonicity. Doppler studies demonstrated antegrade arterial flow in the implanted coronary artery.

The follow-up period in this study ranges from 4 months to 2 years (mean 12 months). Postoperative follow-up studies are listed in Table I. All patients are alive and clinically well. None has had clinical evidence of myocardial ischemia or congestive heart failure after the operation. Intermediate-term follow-up echocardiograms have shown stabilization or improvement in myocardial function as compared with preoperative results. Additionally, the Doppler studies have demonstrated antegrade flow in the implanted coronary artery in all patients.

Discussion

Surgical treatment of anomalous left coronary artery has evolved considerably over the past several decades. Methods like aortopulmonary anastomosis or banding of the pulmonary artery remain of historical interest.^{10, 11} The goals of modern surgical management are as follows: establishment of a two coronary system with long-term patency, use of

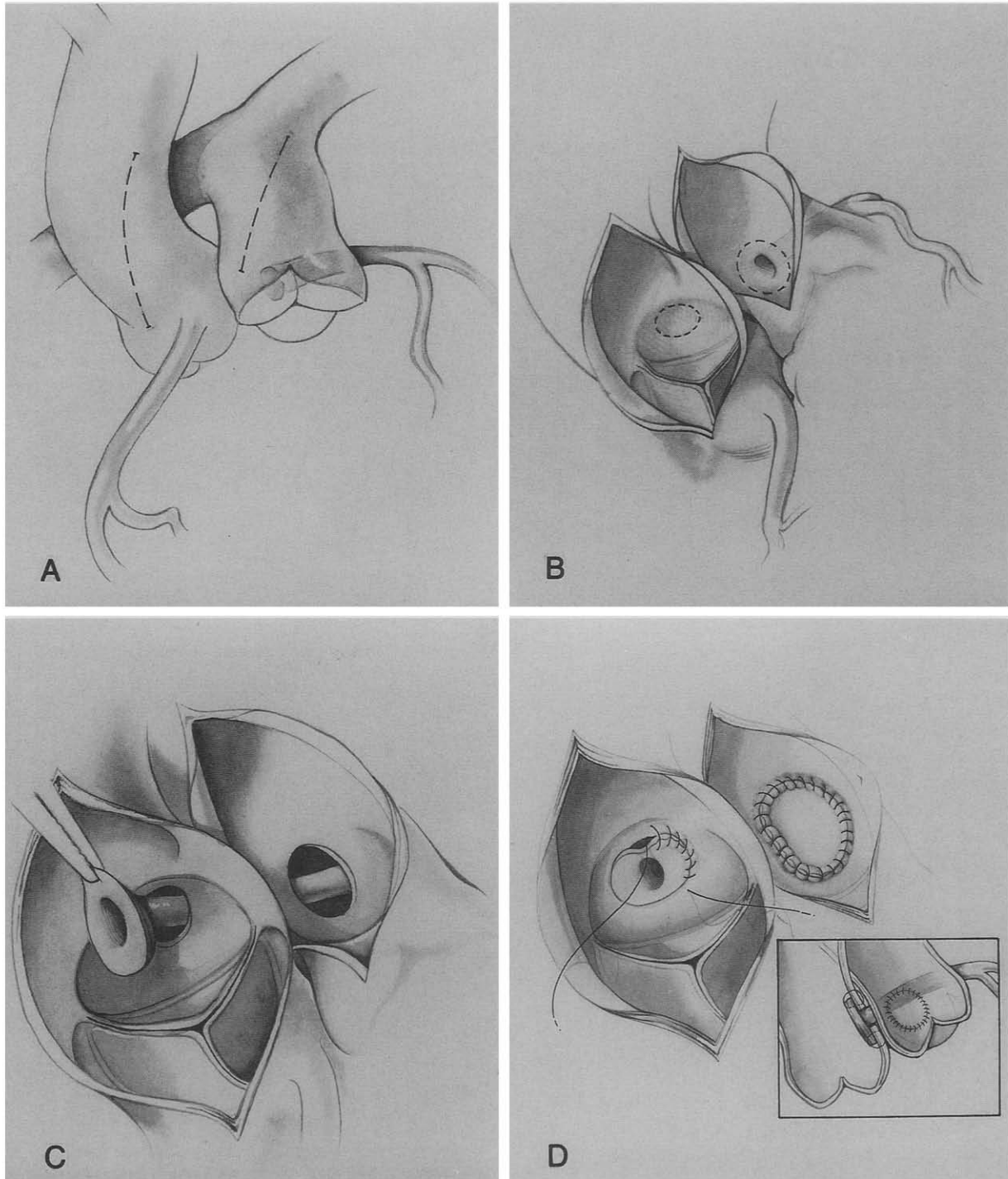


Fig. 1. Technique of direct aortic implantation from inside the aorta. *A*, The location of incisions on the ascending aorta and the pulmonary artery are shown. *B*, The anomalous left coronary artery with a button of pulmonary artery is excised. *C*, The anomalous left coronary artery is mobilized and passed through an opening in the left coronary sinus. *D*, The anastomosis is performed under direct visualization from within the aorta; the defect in the pulmonary artery is closed with a pericardial patch.

native tissue, and potential for normal growth of the coronary ostia and arteries. Simple ligation of the left coronary artery at its origin may provide some benefit to patients with large collateral vessels and a significant shunt to the pulmonary artery.² It does, however, result in a single coronary artery system that may cause late ischemia. The two coronary system can be established via several techniques: ligation of the origin of the anomalous left coronary artery combined with a conduit to bypass the left coronary artery, creation of an aortopulmonary window with an intrapulmonary baffle, and direct implantation of the coronary ostium into the ascending aorta.

The common conduits that have been used to revascularize the left coronary artery are saphenous vein graft, subclavian artery, and left internal mammary artery. The utility of saphenous vein grafts in infants and small children is limited by the small caliber and poor quality of the vein, as well as the prevalence of late occlusion.¹² Subclavian artery-left coronary artery anastomosis has been used in several series.