Management of Porcelain Aorta Using Minimally Invasive Coronary Artery Bypass

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Although infrequently encountered, porcelain aorta poses a serious dilemma for the surgeon.[1] Because of the diffuse, circumferential, plate-like calcification of the proximal aorta, conventional techniques for cannulation, cross-clamping, and attachment of grafts must be modified to reduce the risk of aortic injury and atheroembolism.[2] Several techniques have been proposed to manage various aspects of these problems, including intraoperative ultrasound to detect disease-free areas of the aorta that can be safely cannulated and clamped,[3] proximal aortic endarterectomy to remove plaque,[4] and ascending aorta replacement to repair the diseased aorta.[3] To avoid manipulation of the aorta, "no-touch" techniques have been developed that use peripheral arterial cannulation, cold fibrillatory arrest, and even profound hypothermic circulatory arrest.[5] To limit or eliminate the need to attach bypass grafts to the aorta, internal mammary and innominate arteries have been used as inflow for coronary artery bypass grafts.[6] Each of these methods has disadvantages; none has been accepted as optimal.[7]

Minimally invasive coronary artery bypass (CAB) is a new approach in which anastomoses are constructed while the heart continues to beat, usually avoiding cardiopulmonary bypass. This approach has inherent advantages for those patients with porcelain aortas requiring coronary revascularization. This case report describes a 77-year-old woman with a critical stenosis of the left main coronary artery, poor left ventricular function, and a porcelain aorta, who underwent bilateral mammary artery grafting on a beating heart.

CASE REPORT

Initial Evaluation

In February 1998, a 77-year-old woman with hypertension and emphysema was transferred to our institution because of new-onset atrial fibrillation and chest pain. Cardiac enzyme test results and an electrocardiogram were consistent with a nontransmural anterior wall infarction. Subsequently, a coronary angiography was performed and revealed a 95% stenosis of the left main coronary artery, chronic occlusion of the right coronary artery with left-to-right collaterals, a 25% left ventricular ejection fraction, and mild mitral insufficiency. The ascending, transverse, and descending sections of the aorta were circumferentially calcified (**Figure 1**). The calcification extended beyond the iliac bifurcation. Despite optimal medical management, the patient continued to experience chest pain, and surgery was scheduled. Preoperative duplex ultrasonography demonstrated moderately severe bilateral carotid artery disease and only minimal disease in the left common femoral artery.

Operative Plan

The operative plan included exploration of the left groin, cannulation of the left common femoral artery, median sternotomy, mobilization of both internal mammary arteries, and right atrial cannulation for partial cardiopulmonary bypass. Because the right coronary artery was chronically occluded, the right internal mammary artery was to be anastomosed to the left anterior descending coronary artery (LAD), and the left internal mammary artery was to be anastomosed to the major marginal branch of the left circumflex coronary artery. The grafting procedures would be performed on the beating heart.

Operative Technique

Left groin and midline sternotomy incisions were simultaneously made. The left common femoral artery, which was only mildly diseased, was suitable for cannulation. The internal mammary arteries were mobilized from their distal divisions to the subclavian arteries

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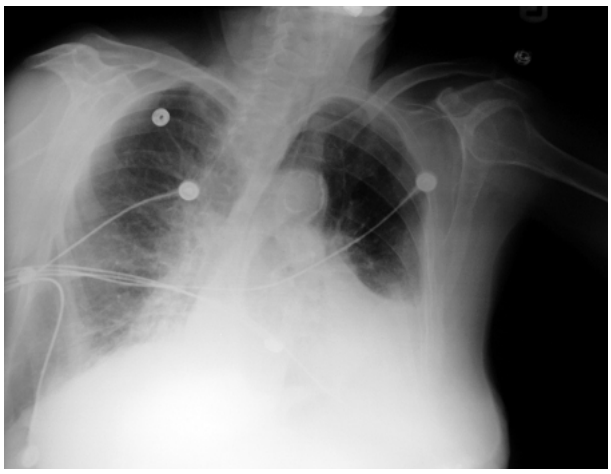

