Hybrid three-stage repair of mega aorta syndrome with the Lupiae technique

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Objective: Open surgical replacement of the whole aorta in mega aorta syndrome remains a surgical challenge. We report our experience in the treatment of patients with mega aorta syndrome using a 3-stage hybrid repair.

Methods: From January 2006 to December 2011, 12 patients with mega aorta syndrome underwent total replacement of the aorta with a 3-stage hybrid repair, consisting of total replacement of the arch (first stage), retrograde revascularization of the visceral vessels (second stage), and deployment of an endograft (third stage). The intraoperative, early (30-day), and follow-up results were analyzed.

Results: No intraoperative mortality occurred in any of the open or endovascular procedures. After the first stage, 1 patient died, resulting in a 30-day mortality of 8.3%. After the second stage, the overall major morbidity was 27.3% (1 surgical revision and 2 temporary dialysis treatments). After the third stage, no conversion or major complication was recorded. The overall mean follow-up period was 31.9 months (range, 1-60 months). One patient died at 10 months postoperatively, and another patient required adjunctive implantation of a stent graft for a type III endoleak. At 3 years, the estimated survival, freedom from any device-related reinterventions, and freedom from type I endoleak was 83.3%, 77.9%, and 100%, respectively.

Conclusions: Our hybrid 3-stage approach seems to be effective in the treatment of mega aorta syndrome. The second stage was affected by non-negligible rates of perioperative complications. The overall mid-term results were encouraging, although a larger sample size with longer follow-up is needed to compare this technique with others. (J Thorac Cardiovasc Surg 2013;145:S171-7)

Multilevel aneurysmal aortic disease is a well-recognized condition.[1] Sometimes, the whole aorta, from the coronary artery ostia to the iliac bifurcation, is involved in the aneurysmal disease. This condition has been described as mega aorta syndrome (MAS).[2]

Open surgical replacement of the whole aorta is a surgical challenge. The substitution of the aorta during a single operation has been described in only a few reports.[2,3] The need to minimize the perioperative mortality and morbidity rates has encouraged many surgeons to investigate less-invasive techniques. Borst and colleagues[4] first described the elephant trunk technique, consisting of a 2-stage open repair. Crawford and colleagues[2] treated most of their patients with MAS using 2 to 3 open surgical steps. Recently, Shah and colleagues[5] described a 2-stage hybrid repair, consisting of a total arch replacement (stage I elephant trunk) followed by a hybrid open or endovascular repair of the thoracoabdominal segment.

We report our experience in the treatment of patients with MAS using a 3-stage hybrid repair, consisting of the total replacement of the arch (first stage), retrograde revascularization of the visceral vessels (second stage), and deployment of an endograft (third stage).

PATIENTS AND METHODS

Patients

From January 2006 to December 2011, we treated 96 patients with multilevel aneurysmal aortic disease. Of these, 12 patients with MAS underwent total replacement of the aorta with a 3-stage hybrid repair. All data concerning these interventions were prospectively collected in a dedicated database with about 80 fields, including demographic data, preoperative risk factors, clinical and diagnostic preoperative assessments, intraoperative features, and early (30-day) and follow-up results. All patients gave their written consent to the procedures, which were approved by the ethics committee. The first 2 stages were performed in the operating room, and the last endovascular stage was performed in the angiographic suite (Figure 1).

First Stage

The first stage has been described in a previous report.[6] After induction of general anesthesia with endotracheal intubation, a transesophageal probe was inserted and transesophageal echocardiography monitoring was performed in all patients. Surgical repair was performed through a median sternotomy with the extension of the incision along the medial border of the left sternocleidomastoid muscle to better expose the supra-aortic vessels. After full intravenous anticoagulation, the brachiocephalic trunk was directly cannulated or exposed through a small right infraclavicular

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Abbreviations and Acronyms
MAS = mega aorta syndrome
TAAA = thoracoabdominal aortic aneurysm

incision using an 8-mm Dacron tube graft. Extracorporeal circulation and systemic cooling were started after cannulation of the right atrium with a standard 2-stage venous cannula, and the heart was vented through the right superior pulmonary vein. The left subclavian artery was then detached from the aortic arch and anastomosed end-to-end to an 8-mm Dacron tube graft connected to a separate low flow (10 mL/kg/min) perfusion line. Next, the ascending aorta was crossclamped. Myocardial protection was achieved using intracoronary infusion of cold (5°C-8°C) crystalloid cardioplegia (Custodiol; Koehler Chemie, Alsbach-Haenlein, Germany). The proximal supracoronary aortic anastomosis was performed with 4-0 monofilament sutures using the Lupiae graft (Vascutek Terumo Inc, Inchinnan, Scotland), constructed with a standard cylindrical Dacron graft, with a trifurcated graft of different sizes (10, 10, and 8 mm) and another side branch of 10 mm coming off the main body of the prosthesis.[7]

