VASCULAR AND ENDOVASCULAR TECHNIQUES

Thomas L. Forbes, MD, Section Editor

Hybrid management of proximal right subclavian artery aneurysms

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Surgical repair of proximal right subclavian artery aneurysms can be difficult. They typically require a combined mediastinal exposure to control the innominate and right common carotid arteries and a supra- or infraclavicular exposure for distal control, with either a segmental resection and bypass or a bifurcated reconstruction. In this report, we present four cases utilizing a single-stage, hybrid technique combining an endovascular stent graft and an extra-anatomical bypass to repair proximal right subclavian artery aneurysms without the need for mediastinal exposure or extensive surgical reconstruction. There were no deaths and two minor neurologic events. (J Vasc Surg 2011;53:528-30.)

Surgical repair of proximal right subclavian artery (RSCAs) aneurysms can be difficult (Fig 1). They typically require a combined mediastinal exposure[1] to control the innominate and right common carotid arteries and a supra- or infraclavicular exposure for distal control, with either a segmental resection and bypass or a bifurcated reconstruction.[2] In this report, we present a case series utilizing a single-stage, hybrid technique combining a stent graft and an extra-anatomical bypass to repair proximal RSCA aneurysms without the need for mediastinal exposure or extensive surgical reconstruction.

TECHNIQUE AND METHODS

All of the patients were evaluated using contrast-enhanced computed tomographic angiography (CTA) of the head, neck, and chest. The status of both vertebral arteries was used to determine the need for vertebral revascularization. A patent right internal mammary graft to a coronary artery would require separate revascularization with appropriate myocardial protection.

Technique. The right common carotid artery (CCA) was exposed through a low cervical incision. The mid-to-lateral segment of the axillary artery behind the insertion of the pectoralis minor was next exposed through an infraclavicular incision. A tunnel beneath and along the lateral third of the clavicle was created from the carotid to the axillary artery.

An 8-mm ringed ePTFE graft (W. L. Gore, Flagstaff, Ariz) was anastomosed to the lateral aspect of the CCA ("carotid conduit"). This conduit was accessed, and a road-mapping arch aortogram was performed to visualize the innominate origin and its bifurcation (Fig 2). A stent graft was deployed from the innominate to the CCA (proximal to the carotid conduit). The distal CCA was not clamped during endograft deployment to allow continued cerebral perfusion (Fig 3).

The conduit was then turned down and anastomosed in an end-to-side manner to the axillary artery through the previously made infraclavicular tunnel (Fig 4). Any patent branches originating from the subclavian aneurysm were coil embolized, and the proximal axillary artery was tied off or the distal RSCA occluded using an intravascular plug (Amplatzer-II; AGA Medical, Plymouth, Minn) to allow retrograde perfusion of any patent interval branches. The patients were maintained postoperatively on 325 mg acetylsalicylic acid daily.

Choice of stent graft. (Warning: off-label use) The Zenith Flex iliac limb (Cook Medical, Bloomington, Ind) was used off-label for all of the procedures. If the innominate diameter is 10 to 11 mm, then the limb may be introduced "as is" with the 12-mm limb deployed in the innominate artery and either an 8- or 10-mm end in the CCA. If the innominate artery is between 12 and 20 mm, then the limb is reverse-loaded on the back table into the original delivery system and deployed. Although not used in the current series, alternatively, Excluder limbs (W. L. Gore), which taper from 16 mm (distal) to 12 or 10 mm (proximal), may be used for innominate arteries ≤15 mm (internal diameter) without the need to invert the device.

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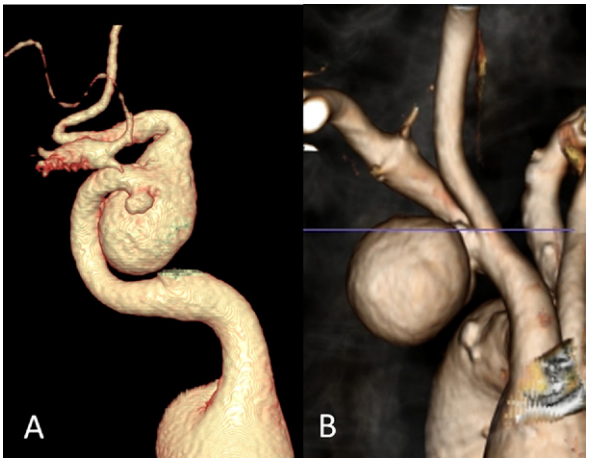

Fig 1. Right subclavian artery aneurysms (3D volume rendering): **(A)** mid-segment; **(B)** proximal.

