Total debranching hybrid total arch replacement with a novel frozen elephant trunk for acute aortic dissection type A

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Central Message

Total debranching of the supra-aortic vessels with a novel frozen elephant trunk technique facilitated total arch replacement, ensuring optimal brain protection in acute aortic dissection type A.

See Commentary on page e5.

Video clip is available online.

Total arch replacement is an ideal surgical procedure for acute aortic type A dissection for preventing adverse events in the downstream aortic segments during later follow-up.¹⁻³ The procedure is occasionally challenging, however, because of the very fragile aortic wall in addition to the deep surgical field. Moreover, dissection often compromises supra-aortic vessels, and ensuring perfusion in the true lumen of the supra-aortic vessels is therefore sometimes difficult during total arch replacement. To simplify the procedure and ensure complete true-lumen perfusion in all supra-aortic vessels during total arch replacement, we used a total debranching method (Video 1), as applied in thoracic endovascular aortic repair.⁴

PREINCISION PREPARATION

A central venous catheter is inserted from the femoral vein. Disinfection and surgical draping are applied in the area of bilateral carotid and axillary arteries.

STEP 1: ENSURING PERFUSION OF THE BRAIN AND UPPER BODY

First, 3 small incisions are made to expose the right and left common carotid arteries and the left axillary

artery. Median sternotomy is performed. A body of a quadrifurcated graft (Intergard, Getinge, Germany) is positioned at the level of the ascending aorta, and the 3 branches are pulled to the 3 small skin incisions. The grafts are tunneled not directly along the common carotid arteries, but rather in the layer just below the sternum to avoid recurrent laryngeal nerve injury. After systemic

VIDEO 1. Total debranching hybrid total arch replacement with novel frozen elephant trunk. CT, Computed tomography; 3DCT, 3-dimensional computed tomography. Video available at: [https://www.jtcvs.org/article/S0022-5223\(19\)31363-7/fulltext](https://www.jtcvs.org/article/S0022-5223(19)31363-7/fulltext).

FIGURE 1. Schema of total arch replacement with total debranching of the supra-aortic vessels by using a quadrifurcated graft and a novel frozen elephant trunk technique for acute aortic type A dissection. A, After median sternotomy, 3 branches of quadrifurcated graft are tunneled to 3 small skin incisions and anastomosed one by one to the right carotid, left carotid, and left axillary arteries. Cardiopulmonary bypass is started through the fourth branch of the quadrifurcated graft. B, The ascending aorta is transected at a level 1 cm distal to the sinotubular junction. A short segment of a single-branched graft is anastomosed to the proximal ascending aorta with external polytetrafluoroethylene felt enforcement, with initial 3-point fixation and then in double running suture fashion. C, After ligation of all 3 native supra-aortic vessels, moderate hypothermic circulatory arrest with selective cerebral perfusion is initiated. The ascending aorta is transected at the level 2 cm proximal to the brachiocephalic trunk, and a frozen elephant trunk device is inserted into the aortic arch. A single-branched graft is anastomosed to the residual native distal ascending aorta together with the frozen elephant trunk. D, The main body of the quadrifurcated graft is anastomosed to the single-branched graft in end-to-side fashion. E, End-to-side anastomosis of the quadrifurcated graft with the single-branched graft is performed, followed by end-to-end anastomosis of the proximal short graft with the distal graft. F, Final schema of the procedure.

heparinization, the right common carotid, left common carotid, and left axillary arteries are anastomosed one by one with branches of the graft (Figure 1, A). After finishing all 3 anastomoses, cardiopulmonary bypass (CPB) is started with 4.5 to 5.0 L/min flow (cardiac index, 2.4) through the fourth branch of the quadrifurcated graft and bicaval venous drainage.

STEP 2: CARDIOPROTECTION AND SURGICAL MANAGEMENT OF THE AORTIC ROOT

The left atrium is vented through the right upper pulmonary vein. The ascending aorta is crossclamped, and

retrograde cardioplegia is applied under control of perfusion pressure. The ascending aorta is transected at 1 cm distal to the sinotubular junction. The dissected intima is fixed with BioGlue (CryoLife International Inc, Kennesaw, Ga) as necessary. A short segment cut from a single-branched Dacron polyester fabric graft (J-Graft; Japan Lifeline, Tokyo, Japan) is anastomosed to the proximal ascending aorta with external polytetrafluoroethylene felt enforcement, with initial 3-point fixation and then in double running suture fashion (Figure 1, B). All lines of anastomosis are sealed with the BioGlue. If needed, root replacement is performed in this phase.

FIGURE 2. A, Preoperative computed tomography showing arch dissection extending to the right common carotid artery (white arrow). B, Postoperative computed tomography showing a patent true lumen in the right common carotid artery (white arrow). C, Postoperative computed tomographic 3-dimensional reconstructed model.

STEP 3: HYBRID REPLACEMENT OF THE AORTIC ARCH

When rectal temperature reaches 28°C, CPB flow is reduced to 2.0 L/min and all 3 native supra-aortic vessels are ligated, thereby inducing moderate hypothermic circulatory arrest with selective cerebral perfusion. The ascending aorta is transected at 2 cm proximal to the brachiocephalic trunk. Regardless of the position of the intimal tear, a very soft frozen elephant trunk device (Frozenix; Japan Lifeline) is inserted into the aortic arch. The size of the frozen elephant trunk is determined by preoperative computed tomography but typically ranges from 27 to 31 mm in diameter and 90 mm in length, because an overly long prosthesis increases the risk of paraplegia.

A single-branched Dacron polyester fabric graft is anastomosed to the residual native distal ascending aorta together with the frozen elephant trunk with a technique similar to that used for the proximal anastomosis (Figure 1, C). Thereafter, the main body of quadrifurcated graft is anastomosed to the single-branched graft in end-to-side fashion (Figure 1, D). The arterial perfusion line is switched from the fourth branch of the quadrifurcated graft to the side branch of the distal ascending graft.

STEP 4: FINALIZATION OF AORTIC CONTINUITY AND END OF EXTRACORPOREAL CIRCULATION

The proximal and distal grafts are anastomosed in end-to-end fashion (Figure 1, D). The aorta is declamped, and active deairing through the fourth branch of the

quadrifurcated graft, weaning from CPB, and closure are achieved according to standard techniques (Figure 1, E).

RESULTS

From November 2017 to December 2018, 7 patients underwent the procedure. Mean operative, CPB, and selective cerebral perfusion times were 443.1 ± 123.8 , 152.7 ± 57.0 , and 34.9 ± 10.4 min, respectively. No patient showed postoperative neurologic symptoms. The false lumens of the right common carotid artery that had previously been seen in 4 patients had completely disappeared in postoperative computed tomography (Figure 2). Median length of hospital stay was 19 days. There was a single 30-day death of acute hepatitis.

DISCUSSION

The procedure might offer a good therapeutic option for acute aortic type A dissection, ensuring optimal brain protection and minimizing the risks, particularly for patients who have preoperative brain malperfusion. Moreover, frozen elephant trunk would be an ideal landing zone for potential thoracic endovascular aortic repair for late-phase aortic events.

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