After completion of the proximal anastomosis and achievement of moderate systemic hypothermia (26°C-28°C), distal aortic flow was discontinued, and selective antegrade cerebral protection was begun, with a flow rate of about 10 mL/kg/min to maintain an arterial pressure in the right radial artery of 40 to 60 mm Hg. The distal anastomosis was performed on the aortic arch, preferring the space between the left carotid artery and left subclavian artery, with 4-0 monofilament sutures. The aortic crossclamp was released, and perfusion of the heart and distal thoracic aorta was guaranteed by connecting the arterial line with the lateral 10-mm Dacron branch of the Lupiae graft. Next, the left carotid artery and thereafter the brachiocephalic trunk were anastomosed to the bovine trunk-like side branch (8 and 10 mm, respectively) of the Lupiae graft. Finally, after rewarming and removing extracorporeal circulation, the 10-mm side lateral branch of the Lupiae graft used for arterial systemic perfusion was anastomosed to the Dacron graft used for selective perfusion of the left subclavian artery (Figure 2, *A*).

Second Stage

With the patient under general anesthesia and in the supine position, a midline laparotomy was performed. The abdominal aorta, common iliac arteries, and initial portion of the celiac trunk, superior mesenteric artery, and renal arteries were exposed. The Lupiae graft or a similar multibranched graft was used for visceral vessel debranching. After intravenous anticoagulation, the abdominal aorta was crossclamped and replaced using the main body of the multibranched Dacron graft, using 4-0 monofilament sutures (Figure 2, *B*).

The side branches were distally anastomosed to the visceral vessels in a retrograde manner. In all reconstructions, the visceral vessels were ligated proximally to prevent retrograde perfusion of the aneurysmal sac. For renal revascularization, diuresis was forced by systemic infusion of furosemide. During renal artery crossclamping, a continuous perfusion of approximately 500 mL of cold (4°C) crystalloid lactated Ringer's solution was administered into the orifice of the renal artery to reduce the temperature of the kidney (to 15°C-18°C). For celiac trunk revascularization, the graft was routed in front of the left renal vein behind the pancreas. The superior mesenteric artery was anastomosed in a lazy-C fashion to avoid kinking. In all cases, the inferior mesenteric artery was reimplanted. All visceral anastomoses were performed in an end-to-side fashion (with the exception of the celiac trunk, which was anastomosed end-to-end) using 5-0 monofilament sutures. A final sequential declamping was performed. The grafts were then covered with retroperitoneum whenever possible.

Third Stage

The endovascular step was performed with the patient under locoregional anesthesia. One of the common femoral arteries was surgically exposed. The contralateral femoral artery was cannulated with a percutaneous puncture. The first step consisted of positioning a 0.035-in. guidewire (Terumo, Terumo Medical Corp, Tokyo, Japan) for the insertion of a 5F short sheath using the percutaneous approach. Next, a 5F pigtail catheter (Cordis Corp, Miami, Fla) was positioned immediately above the ostia of the coronary arteries. An intraoperative angiogram with nonionic contrast medium was performed to visualize the proximal radiopaque markers of the Lupiae graft.

Through the surgical access site, using a 260-cm Lunderquist stiff wire (Cook Inc, Bloomington, Ind), the stent graft with its delivery system was advanced. The image intensifier was positioned at the base of the aortic arch to obtain the optimal angle for deploying the graft. When the proximal radiopaque markers of the Lupiae graft were visualized, delivery was performed. A completion angiogram was always performed to verify immediate technical success. Then the device was removed, and the other modules were deployed to cover the entire aorta up to the aortic anastomosis of the visceral debranching graft, using the radiopaque marker of the Lupiae graft. For adequate sealing of the stent graft, ballooning of the whole graft was performed in all cases with a Reliant balloon (Medtronic Cardiovascular, Santa Rosa, Calif; Figure 2, *C*).

Follow-up and Statistical Analysis

All patients routinely underwent computed tomography scan at each discharge. A computed tomography scan was then performed after the third stage at 6 and 12 months postoperatively and yearly thereafter. Statistical analysis was performed using SPSS, version 15.0, for Windows (SPSS Inc, Chicago, Ill). Continuous data are expressed as the mean ± range. Categorical data are expressed as percentages. Follow-up data in terms of survival, freedom from any device-related reintervention, and freedom from type I endoleak were analyzed using life-table analysis (Kaplan-Meier test).

RESULTS

Preoperative Clinical and Anatomic Features

Patient demographic data and preoperative risk factors are summarized in Table 1. The patients were predominantly men (9/12, 75%), with a mean age of 69.1 years (range, 28-81 years). According to the American Society of Anesthesiologists classification, before the first procedural stage, 4 patients (33.3%) were considered in class IV. All patients had massive dilatation of the aorta; no dissections were present. One young patient had Marfan syndrome. The mean diameter of the aorta was 66.7 mm (range, 56-80 mm).

The intraoperative technical data from each patient at each stage are listed in Table 2. During the first stage, 6 patients (50%) underwent concomitant aortic valve repair, and 2 patients underwent concomitant coronary artery bypass grafting. After each procedure, the patients were admitted to the intensive care unit.

Early Results

No intraoperative mortality occurred in any of the open or endovascular procedures. After the first open surgical stage, 1 patient died of rupture of the descending thoracic aorta, for an overall perioperative 30-day mortality rate of 8.3%