Figure 1. Anteroposterior chest radiograph of the case patient illustrating circumferential calcification of the ascending aorta.

proximally as pedicle grafts. After heparinization (3 mg/kg body weight), a 22F femoral cannula was placed without difficulty. The internal mammary arteries were ligated and divided distally, and the pedicles were locally injected with papaverine solution. The pericardium was opened, and the heart was suspended. The right atrial appendage was cannulated with a 32F 2-stage venous cannula. A saline-moistened sponge was placed behind the heart via the transverse sinus as a "cardiac sling" and used for retraction.

When the activated clotting time was adequate, the patient was placed on partial cardiopulmonary bypass with flows of 2.5 to 4.5 L/min (cardiac index of 0.5 to 2.0 L/min per m^2). Using the sling to rotate the left ventricle medially, the LAD was exposed. The LAD was occluded proximally using a suture tourniquet and a soft plastic pledget to produce 5 minutes of ischemic preconditioning. The artery was allowed to reperfuse for several minutes while the LAD was stabilized with a disposable coronary stabilizer system (CardioThoracic Systems, Inc., Cupertino, CA). The LAD was reoccluded proximal and distal to the site of the anastomosis. After making an arteriotomy, the right internal mammary artery was prepared and grafted to the LAD end-to-side using a single continuous suture. A hand-held gas blower was used to enhance visualization. After release of the distal LAD occlusion, an intraoperative Doppler probe verified diastolic flow in the graft. All retraction devices were removed, and the heart was returned to its normal anatomic position.

Using the cardiac sling, the apex of the heart was retracted cephalad to expose the distal marginal branch. Using similar technique, the left internal mammary artery was grafted to the marginal branch. After diastolic flow was confirmed in the left internal mammary artery using a Doppler probe, all retraction devices were removed, the heart was returned to its normal position, and the patient was weaned from partial cardiopulmonary bypass. After the patient was given an infusion of protamine, the cannulas were removed, the left femoral artery repaired, and the wounds closed.

Postoperatively, the patient's course was complicated by intermittent atrial fibrillation that was eventually controlled with oral antiarrhythmics. The patient was discharged, symptom-free, 8 days after surgery.

DISCUSSION

Minimally invasive CAB involves constructing coronary anastomoses while the heart continues to beat, routinely avoiding cardioplegic arrest and usually avoiding cardiopulmonary bypass.[8,9] If the bilateral internal mammary arteries are used as conduits, coronary revascularization can be accomplished without aortic manipulation. This offers clear advantages over conventional management for patients with heavily calcified proximal aortas that require coronary revascularization by avoiding manipulation of the ascending aorta. First used as a conduit in the 1970s, the internal mammary artery has become the conduit of choice and is routinely used in the majority (80%) of all coronary bypass cases.[10,11]

In the case presented, cardiopulmonary bypass was used because the patient's ejection fraction was low and the heart was dilated. The coronary arteries were small, and the patient had cardiomegaly and chronic atrial fibrillation. Cardiopulmonary bypass allowed us to operate on a partially decompressed heart and to perform anastomosis on the marginal artery more easily.

Past techniques utilized to manage porcelain aorta have several disadvantages. Intraoperative epicardial echocardiography with modified cannulation and cross-clamping and proximal aortic endarterectomy both carry a significant risk of residual atheroembolism.[12] Prosthetic graft replacement of the ascending aorta is a complicated procedure requiring hypothermic circulatory arrest. Cold fibrillatory arrest is not an optimal method of myocardial protection. This procedure is associated with substantial morbidity and increased mortality.[7] Wound healing problems and local vascular injury can complicate peripheral arterial cannulation.[5]

CONCLUSION

For patients with porcelain aorta, less invasive CAB represents a safer and better management alternative than conventional techniques.[13] **HP**

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