Hybrid Off-Pump Debranching and Thoracic Endovascular Arch Repair in a High-Risk Surgical Patient

Olina Dagher[1], Marina Ibrahim[2], Grégoire Cousin[2], Jean-Francois Dorval[2], philippe demers[2], and Nicolas Dürrleman[2]

[1]Libin Cardiovascular Institute of Alberta
[2]Institut De Cardiologie de Montreal

June 9, 2022

Abstract

Management of aortic arch pathologies remains challenging. Open total arch replacements have been associated with significant morbidity and mortality owing to the need for cardiopulmonary bypass and circulatory arrest. On the other hand, aortic arch branched stent grafts are not widely available. In this context, hybrid techniques combining open arch debranching with endovascular graft placement have been identified as an attractive option in select patients. However, there still is a paucity of literature on their application and outcomes. A case is presented of an elderly frail patient diagnosed with a pseudoaneurysm of the aortic arch and who was successfully treated by an off-pump arch debranching followed by endovascular arch repair. This case highlights (i) the feasibility of hybrid debranching techniques, (ii) their technical challenges, and (iii) the need for long-term follow-up data.

Introduction

The adoption of thoracic aortic endovascular repair (TEVAR) has significantly improved treatment options for a variety of aortic pathologies, while decreasing morbidity and mortality compared to conventional open repairs. It has also allowed the use of hybrid techniques which combine surgical and endovascular graft placements. A number of these approaches have been described, but their popularity remains limited, in part due to the paucity of literature on their midterm and long-term outcomes. Here we present the case of a hybrid off-pump debranching and TEVAR with a 1-year follow-up. A discussion on the pearls and pitfalls of this technique is also provided.

Case presentation

A patient in his 80s presented with a severe transfixing chest pain which started suddenly while walking to the bathroom. His past medical history included hypertension, atrial fibrillation, multilevel peripheral arterial disease, open abdominal aortic aneurysm repair and mild neurocognitive disorder. On physical examination, he was hemodynamically stable and well perfused. His electrocardiogram was unremarkable and his troponins were negative. A chest x-ray showed a widened mediastinum and a mild left pleural effusion. A computed tomography angiography revealed a pseudoaneurysm along the inferior posterior wall of the aortic isthmus and measuring 74x88 mm (Fig.1). He was immediately started on a labetolol infusion for blood pressure and heart rate control. Given his frailty, comorbidities and increased risk of bleeding from the use of apixaban, he was deemed too high-risk for conventional total arch replacement. On the other hand, there was no off-the-shelf branched stent grafts available and the acuity of the presentation didn't allow the use of a custom-made stent graft. A multidisciplinary discussion involving the family concluded that a hybrid off-pump approach should be attempted.

1

Operative approach

The intervention was performed in two stages. The first stage consisted in an off-pump supra-aortic arch debranching using a trifurcated Dacron graft. The patient was placed in supine position with his head turned toward his right shoulder. Median sternotomy was extended into the left jugulocarotid gutter. After exposing the ascending aorta and neck vessels (Fig.2A), the patient received partial heparinization. He was kept normothermic during the entire operation. A soft segment was identified on the ascending aorta to apply a partial occluding clamp (Fig.2B). An end-to-side anastomosis was performed on that segment with the trifurcated graft (Fig.2C). The Dacron graft was de-aired by removing the aortic side-biting clamp and allowing the distal limbs to flow up from the aorta. Thereafter, each supra-aortic vessel was detached from the aortic arch near their origin and rerouted to the corresponding limb graft in an end-to-end manner using simple running polypropylene sutures (Fig.2C). The debranching was performed in a standard order, starting with the left common carotid artery and finishing with the left subclavian artery. The three proximal arterial stumps were ligated to prevent a type II endoleak. Small radiodense metallic clips were circumferentially placed on the ascending aorta, 2 cm above the anastomosis with the trifurcated graft (Fig.2D). This allowed for an accurate determination of the endoprosthesis landing zone.

The second stage of the procedure, the TEVAR, was performed 48 hours later under conscious sedation and regional anesthesia. Two endovascular grafts, sized using 3D reconstruction, were successively deployed *via* femoral access from zones 0 to 4, excluding the pseudoaneursym from the aortic lumen and covering the native ostia of the head vessels.

Postoperatively, the patient developed acute kidney injury, pneumonia and delirium. He was discharged home after 10 days. A computed tomography angiography done prior to hospital discharge showed excellent results, with no endoleak (Fig.3). At one-year follow-up, he felt fully recovered and was doing well.

