Total aortic arch replacement using frozen elephant trunk: the beating-heart technique

Selim Mosbahi, Maris Bartkevics, Maria Nucera, Martha Veit, Matthias Siepe, Florian S. Schoenhoff

Department of Cardiac Surgery, Inselspital, University Hospital Bern, Bern, Switzerland

Correspondence to: Florian S. Schoenhoff, MD. Department of Cardiac Surgery, Inselspital, University Hospital Bern, Bern, Switzerland. Email: florian.schoenhoff@insel.ch.

Keywords: Aorta; beating heart; aortic arch; frozen elephant trunk (FET); dissection

Submitted Mar 15, 2025. Accepted for publication Jul 14, 2025. Published online Sep 10, 2025.
doi: 10.21037/acs-2025-evet-18
View this article at: https://dx.doi.org/10.21037/acs-2025-evet-18

Clinical vignette

This report demonstrates the use of the beating-heart frozen elephant trunk (FET) technique in a 59-year-old male patient presenting with a 55-mm proximal descending aortic aneurysm. The patient had suffered from acute type A aortic dissection in 2008, which was managed with mechanical aortic root replacement and hemiarch replacement. In 2016, he underwent aorto-bi-iliac replacement. The accompanying video is an integral part of this article.

Preoperative computed tomography (CT) imaging revealed a large 28-mm bronchial artery aneurysm in the mediastinum, located directly posterior to the pulmonary artery bifurcation. This aneurysm was excluded from circulation using endovascular embolization prior to the arch procedure. Coronary CT scanning showed coronary artery sclerosis without hemodynamically relevant lesions. Transthoracic echocardiography confirmed preserved left ventricular function and no significant valvular heart disease. Brain MRI revealed an abnormal circle of Willis with absent anterior communicating artery (ACOM), right posterior communicating artery (PCOM), and a hypoplastic left PCOM, resulting in symmetric perfusion deficits of the posterior cerebral circulation. These findings were clinically silent but considered during planning to optimize cerebral protection during the procedure.

Operative technique

Preparation and exposition

For total arch replacement, the right axillary artery is the preferred cannulation site, typically exposed at the subclavian level to minimize brachial plexus injury. A 3.5-mm vascular punch is used to prepare the vessel, followed by end-to-side anastomosis of an 8-mm Dacron graft with a 6-0 Prolene suture. The graft is flushed using arterial inflow and then with heparinized saline to prevent thrombus formation. Resternotomy is performed with careful dissection of the heart and supra-aortic vessels. The innominate vein is extensively mobilized, especially towards the left side. Venous cannulation is established, and cardiopulmonary bypass (CPB) is initiated with gradual cooling to 26 ℃ to avoid early ventricular fibrillation. A left ventricular vent is placed via the right superior pulmonary vein, monitored by transesophageal echocardiogram (TEE) to ensure effective decompression during selective myocardial perfusion (SMP).

Initial mobilization of the left common carotid artery facilitates safe exposure of the left subclavian artery. All supra-aortic vessels are looped with double-wrapped vessel loops for secure positioning of cerebral perfusion catheters. The left subclavian artery is occluded with three pledgeted 4-0 Prolene U-stitches, avoiding the fragile aortic arch wall. The artery is clamped distally, opened partially to confirm no residual flow, transected, and oversewn. An 8 mm Dacron graft is sutured end-to-end, reinforced with bovine pericardium. A perfusion catheter is inserted into the graft and selective antegrade cerebral perfusion (SACP) is initiated. In this case, the patient had reached target temperature at that point, so SMP was started next.

Operation

A cardioplegia cannula with a pressure-monitoring side port is inserted into the proximal aortic prosthesis from the previous operation. The graft is clamped distally, and warm blood (32 ℃) is delivered at 250–300 mL/min to maintain root pressure between 50–70 mmHg. The perfusionist monitors vent return; TEE is used to observe ventricular performance. In this case, the heart entered ventricular fibrillation prior to perfusion but returned to sinus rhythm following defibrillation. A heart rate of 80–90 bpm is maintained throughout using epicardial pacing wires.

Due to large communications between lumina, a femoral arterial sheath was placed preoperatively. A soft guidewire and pigtail catheter are advanced to the arch under TEE guidance to confirm placement in the true lumen. Once the temperature reaches 26 ℃, pump flow is lowered, and the innominate artery is clamped. With flow re-established to maintain right arm pressure at ~60 mmHg, the arch is opened and partially resected. A second SACP catheter is inserted into the left common carotid artery. The appropriate FET prosthesis is selected, shaped, and introduced over the guidewire. The guidewire and catheter are withdrawn before releasing the tip capture to prevent entrapment. The distal anastomosis is completed with 3-0 Prolene and reinforced with felt or, preferably, pericardium. Reperfusion is resumed through the FET graft, and cerebral perfusion continues via the 3rd SACP catheter now placed in the graft on the right subclavian artery. The distal anastomosis is generally performed in zone 2.

Completion

A graft-to-graft anastomosis is performed between the FET prosthesis and the left subclavian artery graft, ensuring thorough de-airing. The proximal graft-to-graft anastomosis is then completed during rewarming. Depending on cerebral perfusion patterns, this may be done before or after reconnecting the left common carotid artery. Cross-clamps are released after de-airing, with no electrocardiogram (ECG) changes noted. The left common carotid and innominate arteries are reconnected sequentially using 5-0 Prolene with bovine pericardial reinforcement. Once full rewarming to 36 ℃ is achieved, the patient is weaned from bypass, and the chest is closed in the standard fashion.

Comment

The main advantage of the beating-heart FET technique is the significant reduction in cardiac ischemic time, as only the root procedure is performed under cardioplegic arrest, while the remainder of the surgery is completed with the heart beating. SMP can be routinely applied if the ascending aorta or a previously placed graft is accessible. We recommend beginning with cases where the aortic root has already been replaced, as this greatly simplifies the approach. Although there are few contraindications, SMP should be avoided in acute dissections with fragile supracoronary replacements due to the risk of pressure-related rupture. SMP is only suitable in patients with no more than mild aortic regurgitation to prevent left ventricular dilatation.

The success of SMP depends on close collaboration between the surgeon, anesthesiologist, and perfusionist. While the surgeon focuses on distal repair, the team must ensure proper left ventricular decompression and stable coronary perfusion. If perfusion pressures drop or signs of ischemia arise, immediate conversion to cardioplegia is advised and can be done safely without additional cardiac manipulation.

In our experience, SMP shortens not only duration of cardiac ischemia but also CPB times by minimizing cooling and rewarming phases. While we perform these operations at 26 ℃ core temperature, the comprehensive use of SMP and SACP may allow for higher core temperatures in future protocols. The patient in our video recovered uneventfully except for right-sided pneumonia and was discharged on postoperative day 10, with thoracic endovascular aortic repair (TEVAR) planned subsequently.

Acknowledgments

None.

Footnote

Funding: None.

Conflicts of Interest: The authors have no conflicts of interest to declare.

Cite this article as: Mosbahi S, Bartkevics M, Nucera M, Veit M, Siepe M, Schoenhoff FS. Total aortic arch replacement using frozen elephant trunk: the beating-heart technique. Ann Cardiothorac Surg 2025;14(5):389-391. doi: 10.21037/acs-2025-evet-18