Outcomes of total arch replacement with stepwise distal anastomosis technique and modified perfusion strategy

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Objective: Total arch replacement has been reported to present high morbidity and mortality. We have introduced a stepwise distal anastomosis technique and modified perfusion strategy, including selective antegrade cerebral perfusion, moderate hypothermia, and separate lower-body perfusion, to minimize organ ischemia and secondary morbidities. We report the operative outcomes of total arch replacement with our modified perfusion strategy.

Methods: Between August 2006 and December 2008, 119 patients underwent total arch replacement with the current perfusion strategy. Of these patients, 56 (47%) underwent emergency operation for acute type A aortic dissection (n = 48) or ruptured thoracic aneurysm (n = 8). The mean age of patients was 68 years, and the mean follow-up period was 25 months. We analyzed operative mortality, morbidity, and 4-year survival of this patient group.

Results: The mean operation, cardiopulmonary bypass, and circulatory arrest times were 313, 183, and 47 minutes, respectively. Operative mortality was 3.4%. Operative mortality of elective cases was 1.6%. The incidences of permanent neurologic deficit, paraparesis, and renal insufficiency were 5.0%, 1.7%, and 7.6%, respectively. Actuarial 4-year survival was 86.5%.

Conclusions: Total arch replacement with our modified perfusion strategy has demonstrated low operative mortality and morbidity. (J Thorac Cardiovasc Surg 2012;143:1377-81)

Total arch replacement (TAR) has been reported to demonstrate high morbidity and mortality. Various operative techniques and cerebral protection strategies have been presented to improve the operative outcomes of TAR. The stepwise distal anastomosis technique was introduced as an effective method to control bleeding from the distal anastomosis.[1] In this technique, an invaginated tube graft is inserted into the distal aorta, the graft is sewn on the aorta with running sutures, the end of the inserted graft is pulled out, and the graft is anastomosed in a 4-branched graft.[1] We have used this technique as a routine in TAR. One of its drawbacks is a prolonged hypothermic circulatory arrest (HCA) time because of an additional anastomosis.[1] To shorten HCA time and prevent organ ischemia, we introduced separate lower-body perfusion and antegrade selective cerebral perfusion (SCP) in 2006. We report the outcomes of a recent series of TAR using this stepwise distal anastomosis technique and modified perfusion strategy. We also compared these outcomes with those of our previous series using the arch first technique with retrograde cerebral perfusion (RCP).

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PATIENTS AND METHODS

This study was approved by the institutional review board, and a waiver of informed consent was obtained. Between August 2006 and December 2008, 119 patients underwent TAR at Sakakibara Heart Institute. Fifty-six patients (47%) had an emergency operation. Of these patients, 48 had acute type A aortic dissection and 8 had ruptured thoracic aortic aneurysm. Among 63 patients undergoing elective surgery, 56 had true aneurysm and 7 had chronic dissected aneurysm. Our indication of TAR included aneurysm of the aortic arch and acute aortic dissection with distal arch dilation or entry located in the distal aortic arch. The mean age of patients was 68 ± 12 years, and 25 (21%) were women. Fifteen patients (12.5%) had a reoperative sternotomy after previous cardiac surgery. The other patients' characteristics are shown in Table 1. We performed concomitant procedures in 37 patients: coronary artery bypass grafting in 30, aortic valve replacement in 4 (including 2 patients undergoing concomitant coronary artery bypass grafting and aortic valve replacement), Bentall operation in 3, and aortic reimplantation in 2. The mean follow-up period was 25 ± 15 months.

Between January 2004 and August 2006, 67 patients underwent TAR using the arch first technique with RCP. Preoperative characteristics and operative variables are shown in Table 1.

Perioperative data were collected from patients' medical records. Transient neurologic deficit was defined as a central neurologic deficit that has resolved within 72 hours, and permanent neurologic deficit was defined as a central neurologic deficit persisting for more than 72 hours. All permanent neurologic deficits were confirmed by computed tomography or magnetic resonance imaging. Postoperative renal insufficiency was defined as serum creatinine more than 2.0 mg/dL, 2 times more than the most recent preoperative creatinine level, or new requirement for dialysis postoperatively.

Abbreviations and Acronyms
HCA = hypothermic circulatory arrest
RCP = retrograde cerebral perfusion
SCP = selective cerebral perfusion
TAR = total arch replacement

Respiratory failure was defined as a requirement for mechanical ventilation for more than 48 hours postoperatively. Operative mortality was defined as any death within 30 days after surgery or before discharge.

Summary statistics were constructed using frequencies and proportions for categoric data, and mean ± standard deviation or median if appropriate for continuous variables. Univariate analyses were carried out using the *t* test or Mann–Whitney *U* test for continuous variables and the chi-square or Fisher exact test for categoric variables. Survival was estimated using the Kaplan–Meier method.

Surgical Procedure

All operations were performed via a median sternotomy. In aortic dissection cases, the initial arterial cannula was placed in the femoral artery in most cases. The axillary artery or left ventricular apex was cannulated if the femoral artery was unavailable. In true aneurysm, the initial arterial cannula was placed in the ascending aorta.

