

Hybrid repair of an aortic arch aneurysm with complex anatomy: Right aortic arch and anomalous origin of supra-aortic vessels

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We performed a one-stage hybrid surgical and endovascular procedure to manage a 6.5-cm right aortic arch aneurysm associated with anomalous origin of the supra-aortic vessels in a 70-year-old man. Complete surgical rerouting of the supra-aortic vessels was followed by the endovascular repair of the right aortic arch aneurysm with a Zenith TX2 stent graft (Cook, Bloomington, Ind) and Z-track plus introducer system. The procedure was successfully completed with exclusion of the aortic arch aneurysm, and the patient was discharged on postoperative day 7. Aortic arch aneurysms with complex anatomy may be successfully treated with a less invasive hybrid approach using new generation devices. (*J Vasc Surg* 2007;46:128-30.)

There are several different morphologic variations in the arrangement of the ascending, transverse, and descending aorta and its branches. A right aortic arch is rare (0.5% to 0.1% of radiology series and in 0.04% to 0.1% of autopsy series)^{1,2} and is often associated with other congenital anomalies such as tetralogy of Fallot and truncus arteriosus. It is even more rare as an isolated finding. Symptoms in infancy may be related to associated congenital heart anomalies, when present. In the adult population, symptoms may be the result of atherosclerotic changes or compression of the surrounding structures.³

An aneurysm of a right aortic arch involving the origin of both common carotid arteries has been reported in two cases and both were managed with open surgical repair.^{4,5} We report a case of a right aortic arch aneurysm with anomalous origins of the supra-aortic vessels that was successfully treated with a combined approach of arch debranching and endovascular exclusion.

CASE REPORT

A 70-year-old man was referred for an abnormal shadow in the upper mediastinum demonstrated by chest radiograph. The patient was asymptomatic from his known right aortic arch. His medical history was significant for smoking and episodes of acute exacerbations of chronic obstructive pulmonary disease. A multislice computed tomography (CT) scan and digital subtraction angiography demonstrated a 6.5-cm aneurysm of the right aortic arch with a retroesophageal course (Fig 1). Imaging studies showed a type 3 right aortic arch¹ and a common origin of the left and right common carotid arteries (LCCA and RCCA) as the first aortic branch. The right subclavian artery originated posterolater-

ally (the diameter at the origin was 12 mm) as the second branch from the aneurysm. A hypertrophic dominant right vertebral artery originated from the right subclavian artery 2 cm from its origin from the aneurysm. The left subclavian artery originated as the third branch posteriorly from the aortic arch aneurysm with an anomalous retroesophageal course.

The patient was treated with a one-stage hybrid surgical and endovascular procedure. Surgical off-pump rerouting of the supra-aortic vessels was followed by endovascular stent graft repair of the right aortic arch aneurysm. The procedure was performed under general anesthesia, and cerebral activity was monitored by means of a continuous electroencephalogram reading.

The operation began with a median sternotomy incision, and the ascending aorta, the common carotid trunk, the RCCA, and the LCCA were exposed. The origin of both left and right subclavian arteries could not be accessed because of their posterior and lateral origin. A bilateral supraclavicular incision was performed, exposing both subclavian arteries and the LCCA.

A triple-branched graft was tailored from a bifurcated InterGard 14-mm × 7-mm Dacron graft (InterVascular, la Ciotat, France) and from a 7-mm Dacron graft anastomosed in an end-to-side fashion to the right branch of the bifurcated graft (Fig 2). After systemic heparinization (70 IU/Kg), the ascending aorta was side-clamped and the trunk of the graft was anastomosed end-to-side with 4-0 Prolene (Ethicon, Somerville, NJ). The RCCA and LCCA were individually divided, ligated, and anastomosed end-to-end to the graft with 5-0 Prolene (Fig 2, A). All three branches were running behind the innominate vein.