^{3, 7, 13} The potential problems with the use of the subclavian artery are caliber mismatch, technical difficulty of performing the anastomosis on a beating heart via the left side of the chest, kinking of the subclavian artery at its origin, and anastomotic stenosis as reported in long-term follow-up series.³ The left internal mammary artery has also been used to revascularize the left coronary artery.³ In infants and small children, the size of the left internal mammary artery is a potential problem and long-term growth of the anastomosis has not been documented.

Aortopulmonary window with an intrapulmonary baffle (Takeuchi procedure) is a useful technique for establishment of a two coronary artery system in cases in which direct implantation is not technically feasible.⁵ This technique can be performed irrespective of the distance of the ostium of the anomalous left coronary artery to the aorta and has the added advantage of using the autologous pulmonary artery tissue to create the baffle. However, several complications are associated with the Takeuchi procedure, which include supra-valvular pulmonary artery stenosis, obstructed tunnel, and tunnel-pulmonary artery fistula.⁴

Direct implantation of the anomalous left coronary artery into the ascending aorta is the preferred technique for the establishment of a two coronary artery system, when technically feasible. This technique requires excision of the ostium of the anomalous

left coronary artery with a cuff of pulmonary artery, mobilization of the artery, and direct anastomosis into the ascending aorta. Optimal results depend on avoidance of excessive tension or twisting of the coronary artery. Direct implantation is conventionally performed on the left posterolateral wall of the ascending aorta from outside. Because of the difficulty in exposing this aspect of the aorta, the technique of transection of the pulmonary artery to achieve adequate exposure of the posterolateral aspect of the aorta has been used.⁹ Yacoub described to us the technique of direct implantation of the coronary artery through an anterior aortic approach. This technique allows the anastomosis to be performed from within the aorta. The potential advantages of the described technique are (1) improved operative exposure and direct access to the anastomosis, (2) ability to implant the anomalous left coronary artery in the sinus, which could offer hemodynamic advantages, (3) avoidance of the aortic valvular apparatus under direct visualization, and (4) applicability to patients of all ages. The clinical results have been encouraging in that all patients survived the procedure with improved or stabilized left ventricular function. Intermediate-term follow-up studies by Doppler echocardiography have shown a patent left coronary artery system in all patients.

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