Total arch replacement using antegrade cerebral perfusion for distal aortic arch aneurysm

Yutaka Okita

Division of Cardiovascular Surgery, Department of Surgery, Kobe University, Japan

Corresponding to: Yutaka Okita. Division of Cardiovascular Surgery, Department of Surgery, Kobe University, Japan. Email: yokita@med.kobe-u.ac.jp.

Total aortic arch replacement remains a complex surgical procedure, best practiced in high-volume aortic centers. The following report details the surgical procedure for total arch replacement with selective antegrade cerebral perfusion (SACP) for distal arch aneurysm. Following moderate hypothermic circulatory arrest and SACP, the distal arch, and then the proximal arch, is reconstructed, followed by re-implantation of epi-aortic vessels.

Keywords: Total arch replacement; selective antegrade cerebral perfusion; distal aortic aneurysm; case report

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Introduction

This is a 75 year-old man with a fusiform aneurysm located in the distal arch. The aneurysm was 6 cm in diameter and contained thick mural thrombi. The associated video aims to guide the reader through the significant steps in total aortic arch replacement using selective antegrade cerebral perfusion (*Video 1*). Total arch replacement was conducted in the following sequence: cerebral protection using moderate hypothermic circulatory arrest combined with selective antegrade cerebral perfusion (SACP), distal arch reconstruction, proximal arch reconstruction, and finally epi-aortic vessel re-implantation. This allows perfusion of the myocardium at a much early stage of the operation and the patient can be weaned off from cardiopulmonary bypass (CPB) immediately following the last epi-aortic vessel anastomosis.

Operative techniques

Exposure

After standard median sternotomy, CPB was established by ascending aorta cannulation using a 24 Fr cannula, oriented towards the aortic valve, as preoperative echocardiogram identified little or no atheromatous change in the ascending aorta. Two venous cannulae were inserted from the right atrium into the superior and inferior vena cava. Three traction sutures at the root of the arch vessels and one at the lesser curvature of the arch were liberally used to facilitate exposure. Dissection of the aneurysm, aortic arch branches, or the vagal nerve were not attempted. No taping around the arch or arch vessels was applied.

Cerebral protection

Core cooling was instituted until both tympanic and rectal temperatures reached 23 and 30 ℃ respectively. Total circulatory arrest was applied, with central venous (CVP) pressure rising to 5 mmHg. The heart was arrested with retrograde cardioplegia. The aortic cannula was removed and the arch was opened longitudinally. A flexible sucker was placed inside the arch, and 3 serrated balloon tipped cannulae (Fuji systems, Tokyo) were inserted into the left subclavian artery (12 Fr), left carotid artery (12 Fr) and the brachiocephalic artery (16 Fr). In severely atherosclerotic arch vessels, arteriotomies of the arch vessels were extended from the diseased ostium to a relatively clear distal part. Cannulae were then placed in position under direct vision, and were fixed to the left side of the skin and secured by stay stitches. After the CVP reduced to zero, SACP was initiated using a single roller pump with flow of 10 to 12 mL/kg/min and perfusate temperature of 23 ℃. The left and the right radial pressure, as well as line pressure of the balloon catheters, were monitored to maintain the pressure between 30 to 50 mmHg.

Cerebral oxygen saturation (rSO_2) was monitored bilaterally in the forehead using near infrared spectroscopy.

Distal arch exposure

Keeping a flexible sucker and gauze sponge in the descending aorta, mural thrombi were removed completely with the aid of copious saline irrigation. The orifice of the descending aorta, distal to the aneurysm, was transected starting at the 3 o'clock position. The adventitia of the descending aorta was identified using electrocautery. The incision was then extended circumferentially in a clockwise manner. To prevent left recurrent nerve injury, we carefully avoid dissection of the vagal nerve. This procedure can also alleviate inadvertent trauma to the esophagus, which is usually located at the 6 o'clock position. The first pair of the intercostal artery and some bronchial artery were carefully ligated or clipped. Usually the ligamentum arteriosus was divided. On the counterclockwise side from 3 o'clock, the aorta was incised, taking care not to injury the parietal pleura. It is vital at this stage not to lose the adventitia and or enter the media layer of the aorta. The descending aorta was then mobilized 2 to 3 cm distally.

Distal arch reconstruction

In this particular patient, as the descending aorta appeared to be in a poor state, a 5 cm graft (Triplex 24 mm: Terumo, Japan) was inserted in the descending aorta to reinforce the anastomosis. A 15 mm wide Teflon felt was wrapped around the aorta and fixed to the elephant trunk and the aorta using several 4-0 polypropylene (Nespilene: Alfresa, Japan) mattress sutures. We have found that this procedure is particularly useful in aortic dissection case.

A triple-layered graft or Gelatin impregnated woven Dacron graft with 4 branches have been exclusively used for total arch replacement. The flexible sucker was placed inside the graft to remove the blood in the descending aorta. A long 4-0 monofluorvinylydene suture (Monofulene 120 cm, 22 mm needle; Alfresa, Japan) was then selected for the anastomosis. As this is a critical anastomosis, meticulous suturing and handling of the tissue is of utmost importance. Suturing should be steady and completed in a step-by-step manner, with at least 1 cm bites to ensure security.

After the flexible sucker was removed and the descending aorta was filled with blood, antegrade perfusion of the lower body was slowly started through the 4th side branch of the graft. Distal anastomosis were inspected for leaks, followed by initiation of patient rewarming. Concurrently, SACP flow was gradually increased while maintaining the baseline values of rSO_2. SACP flow was limited to below 1,200 mL/min to prevent cerebral edema.

Proximal reconstruction

The ascending aorta was transected 2-3 cm above the sinotubular junction. The same Teflon strip was wrapped around the aorta and the proximal anastomosis to the aorta was done using a 4-0 polypropylene suture (Nespilene 120 cm, 17 mm needle; Alfresa, Japan).

Epi-aortic vessel re-implantation

After deairing procedures, the graft clamp was released and the heart was reperfused. The aortic arch was divided to form arch vessel buttons with traction sutures. Three arch vessels were reconstructed in tandem to the graft branches using a 5-0, 17 mm needle polypropylene suture (Nespilene, Alfresa, Japan). If the arterial wall was very atheromatous, distal extension of the arteriotomy was performed until suitable healthy arterial wall was located. Usually the parachute technique was used. The balloon cannula was removed near the end of each anastomosis and liberal back flow was used for flushing the debris.

Comments

Duration of cardiopulmonary bypass was 135 minutes, cardiac ischemia 57 minutes, distal circulatory arrest 39 minutes, and selective antegrade cerebral perfusion 81 minutes. Minimum typanic temperature was 21 ℃ and rectal tepmerature was 28 ℃.

Our sequence of total arch replacement is as follows: cerebral protection using moderate hypothermia with SACP, distal arch reconstruction, proximal anastomosis before re-implantation of epi-aortic vessels. This is to allow early re-warming and perfusion of the heart, so that CPB can then be immediately weaned-off after the anastomosis of the brachiocephalic artery.

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