



Endovascular Total Arch Repair Using *In Situ* Laser Fenestration

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Abstract

Repair of the aortic arch can pose a challenge to surgeons regardless of pathology. Although open surgical techniques offer solutions for complex aortic abnormalities, they are morbid and technically difficult procedures that carry considerable risk. Many techniques are associated with serious post-operative setbacks. In the aortic arch, cerebral perfusion must be balanced with repair of complex pathology. *In situ* fenestration of aortic stent grafts with temporary cerebral perfusion may allow these complex aortic pathologies to be treated minimally invasively with faster recovery, lower morbidity, and lower mortality.

Case Presentation

We present the case of a 45-year-old man with past medical history of gastroesophageal reflux disease, GI bleeding, left below-knee amputation, and prior type A aortic dissection repair three years prior. He presented with chest pain and was ruled out for myocardial infarction and pulmonary embolism. A computed tomography (CT) scan was performed, revealing a residual dissection involving the aortic arch and normal supra-aortic arch anatomy (Figure 1). Despite adequate blood pressure treatment and appropriate analgesics, he continued to experience severe sub-sternal and back pain, similar to the symptoms he experienced at the time of his dissection. Considering his previous surgery, the risks associated with sternal re-entry and hypothermic circulatory arrest, and his limited mobility, an endovascular repair was advised. Here we describe the first endovascular total arch repair using *In situ* fenestration with LASER of all supra-aortic trunks.

The patient was taken to the operating room and anesthetized. The right common femoral vein was cannulated percutaneously, and a pacing balloon catheter was advanced into the right atrium for pacing during delivery of the endostent. The right common femoral artery was cannulated percutaneously using the pre-close technique with 2 Perclose ProGlide SCM devices (Abbott Vascular, Abbott Park, Illinois), and the vessel was prepared for delivery of the endostent. The left common femoral artery (LCFA), both common carotid arteries, and both axillary arteries were accessed surgically. Heparin was given (100 u/kg) to achieve an ACT >250 in preparation for construction of the cerebral perfusion bypass circuit.

An 8 mm Hemashield graft (Maquet Cardiovascular LLC, Wayne NJ) was sewn end-to-side onto the LCFA for inflow. Each carotid artery was accessed antegrade with 13 Fr Guthrie balloon-tipped catheters through small arteriotomies for outflow. The circuit was connected through a Medtronic Biomedicus centrifugal pump at 800 ml/min flow rate. The system was appropriately purged of air. Cerebral perfusion was assessed with INVOS cerebral oximeter (Somanetics, Troy, MI).

The supra-aortic vessels were then prepared for retrograde cannulation with AptusTourGuide sheaths (Medtronic, Santa Rosa, CA): 7 Fr in the left axillary and left common carotid arteries, and 8 Fr in the right axillary artery. These sheaths were used to guide a 2.5 mm Turbo Elite LASER catheter (Spectranetics, Colorado Springs, CO) over a 0.035" wire to rest perpendicular over the thoracic endostent in preparation for fenestration. A 32 mm × 32 mm × 150 mm Thoracic Valiant Captivia endograft (Medtronic, Santa Rosa, CA) was deployed across the arch covering zones 0 to 3.

Each fenestration was made by applying LASER energy (45 mJ/mm² fluence at 25 pulses/s), and then patency was maintained by passing balloon expanded stents such that one third of the stent remained within the lumen of the aorta. The LCCA was fenestrated first with a 7 mm × 38 mm balloon-expandable iCAST covered stent (Atrium Medical, Hudson, NH, USA). The brachiocephalic orifice

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Figure 1: Pre-operative CT angiography demonstrating residual arch dissection.

