Minimizing Atheromatous Emboli During Arch Surgery With a Sequential Debranching Procedure

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High-grade atheroma of the aortic arch remains a significant surgical challenge owing to the risk of brain emboli. Systemic cooling during cardiopulmonary bypass is recognized as a period at risk for embolic strokes in presence of severe atherosclerosis of the arch.[1,2]

We report a case of a giant aortic arch clot originating from an atherosclerotic plaque in a young female patient consulting for recurrent systemic emboli. To minimize the risk of cerebral emboli, we suggest a technique of sequential arch vessel debranching with partial cardiopulmonary bypass before initiating systemic cooling.

Intraoperative view of the supra-aortic debranching and continuous partial CPB.

Central Message

A novel surgical technique of complete arch vessel debranching with controlled CPB perfusion before initiating systemic cooling in a high embolic risk arch replacement is described.

CLINICAL SUMMARY

A 47-year-old female was transferred after a second event of acute arterial emboli to the left arm necessitating a left brachial artery embolectomy. Extensive investigation for thrombophilia was negative. A transthoracic echocardiogram showed a 4 × 3 cm mass in the distal arch. MRI confirmed the probable diagnosis of a thrombus (Fig. 1A, B). In bloc arch and thrombus resection with minimal arch manipulation was planned.

OPERATIVE TECHNIQUE (SEE THE VIDEO)

In addition to the standard preoperative investigation, thorough assessment of the arch anatomy and circle of Willis is required. Operative monitoring include INVOS (Medtronic; Boulder, CO) cerebral saturation and bilateral radial artery pressure monitoring. A hybrid arch graft was fashioned by adding an 8 mm Dacron branch opposite to second branch of a standard 12–8–8 mm Hemashield Gold Oven trifurcated branched graft. A 20F aortic cannula was connected to added branch and used for cerebral perfusion (Fig. 2A).

Through a median sternotomy approach, a standard double-stage right atrial cannulation was performed. The arterial line was "Y" at the perfusionist end. A flowmeter (stökert, SORIN GROUP, Germany, GMBH) (Fig. 2B, 1*) adapted on the arch line was used to monitor cerebral perfusion. The arch debranching was initially performed by clamping the innominate artery proximally and distally and performing an end-to-end anastomosis using the 12 mm branch of the trifurcated graft. After de-airing, isolated innominate perfusion was begun at 3–4 cc/kg/min and titrated to maintain the baseline cerebral saturation and a mean right radial artery pressure of approximately 60 mm Hg. The left carotid and left subclavian arteries were revascularized in a similar fashion with the 2 remaining 8 mm branches of the trifurcated graft and the arch perfusion

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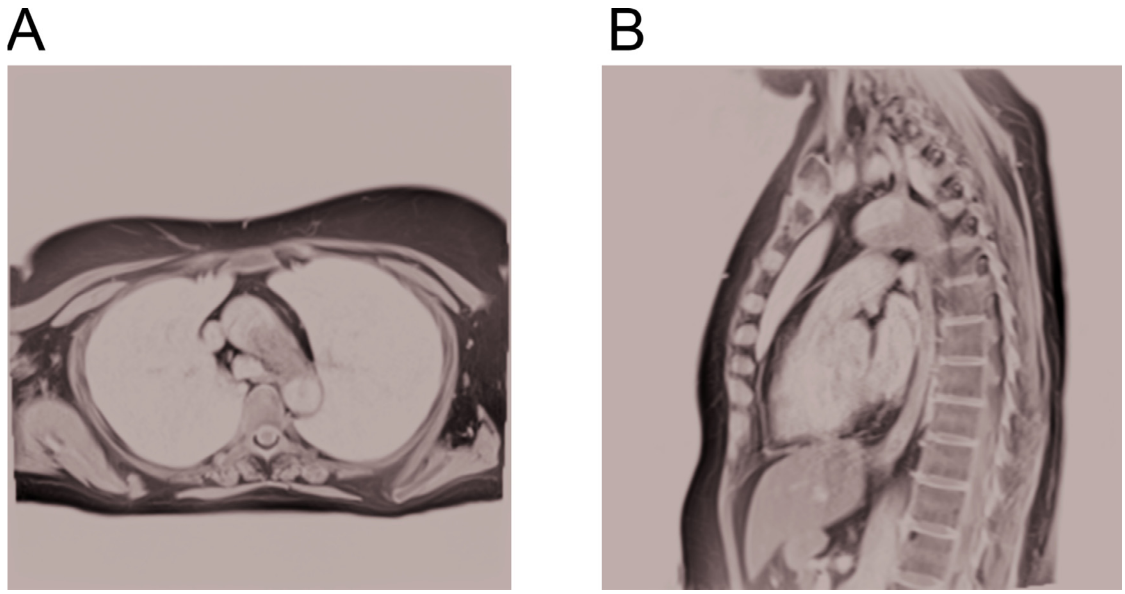


Figure 1. (A) Preoperative MRI showing a giant clot in the aortic arch, (B) with extension to the subclavian artery.

