

Repairing a Challenging Aortic Arch Aneurysm

Concomitant endovascular exclusion of a contained ruptured aortic arch aneurysm with an Endofit cartridge-loaded stent graft and supra-aortic debranching.

BY LEFENG QU, MD, PhD, AND DIETER RAITHEL, MD, PhD

An 80-year-old woman with sudden upper chest pain and hoarseness had a ruptured aortic arch aneurysm and was admitted to our unit. Her multiple comorbidities included arterial hypertension, coronary artery disease, diabetes mellitus, hypercholesterolemia, chronic obstructive pulmonary disease, chronic renal insufficiency, and peripheral arterial disease. Physical examination revealed a poor general condition with a blood pressure of 180/110 mm Hg and weak femoral pulses. Magnetic resonance angiography showed an atherosclerotic saccular aortic arch aneurysm that was 6.5 cm in diameter (Figure 1). Digital subtraction angiography (DSA) also showed a contained ruptured saccular arch aneurysm (Figure 2).

THERAPEUTIC STRATEGY

Although the indication for open surgery was very strong, this patient was considered prohibitively high risk for conventional open arch aneurysm repair due to her comorbidities. Thoracic endovascular aortic aneurysm repair (TEVAR) is a proven, minimally invasive procedure that has had promising results

in the past decade. In this arch aneurysm, however, there were no proximal or even distal landing zones for the stent graft, so we planned a hybrid procedure involving a debranching technique with supra-aortic extra-anatomic bypass to achieve a landing zone and to preserve the blood perfusion to the upper body, as well as an endovascular technique with stent graft placement to exclude the arch aneurysm.



Figure 1. Magnetic resonance angiogram showing a saccular aortic arch aneurysm 6.5 cm in diameter.

OPERATIVE TECHNIQUE

The procedure was performed in an operating room equipped with a mobile DSA C-arm system. The cardiopulmonary bypass (CPB) was ready for possible use in the operation. The ascending aorta, the brachiocephalic trunk, and the left common carotid artery were exposed with a midline sternotomy incision and extension to the neck. We decided not to perform revascularization of the left subclavian artery because it was not accessible via this incision and because magnetic resonance angiography did not show a dominant left vertebral artery; there was also no history of coronary bypass with the left mammary artery. The



Figure 2. DSA showing a contained ruptured saccular aortic arch aneurysm.

right subclavian artery was exposed for preparation of CPB.

After full-systemic heparinization, a 10-mm Dacron graft was anastomosed to the right subclavian artery for CPB preparation. A side-biting clamp was then placed near the root of the ascending aorta, and the short common part of a Y-bifurcated prosthesis (Hemashield, Boston Scientific Corporation, Natick, MA), measuring 14 mm in diameter at the common part of the prosthesis and 8 mm in diameter at each branch, was anastomosed to the ascending aorta in an end-to-side fashion using 2–0 prolene sutures. Once the anastomosis was completed, the other side of the 10-mm Dacron graft that was already anastomosed to the right subclavian artery was anastomosed to the common part of the Y-bifurcated prosthesis. This 10-mm Dacron graft was designed for CPB and could subsequently be used for antegrade delivery of the stent graft. One branch of the Y-prosthesis was anastomosed to the right common carotid artery in an end-to-side fashion as the brachiocephalic trunk dilated, and the root of the brachiocephalic trunk was double suture ligated and enhanced with a band. Thus, the

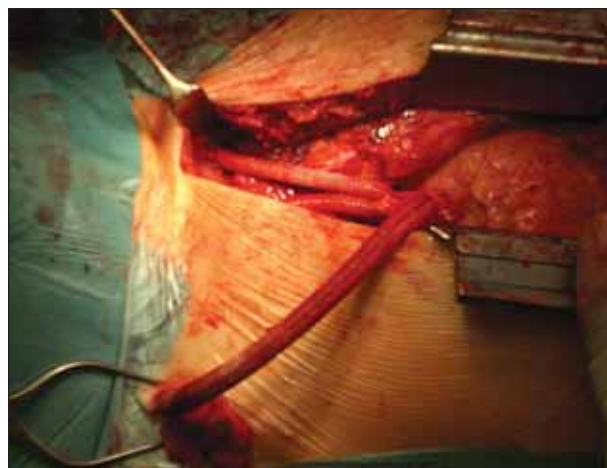


Figure 3. Extra-anatomic bypasses: Y-bifurcated prosthesis from the ascending aorta to the brachiocephalic and left carotid arteries. A 10-mm Dacron graft connected the right subclavian artery and the trunk of the Y-bifurcated prosthesis.



Figure 4. The supra-aortic bypass can be compressed between the sternum and the large aneurysm if the chest is closed.

right subclavian artery was irrigated by retrograde blood flow. The other branch was made into an end-to-end anastomosis to the left common carotid artery, and the stump of the left common carotid artery was double ligated (Figure 3).

The debranching procedure was done smoothly and without CPB support. We had planned to perform TEVAR in a second stage, but during the chest closure, we found that the supra-aortic bypasses could be compressed between the sternum and the large arch aneurysm (Figure 4). To depressurize the large aneurysm to gain some space for the bypass prosthesis, we decided to perform concomitant endovascular therapy.