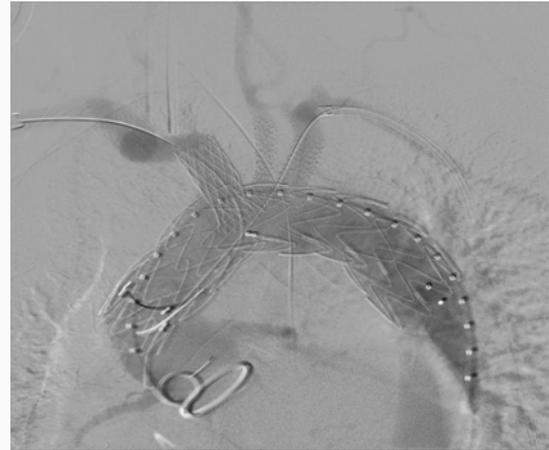


Figure 2: Completion angiography demonstrating the arch endostent and perforating vessel stents. The patient's prosthetic aortic valve is also visible.

was completed second by exchanging the 8 Fr sheath for a larger 14 Fr Cook sheath to deliver a 12 mm × 40 mm Palmaz stent (Cordis Corp, Fremont, CA). The left subclavian was completed last with a 10 mm × 38 mm iCAST stent.

A completion angiogram demonstrated good seals proximally and distally (Figure 2). All three trunks were widely patent. The arterial sheaths and carotid perfusion catheters were removed sequentially. All arteriotomies were repaired with Prolene suture. The left common femoral artery conduit was oversewn. All wounds were closed in standard fashion. He discharged to home on POD# 4. CT angiogram at one month showed a small, persistent endoleak at the origin of the Palmaz stent that resolved without intervention. Two head CTs were ordered in the first post-operative month for transient neurologic complaints; both were normal. The patient's acute chest pain resolved. Follow-up CT angiograms have demonstrated excellent graft position, graft patency, and no progression of aortic dissection.

Discussion

During surgery of the aortic arch, minimizing cerebral and spinal cord injury is paramount [1,2]. The most common methods of cerebral protection are deep hypothermic circulatory arrest, retrograde cerebral perfusion, and antegrade cerebral perfusion. Rates of neurologic injury vary, but excellent results have been reported with each technique [3]. Endograft fenestration facilitates arch repair by allowing grafts to be deployed without interruption of blood flow [4]. Maneuvers such as bare stent placement, vessel transposition, and bypass grafting have been used to achieve this [5]. Cerebral protection was achieved in our patient through temporary bypass to both carotids from a femoral artery as described by Sonesson et al. [6].

Despite widespread increases in endovascular surgery, much thoracic aortic pathology is still treated conventionally. Post-operative mortality rates range from 6% to 13% in the first month [1]. Endovascular treatments for similar cases have significantly reduced rates of complications and mortality [7,8]. However, the risks have not been eliminated. Incidences of stroke and paraplegia vary widely. A review of literature [8] published in 2006 revealed a 2.2% incidence of stroke in patients who underwent thoracic aortic endograft treatment. In a prospective cohort study of 606 patients, Buth et al. [1] reported the combined incidence of stroke and paraplegia following endovascular surgery to be 5%. The authors noted that

such complications occurred only if the left subclavian artery was not revascularized (8.4% vs. 0%).

In situ laser fenestration of endografts is an effective surgical alternative to open repair. An endovascular total arch repair has been described with branched endografts, but this technology is not yet commercially available in the United States. Domestic reports of *In situ* fenestration in the aortic arch have thus far been limited to one or two branches typically the left subclavian, and sporadically the brachiocephalic trunk [6]. Methods of fenestration include radiofrequency devices, septal perforating needles, and LASER. To our knowledge, while reports of endograft fenestration of the arch have been conducted in Asia and Europe, this is the first case of total arch fenestration using the LASER technique.

Conclusion

In conclusion, we present the case of a 45-year-old man with a symptomatic residual dissection of the aortic arch after a type A aortic dissection repair. He underwent successful endovascular total arch repair using *In situ* LASER fenestration and stenting of all three supra-aortic trunks. We have demonstrated that these complex arch cases can be performed with commercially available devices in the United States. It is still unknown when branched endografts for the treatment of the aortic arch will be available. Meanwhile this technique offers a feasible alternative for complex patients with limited options to undergo successful repair.

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