Revascularization of the subclavian arteries was carried through the cervical incisions. First, a left carotid-subclavian bypass was performed with a 7-mm Dacron graft (Fig 2, B). The left subclavian artery was then ligated to avoid type II endoleak. The right subclavian artery was directly cannulated with an Amplatz wire (Boston Scientific Corp, Natick, Mass), with retrograde deployment of a 16-mm over-the-wire ZIP iliac occluder (Cook Inc, Bloomington, Ind). The occluder was placed at the origin of the right subclavian artery proximally to the origin of right vertebral artery, with successful occlusion of the right subclavian artery [Fig 2, C]. An end-to-side anastomosis between the third branch of the

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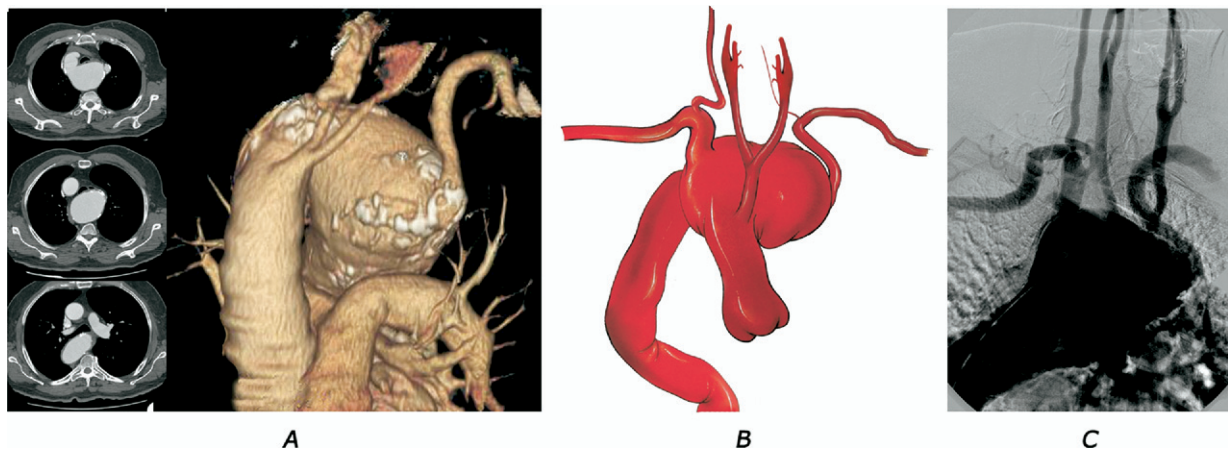


Fig 1. **A**, Preoperative computed tomography scan demonstrates an aneurysm of the right aortic arch. **B**, Schematic illustration of morphology of the right aortic arch and the anomaly of the supraortic vessel. **C**, Preoperative angiography demonstrates the common origin of both carotid and the hypertrophic right vertebral artery.

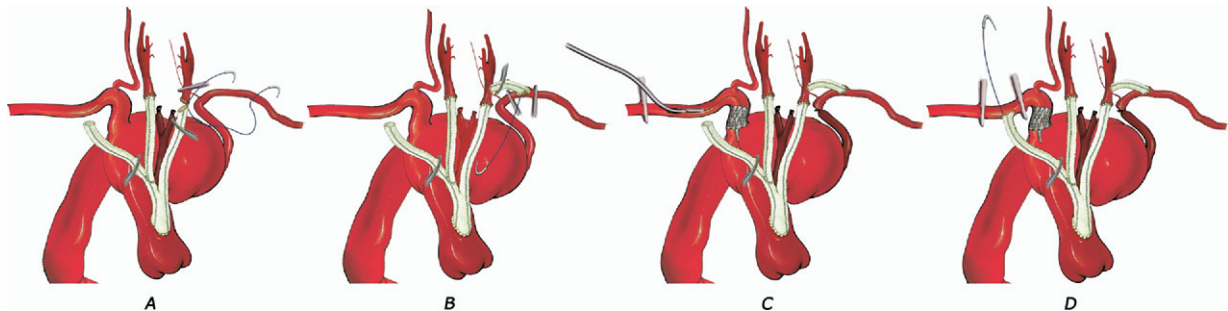


Fig 2. Schematic illustration of surgical repair steps: **(A)** revascularization of both carotid arteries from the ascending aorta, **(B)** left carotid-subclavian artery bypass, **(C)** endovascular exclusion of right prevertebral subclavian artery, and **(D)** revascularization of the right subclavian artery and proximal ligation of the left subclavian artery.

trifurcated graft and the right subclavian artery was performed [Fig 2, D]. Intraoperative angiography showed patency of all supra-aortic vessels.

The procedure continued with stent graft deployment in the aortic arch. The right common femoral artery was isolated and cannulated. A superstiff Lunderquist precurved guidewire (Cook) was advanced to the ascending aorta. A Zenith TX2-P 38-mm × 202-mm device with Z-track plus delivery system (Cook) was positioned with the proximal marker just distal to the proximal anastomosis of the trifurcated graft and deployed. Completion angiography demonstrated complete exclusion of the right aortic arch aneurysm.