Figure 5. DSA showed that the supra-aortic extra-anatomic bypasses were patent and there were sufficient proximal and distal landing zones.

ENDOVASCULAR PROCEDURE

DSA showed that the supra-aortic extra-anatomic bypasses were patent and there was a sufficient proximal landing zone (Figure 5). Because the 10-mm Dacron graft anastomosed to the Y-prosthesis was cut, the stent graft was placed via the femoral or iliac artery. There were stenoses in both femoral and iliac arteries, so we performed predilatation with a tapered dilator. Because the anastomosis in the ascending aorta was very close to the aortic root and the left ventricle, the stent graft was deployed just distal to this anastomosis. For a regular stent graft delivery system used via a retrograde approach, the nose cone or the tip of the introducer will go into the aortic root or even the left ventricle to bring the stent graft to the anastomotic level. To avoid disturbance of the aortic root or even the left ventricle by the nose cone or the tip of the introducer, we prefer the cartridge-loaded Endofit stent graft (LeMaitre Vascular, Burlington, MA) for this very proximal placement (Figures 6 and 7). The introducer was negotiated to the ascending aorta, the pusher was withdrawn outside, and a cartridge-loaded Endofit stent graft (36 mm in diameter and 200-mm long) was pushed into the sheath, which remained *in situ*, to the point of the proximal part using the caudal part of the pusher rod. While the heart was temporarily arrested with 90-mg intra-

venous adenosine, the stent graft was deployed just distal to the ascending aortic anastomosis.

RESULT

The completion angiogram revealed complete exclusion of the large saccular arch aneurysm with patent blood perfusion to the supra-arch vessels (Figure 8). Due to the multiple comorbidities, this 80-year-old patient with a large contained ruptured saccular aortic arch aneurysm was challenging not only to open surgery, but also to our hybrid approach. According to the limited experience (but promising results) from some small series of combined debranching technique and endovascular repair,¹⁻³ the major advantages of this approach are the avoidance of CPB and avoidance of deep hypothermic circulatory arrest, the lack of aortic cross-clamping occlusion, and the avoidance of subsequent reperfusion injury.

To achieve the final success of endovascular exclusion, debranching and extra-anatomic bypasses are mandatory to gain sufficient proximal and distal landing zones for the stent graft. We prefer to perform a bypass using a Y-bifurcated prosthesis from the ascending aorta to the brachiocephalic trunk, the left common carotid artery, and the left subclavian artery without CPB support. The left subclavian artery was not reachable via this incision even with extension, the left vertebral artery was not dominant, there was no coronary bypass with the left mammary artery, and there was no previous aortic surgery; therefore, we cancelled the revascularization of the

left subclavian artery. A side-biting clamp in the ascending aorta can, not only provide enough manipulation space for the anastomosis, but can also allow continuous distal blood perfusion. Notably, when creating a proximal landing zone for the stent graft, the anastomosis in the ascending aorta should be performed as proximal as possible, just distal to the sinotubular junction, to allow placement of the stent graft in the ascending aorta without compromise to the proximal inflow anastomosis. The average length of ascending aorta from sinotubular junction to brachiocephalic trunk was 6 cm to 7 cm, thus allowing an adequate proximal landing zone.¹

Endovascular repair can be done concomitantly or in a second stage, and we normally prefer the former because patency of the extra-anatomic bypasses can be evaluated after



Figure 6. The Endofit thoracic straight stent graft.



Figure 7. The Endofit cartridge-loaded stent graft showing the Endofit stent graft compressed inside the cartridge.

debranching. If performed concomitantly, we prefer to deliver the stent graft via the antegrade approach through the graft conduit. In this case, we had planned to undertake the endovascular procedure in a second stage due to some special reasons; however, we found that the bypass prosthesis would be jammed between the sternum and the aneurysm during chest closure. We could remove neither the sternum nor the aneurysm, but we could depressurize the aneurysm to make more space for the prosthesis. Therefore, we performed TEVAR in the same stage and then closed the chest without compression on the prosthesis.

“Another challenge of this case was the stenosis of the left iliac artery, which we successfully predilated with a tapered introducer.”

Because the stent graft should be placed just distal to the anastomosis, which is very close to the aortic root, the nose cone or the tip of the introducer can readily go inside the aortic root, causing disturbance of the aortic valve or perforation of the left ventricle.⁴ One solution is antegrade delivery via the graft conduit as reported by Diethrich et al.⁵ Another solution is to use a cartridge-loaded stent graft with retrograde delivery via femoral or iliac access. LeMaitre Vascular provides the cartridge-loaded Endofit stent graft, which is pushed upward with the reversed pusher, and the outer sheath is then withdrawn to deploy the stent graft.



Figure 8. Completion angiogram revealing complete exclusion of the large saccular arch aneurysm with patent blood perfusion to the supra-arch vessels.

Another challenge of this case was the stenosis of the left iliac artery, which we successfully predilated with a tapered introducer. If that is unsuccessful, we prefer iliac conduit graft for delivery or retrograde iliac endarterectomy with a MollRing cutter (Vascular Architects, Nashville, TN). In conclusion, this challenging case demonstrated that a hybrid approach to total arch repair can be technically achieved. ■

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