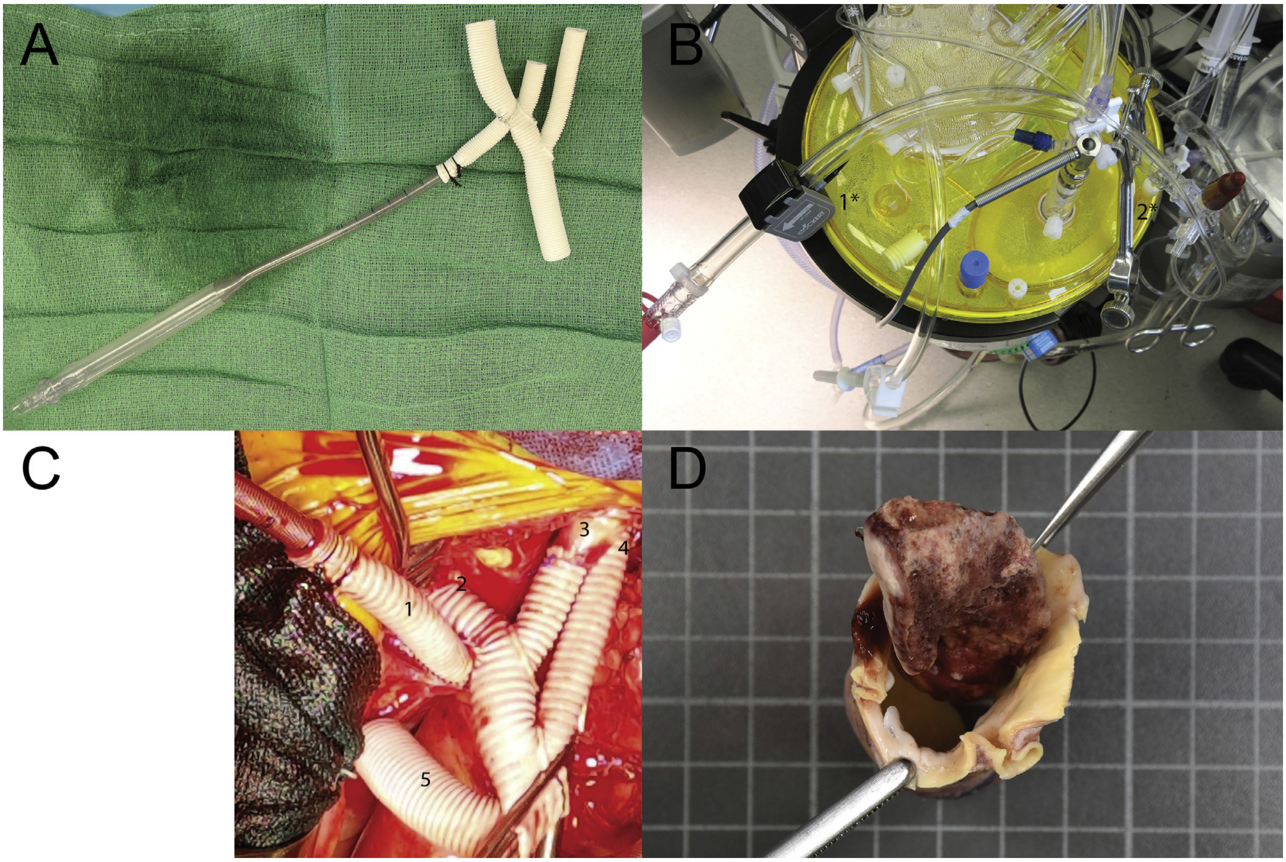


Figure 2. (A) Hybrid arch graft connected to a 20F aortic cannula. (B, 1*) Flowmeter monitoring the cerebral perfusion line, (2*) metallic pusher plate positioned proximal to the flowmeter device allowing to "pinch" the arterial line thus controlling the cerebral flow. (C) Operative view of final arch debranching; (1) arterial cannula, (2) innominate artery, (3) left carotid artery, (4) left subclavian artery, (5) proximal graft will be connected to the 26 mm graft replacing the ascending aorta. (D) Aortic arch section showing the clot originating on an atherosclerotic plaque.

increased to 8 cc/kg/min after the left carotid anastomosis and subsequently to 10−12 cc/kg/min. The cerebral flow perfusion was adjusted according to the cerebral saturation and the radial artery pressure. At this point, the upper limbs and brain were solely perfused by the partial CPB and isolated from the risk of arch emboli during systemic cooling. An additional cannula was inserted in the ascending aorta, connected to the other arm of the arterial line and systemic cooling initiated. Cerebral flow was maintained stable by partially clamping the cerebral arterial line with a metallic "pusher-plate" device added just proximal to the flowmeter (Fig. 2B, 2*).