Comment

Three options are available for the management of extensive arch disease: (i) total arch replacement with the elephant trunk technique, (ii) total endovascular intervention or (iii) hybrid repair. A total arch replacement is a major intervention which requires the use of CPB and circulatory arrest, and might not be suitable for patients with unacceptable surgical risk. On the other hand, off-the-shelf arch branched stent grafts are not yet widely available. In addition, customized branched stent-grafts cannot be used in urgent scenarios. Bearing those challenges in mind, we presented a hybrid technique used to manage a pseudoaneurysm of the arch and which allowed for a total debranching without the need for CBP or circulatory arrest.

This attractive option comes with its own sets of challenges. The main difficulty is to secure a sufficient landing zone of at least 2 cm in the ascending aorta while finding a healthy portion of aorta for the side clamping. Some surgeons choose to institute CPB in cases where partial clamping is too close to the level of the sinotubular junction[1]. Another procedural variation is to do a one-stage approach where the endovascular graft is placed in the same setting, giving the option for antegrade deployment via transaortic route[2]. While antegrade deployment reduces the occurrence of type A retrograde ascending aortic dissection, it makes it harder to negotiate the curvature of the arch angle and carries a risk of iatrogenic type B dissection.

Osler's statement on aneurysmal disease is certainly applicable to the aortic arch; arch disease is very humbling. The smoothest surgery sometimes leads to devastating and unforeseen neurological complications. There is no good or bad operation, only a more favorable option which stays in line with the patient's risk profile, values and preferences. Indeed, the goal of surgery is not only to have an alive patient but to also maximize their neurologic and metabolic recoveries. As with any complex surgical case, careful preoperative planning is of the essence and should include a multidisciplinary discussion by a specialized thoracic aortic team. Criteria for patient selection should include their level of care, age, surgical risk, level of frailty, extent of their peripheral vascular disease, as well as the interpretation of the arch anatomy and landing zone determination.

In conclusion, this case illustrates a hybrid repair of an extensive arch disease which allows for total de-

branching without the use of CPB or circulatory arrest, thereby potentially carrying a lower mortality and morbidity. This safe and reproducible procedure can provide favorable results and remains an attractive option in patients considered unfit for conventional total arch replacement or in centers where total endovascular interventions are not feasible. We believe this technique deserves more attention, especially as the elderly population is experiencing rapid growth. Longer term radiographic and clinical follow-up are needed to evaluate the full merits of this approach.

References

Szeto WY, Bavaria JE, Bowen FW, Woo EY, Fairman RM, Pochettino A. The hybrid total arch repair: brachiocephalic bypass and concomitant endovascular aortic arch stent graft placement. *J Card Surg* . 2007;22(2):97-104.

Ghazy T, Mashhour A, Schmidt T, et al. Off-Pump Debranching and Thoracic Endovascular Aortic Repair for Aortic Arch Pathology. Innovations (Phila). 2015;10(3):163-169.

Figure 1. Preoperative 3D reconstruction obtained from computed tomography angiogram of the chest showing a pseudoaneurysm located at the inferior-posterior wall of the aortic isthmus, in anterior (A) and posterior (B) views.

Figure 2. Schematic illustration and intraoperative pictures (anesthetist view). A and B, Exposure of the ascending aorta and head vessels; C, A plaque-free portion of the ascending aorta is clamped tangentially using a partial side-biting clamp, followed by longitudinal arteriotomy; D, Completed end-to-side anastomosis of the main graft limb to the ascending aorta; E, Anastomosis of the middle graft limb to the distal end of the left common carotid artery. Each proximal arterial stump is ligated to prevent a type II endoleak (white arrow); F, Final result of the procedure. Metal clips were circumferentially placed 2 cm above the proximal aorta-to-graft anastomotic line to allow determination of the endoprosthesis landing zone in the second stage of the procedure (white arrows). 1, ascending aorta; 2, left brachiocephalic vein; 3, left common carotid artery; 4, innominate artery; 5, limb graft elongating the left subclavian artery distally.

Figure 3. Final result of the two-stage procedure in 3D reconstruction obtained from a computed tomography angiogram of the chest showing the supra-aortic vessels being rerouted to the ascending aorta and the proper position of the aortic stent with proximal landing in zone 0, excluding the pseudoaneurysm from the aortic lumen, in left anterior (A) and right posterior (B) views.