Hypothermic Circulatory Arrest for the Surgical Treatment of Complicated Adult Coarctation of the Aorta

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OBJECTIVES
This study was designed to evaluate the surgical treatment of recurrent coarctation by a new technique.

BACKGROUND
Recurrent coarctation either from aneurysm or recurrent constriction is a difficult problem in the adult because of the possible interruption of important collateral circulation.

METHODS
We reviewed four patients who underwent recurrent coarctation surgery with the use of deep hypothermic circulatory arrest (HCA).

RESULTS
All four patients survived. Deep HCA facilitated precise surgical resection and there was no postoperative paraplegia, stroke, or myocardial infarction.

CONCLUSIONS
Deep HCA and resection and grafting of the coarctation is indicated for complicated adult coarctations, particularly when the collateral circulation is in doubt. (J Am Coll Cardiol 2003;41:849–51) © 2003 by the American College of Cardiology Foundation

Coarctation of the aorta is usually recognized and corrected in infancy. Despite early repair, there is an incidence of recurrence and late aneurysm development (1–3). Adult aortic coarctation presents most often as a recurrence after previous repair or as a previously undiagnosed coarctation in patients with hypertension. Difficulties and risks of surgery for recurrent coarctation have been well described (4). Recently, interest in hypothermic circulatory arrest (HCA) for treatment of descending aortic aneurysm has been popularized by Kouchoukos et al. (5). We describe the use of HCA with cardiopulmonary bypass (CPB) for the treatment of the difficult adult coarctation.

PATIENTS

Case 1. A 55-year-old male was investigated for hypertension. At the age of 17 he underwent repair for coarctation with a subclavian patch aortoplasty. Computerized tomography scans and magnetic resonance imaging (MRI) showed a calcified aortic arch and three small saccular aneurysms adjacent to a recurrent coarctation with the smallest diameter of 15 mm and a peak trans-coarctation gradient of 24 mm Hg. The aortic arch was also hypoplastic (16 mm in diameter) and calcified. Preoperative coronary angiogram revealed a 70% left main coronary stenosis. Uncomplicated coronary artery bypass grafting was performed before coarctation repair as a separate operation, using the right internal mammary artery to the left anterior descending artery and a saphenous vein graft to the obtuse marginal.

Six weeks later the patient underwent a left fourth interspace posterolateral thoracotomy. The left common femoral artery and vein were cannulated for CPB, the patient was cooled to 20°C, and the circulation was arrested. The entire coarctation segment and the adjacent aneurysms were resected. A 24-mm Hemashield graft was then anastomosed proximally to the aortic arch, just distal to the left carotid artery and distally to the proximal descending aorta. Total circulatory arrest time was 20 min. The patient was re-warmed and weaned from bypass without difficulty after 99 min. There were no postoperative complications and the patient was discharged on postoperative day 5.

Case 2. A 40-year-old female presented with fatigue, claudication, and hypertension and had a coarctation repair at the age of 13. Imaging studies documented a recurrent coarctation with a 40% narrowing of the proximal descending thoracic aorta with mild post-stenotic dilation and mean gradient of 24 mm Hg on angiography (Fig. 1). Coronary angiography was normal.

Through a fourth intercostal posterolateral thoracotomy, the aorta was found to be calcified with mild poststenotic dilation. The distal descending aorta was directly cannulated and the right femoral vein cannulated for CPB. The patient was cooled to 15°C and the circulation arrested. The coarctation was resected and a 20 mm Hemashield graft anastomosed between the distal aortic arch just beyond the left subclavian and the proximal descending aorta. The total circulatory arrest time was 30 min. A postoperative hoarse voice was presumed to be recurrent laryngeal nerve neuropathy after normal indirect laryngoscopy. The patient was discharged on postoperative day 10 without complications.
Case 3. A 25-year-old woman, 25 weeks pregnant, was found to have a murmur and differential upper limb blood pressure readings at a routine prenatal visit. As a child, she was told she had an abnormal aorta after incidental findings of a widened mediastinum on X-ray. A moderate aortic coarctation with a poststenotic calcified 6.4 × 4.4-cm aneurysm was confirmed by MRI. She was first admitted to the obstetric department for strict blood pressure control. At 32 weeks of gestation she had an elective caesarian section. One week later elective aortic surgery was performed, through fourth interspace left posterolateral thoracotomy. The distal descending aorta was cannulated, the femoral vein percutaneously, and CPB was established. After cooling to 15 °C the circulation was arrested for 30 min. Both the aneurysm and coarctation were resected and the proximal anastomosis was performed just distal to the left carotid. The graft was clamped and cannulated and proximal perfusion re-established. The distal anastomosis was then performed to the mid descending aorta. She had no postoperative complications and was discharged on day 6.