At 28°C, the ascending aorta was clamped and the heart arrested with del Nido cardioplegia. While maintaining cerebral perfusion, the distal systemic perfusion was interrupted and the arch was carefully resected in bloc with the thrombus. An end-to-end anastomosis using a 26 mm Hemashield graft was performed just distal to the left subclavian artery (Fig. 2C). The distal perfusion was resumed through a side-branch reperfusion limb and systemic rewarming begun. The 26 mm Hemashield graft was anastomosed proximally at the level of the sinotubular junction followed by reimplantation of the trifurcated graft on the main 26 mm graft. The added 8 mm graft of the trifurcated graft was simply ligated at its' base once the repair was completed.

CPB, aortic cross clamp and circulatory arrest times were, respectively, 98, 41, and 19 minutes.

The pathology report confirmed a large clot originating from an ulcerated atherosclerotic plaque (Fig. 2D).

The patient was extubated within 6 hours and underwent an uneventful postoperative course leaving the hospital on postoperative day 6.

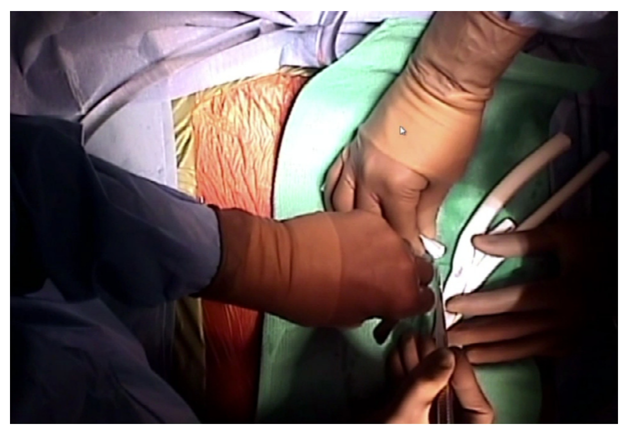
DISCUSSION

Arch replacement in the clinical setting of a significant arch clot or atherosclerotic burden is associated with a high stroke rate. Loss of laminar flow and the high velocity jet of the CPB perfusion may lead to debris dislodgement and embolic stroke. External aortic manipulation, aortic clamping, and retrograde femoral perfusion may also increase the risk of cerebral emboli.[3] To prevent such embolic events, an integrated approach with optimal operative planning is mandatory. Use of the axillary cannulation and positioning of the tip of the aortic cannula toward the aortic valve have been proposed to minimize the risk of "shower" emboli. We propose a novel strategy of complete arch vessel debranching with controlled CPB perfusion before initiating systemic cooling. Meticulous evaluation of the preoperative chest CT/MRI to assess the extent of the atherosclerotic burden is essential to establish the safe site for arch vessel revascularization and optimal site for aortic cannulation. For example, severe atherosclerosis of the innominate artery may require direct revascularization of the right carotid artery with in situ or extra-anatomical revascularization of the right subclavian artery. Severe atheroma of the ascending aorta may preclude safe aortic cannulation. In such a circumstance, the axillary artery may be used for systemic cooling and the debranching performed on the right carotid artery with extra-anatomical revascularization of the right axillary artery following completion of the surgery. In cases where the left subclavian may be difficult to access or in presence of a left vertebral artery originating from the aorta, a preoperative carotid-subclavian bypass (with revascularization of a vertebral artery arising from the aorta) may be performed. Advantages of this technique include minimal arch manipulation before circulatory arrest, complete antegrade brain perfusion during circulatory arrest and mainly, cerebral isolation when the laminar flow is lost with CPB initiation; period we believe is at high risk of debris dislodgement within the arch.[4] Furthermore, time of distal circulatory arrest is reduced since solely the distal anastomosis has to be performed before rewarming.

In conclusion, we provide a novel technique to protect the brain from embolic stroke during high risk arch surgery. The technique requires a comprehensive team approach. Further experience with this operative strategy may allow to expand the technique to most cases of total arch replacements.

SUPPLEMENTARY MATERIAL

The following is the supplementary data to this article:



Video 1. Sequential arch debranching to prevent cerebral emboli in a distal arch atherosclerotic aneurysm.

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