No evidence of endoleak and patency of all the supra-aortic vessels were observed. An intraoperative transesophageal echocardiography demonstrated no evidence of flow within the aneurysmal sac.

The patient was transferred to the intensive care unit after the procedure and was moved to the surgical ward on postoperative day 2. His postoperative course was uneventful, with the exception of a bilateral pneumothorax that required the placement of percutaneous drainage. Postoperative CT showed satisfactory placement

of the endograft, with complete thrombosis of the aneurysmal sac (Fig 3). The patient was discharged on postoperative day 7.

DISCUSSION

Aneurysmal degeneration of right aortic arch usually involves the origin of the subclavian artery proximally and the descending thoracic aorta distally. The surgical treatment of a true aneurysm of a right aortic arch involving the origin of subclavian artery was first reported in 1976 by Cooley et al.⁶ Sacular aneurysms located between the right carotid artery and the right subclavian artery without distal involvement of the thoracic aorta are extremely rare, with only two cases reported in literature.^{4,5} The complex variability of anatomic morphology of the right aortic arch itself and the frequent associated anomalies of the supra-aortic vessels origin require tailoring treatment to the individual patient.

The presence of a right aortic arch aneurysm makes open treatment difficult because of the pattern of the supra-aortic vessels, the location of following the descend-

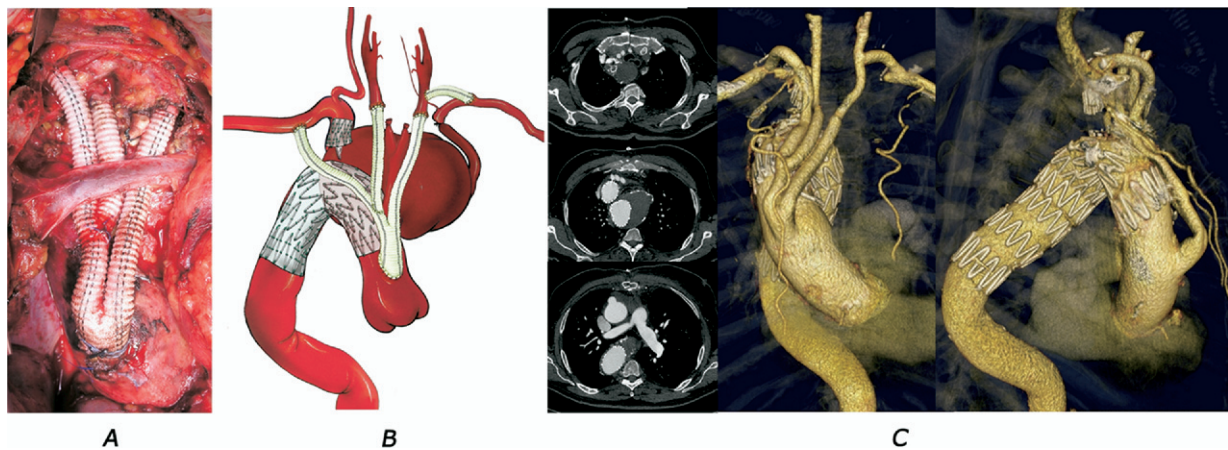


Fig 3. **A,** Intraoperative view of the revascularization of both carotid arteries and of the right subclavian artery from the ascending aorta. **B,** Schematic illustration after the deployment of the stent graft on the right aortic arch. **C,** Postoperative computed tomography scan shows complete exclusion of right aortic arch aneurysm.

ing aorta, and the relation between the esophagus and the aortic arch.⁷ Hybrid treatment of aortic arch pathology has been recently proposed as an alternative solution for high-risk patients.⁸⁻¹⁵ This avoids cardiopulmonary bypass and hypothermic arrest with its well-known risks.¹⁶ Complete rerouting of supra-aortic vessels and endovascular treatment of a right aortic arch aneurysm has not yet been reported in literature, to our knowledge.

CONCLUSION

Excessive tortuosity of the aorta, as in our patient, has limited the use of stent grafts; but now, more advanced devices and delivery systems have been made commercially available. The new Cook delivery system (Z-track plus) is most notable for its flexibility, trackability, and smooth external profile, all of which are important when the stent graft has to traverse the entire aortic arch. These improvements allowed us to take full advantage of the Zenith TX2 stent graft flexibility. Aortic arch aneurysm with complex anatomy may be successfully treated less invasively thanks to a hybrid approach and a new generation of endovascular devices.

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