Case 4. A 69-year-old man underwent repair of an aortic coarctation at the age of 27 and an aortic valve replacement at age 64. Before this, it was noted that he had had an aneurysm of the descending aorta at the coarctation site and imaging studies documented increasing size of a 4.5 cm pseudoaneurysm just below the left subclavian artery. Coronary angiography was normal.

A fourth intercostal posterolateral thoracotomy was performed after cannulation of both the left femoral artery and vein. The thin-walled pseudoaneurysm originated from a dehiscence of the proximal anastomosis of the previously placed tube graft. While cooling to 15 °C, the left recurrent nerve was dissected free from surrounding scar tissue. The entire tube graft was excised and a 26-mm Hemashield graft was placed between the distal aortic arch and the proximal descending aorta. Both anastomoses were performed during 30 min of circulatory arrest.

Postoperatively, the patient was reoperated upon for bleeding, had a left recurrent nerve paresis treated with sclerotherapy, and a left-sided chylothorax that required video-assisted ligation of the thoracic duct. He was discharged on postoperative day 23.

In all four patients preoperative transesophageal echocardiography was used to exclude aortic regurgitation and to monitor left ventricular function. During HCA the head was packed in ice, and intravenous methylprednisolone and penthothal were administered before the arrest period. In all cases the perfusion pressure was carefully monitored and maintained ≥60 mm Hg.

**DISCUSSION**

Hypothermic circulatory arrest in the management of adult aortic coarctation has several advantages over the standard techniques of clamp and sew or distal perfusion via shunting or left heart bypass. First, only minimal dissection of the aorta is required, which is beneficial because the adult aorta is relatively immobile, especially in the recurrent setting. Also, there are frequently large collaterals immediately adjacent to the coarctation, making dissection hazardous and risking important collaterals.

Another advantage is the elimination of aortic clamping. The aorta in patients with adult coarctation is small, often calcified, and avoidance of clamping reduces the risk of cerebral and peripheral embolization.

Access to the proximal aortic arch is also improved. With the standard technique, a cross-clamp between the left carotid and subclavian artery leaves limited space to perform an anastomosis after the coarctation has been resected, especially when associated with an aneurysm. A bloodless field allows the true extent of the coarctation and adjacent abnormal aorta to be excised with a more accurate anastomosis.

Hypothermic circulatory arrest provides effective protection of the brain, spinal cord, and viscera. By reducing the oxygen demand there is an increased ischemic tolerance as well as inhibition of the biosynthesis, release, and uptake of excitotoxic neurotransmitters that have been implicated in spinal cord ischemic injury. This technique is increasingly used successfully for descending and thoracoabdominal aneurysms.

Hypothermic circulatory arrest for adult coarctation has
some shortcomings. Some patients with coarctation have very small femoral arteries unsuitable for cannulation, and in this situation the distal descending aorta should be used for cannulation (Cases 2 and 3). Also, if there is significant coarctation gradient with a severe stenosis, the retrograde perfusion through the coarctation may provide inadequate myocardial and cerebral perfusion. This can be monitored by a right radial arterial monitor. If retrograde flow is inadequate to provide an adequate proximal perfusion pressure, then consideration should be given to left heart bypass (heart ejecting, distal perfusion) or the standard method of clamp and sew.

The technique of hypothermic arrest for complicated adult coarctation is simple, safe, and reproducible, and has been associated with an excellent outcome in our four patients. This technique is appropriate for repair of adult coarctations that are recurrent, when difficult dissection is anticipated, when associated with a calcified aorta or aneurysm, and when proximal aortic disease makes clamping unsafe. Finally, in adult coarctations where collateral circulation to the spinal cord and lower part of the body is in question and the risk of developing paraplegia is increased, the technique should also be considered.

**REFERENCES**