All patients were cooled to 25°C for circulatory arrest. We established SCP during circulatory arrest by inserting 12F balloon catheters into 3 cerebral branches and snaring them to prevent balloon dislodgement. The balloon catheters were set inside each branch of the 4-branched vascular graft before circulatory arrest. A separate circuit was used for SCP. The flow rate of SCP was kept at 15 to 20 mL/kg/min to maintain the perfusion pressure at more than 50 mm Hg, and the temperature of SCP was kept at 25°C after starting to rewarm the body. Intermittent cold blood cardioplegia was administered both antegradely and retrogradely every 20 to 30 minutes. To avoid recurrent laryngeal nerve injury, we divided the greater curvature of the distal arch and transected the aorta distally to the nerve. A folded elephant trunk graft was inserted into the distal aorta and anastomosed to the aorta with running sutures. The elephant trunk graft was then unfolded to pull up the proximal end of the graft. Hemostasis of the distal anastomosis was confirmed by pumping blood through a cannula in the femoral artery and clamping the proximal end of the graft. Then, separate lower-body perfusion was resumed through a femoral arterial cannula with the balloon occlusion of the elephant trunk. If the femoral artery was unavailable or the descending or abdominal aorta was atheromatous, lower-body perfusion was established through a balloon catheter placed in the elephant trunk. The patient was warmed to 30°C after establishing lower-body perfusion in addition to SCP. A 4-branched vascular graft was anastomosed to the elephant trunk graft (Figure 1), and cerebral branches were separately reconstructed. The 4-branched graft and elephant trunk graft always have the same size because we divide 1 graft into 2 pieces. Total body perfusion was resumed through the fourth branch of the prosthesis after SCP was discontinued, and the patient was warmed to 35°C. Subsequently, hemostasis of graft-to-graft and 3 cerebral anastomoses was confirmed. The proximal anastomosis was performed during rewarming. The sequence of anastomoses is shown in Figure 2. The surgical techniques of previous series using the arch first technique and RCP have been described.[2]

RESULTS

The operative variables and outcomes are shown in Table 2. The mean operation, cardiopulmonary bypass, SCP, and lower-body HCA times (including all concomitant procedures) were 313 ± 67, 183 ± 41, 89 ± 18, and 47 ± 15 minutes, respectively. Compared with our previous series, the times were significantly shorter. The operative mortalities were 3.4% (4/119) in all cases, 1.6% (1/63) in elective cases, 5.4% (3/56) in emergency cases, and 4.2% (2/48) in acute aortic dissection cases. The causes of

TABLE 1. Preoperative characteristics

Variables	Current technique (n = 119)	Arch first technique (n = 67)	*P* value
Age (y)	68 ± 12	68 ± 11	.779
Male	94 (79%)	50 (74.6%)	.494
Emergency operation	56 (47.1%)	43 (64.2%)	.025
True aortic aneurysm	64 (53.8%)	34 (50.7%)	.691
Acute aortic dissection	48 (38.7%)	31 (46.3%)	.432
Chronic aortic dissection	7 (5.9%)	2 (3.0%)	.308
Concomitant procedures	37 (31.1%)	18 (26.9%)	.470
Coronary artery bypass grafting	30 (25.2%)	14 (20.9%)	.506
Aortic root replacement	5 (4.2%)	4 (6.0%)	.416
Aortic valve replacement	4 (3.4%)	0 (0%)	.104
Hypertension	99 (83.2%)	51 (76.1%)	.241
History of cerebrovascular disease	18 (15.1%)	8 (11.9%)	.548
Previous cardiac operation	15 (12.6%)	2 (3.0%)	.029
Moderate or severe chronic obstructive pulmonary disease	9 (7.6%)	2 (3.0%)	.204
Hemodialysis	3 (2.5%)	1 (1.5%)	.643

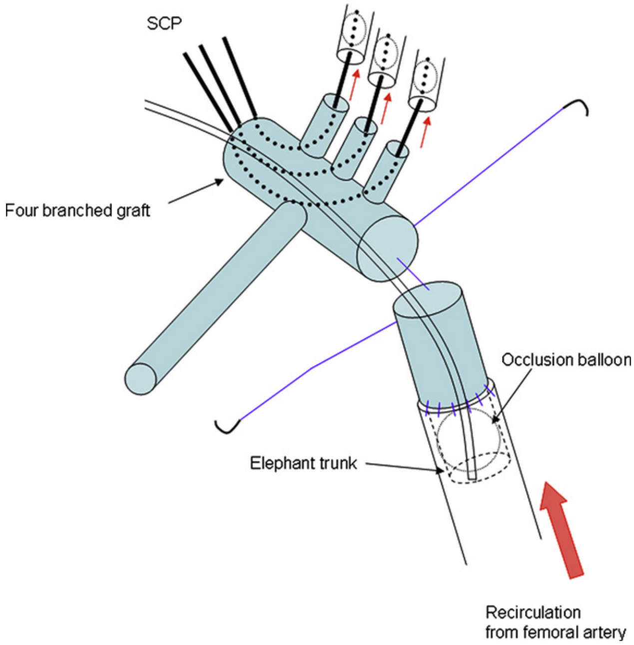

FIGURE 1. Separate lower-body perfusion. After the distal anastomosis, lower-body perfusion is resumed through a cannula placed in the femoral artery with balloon occlusion of the elephant trunk, and a 4-branched vascular graft is anastomosed to the elephant trunk graft. *SCP,* Selective cerebral perfusion.