Fig 2. Initial arch aortogram obtained at 30° RAO projection using a straight angiographic catheter introduced through the carotid conduit.

CASE SERIES

Between October 2008 and March 2010, this technique was used in four cases to repair proximal RSCAs (Table). There were two intraoperative adverse events involving a minor right hemispheric stroke, which resolved completely within 36 hours and an improving left hemianopsia.

Patient 1. A 45-year-old left-handed woman with a history of multiple sclerosis and Marfan syndrome had an asymptomatic 3-cm RSCA on a routine transthoracic echocardiogram. Her aortic valve and ascending aorta were normal.

Patient 2. A 39-year-old right-handed man had a history of a Blalock-Taussig shunt using a vein conduit, which was later ligated at the time of his staged cardiac reconstruction. A CTA performed for extremity weakness and peripheral

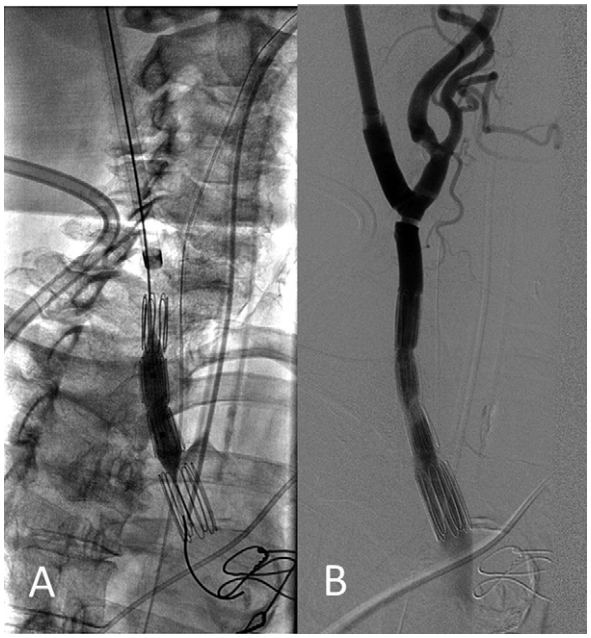

Fig 3. The stent graft is deployed into the innominate and common carotid arteries. **A,** Balloon molding. **B,** Angiogram to confirm exclusion of antegrade flow.

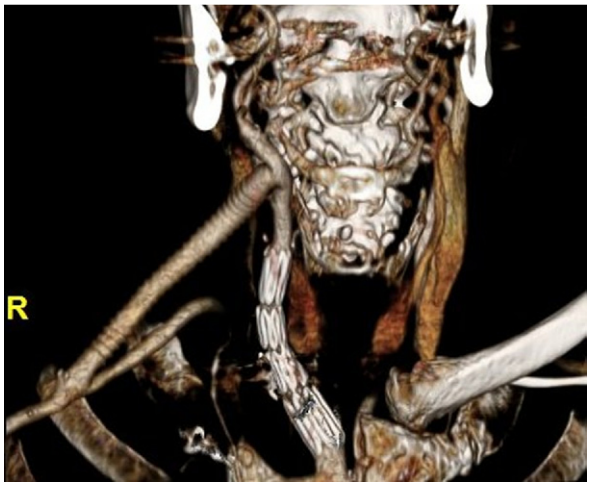

Fig 4. Follow-up CTA of the excluded aneurysm and completed carotid-axillary bypass.

Table. Anatomical and stent graft dimensions and select perioperative results

Patient No.	*1*	*2*	*3*	*4*
Aneurysm size (cm)	3.0	4.0	5.2	5.3
Carotid diameter (mm)	6.5	8.0	7.4	11.0
Innominate diameter (mm)	10	16	11	18
Innominate length (mm)	41	36	42	26
Stent graft size (P × D × L mm)	12 × 8 × 54	18 × 12 × 73	12 × 8 × 71	20 × 12 × 54
Procedure time (min)	231	324	230	317
Estimated blood loss (mL)	300	260	200	400
Length of stay (days)	1	1	11[a]	3[b]
Follow-up (days)	564	167	145	50
Carotid-axillary graft patency (Y/N)	Y	Y	Y	Y
Stent graft patency (Y/N)	Y	Y	Y	Y
Endoleak (Y/N)	N	N	N	N

D, Distal (carotid end); *L*, length; *P*, proximal (innominate end).
[a]Right hemispheric stroke.
[b]Left hemianopsia.

vision loss showed a 4-cm aneurysmal degeneration of the vein graft stump originating from his proximal RSCA.

Patient 3. An 81-year-old right-handed woman sustained an arterial puncture during an attempt at a central venous line placement before coronary artery bypass grafting, which was complicated by sternal infection and dehiscence. Six weeks later, a CTA showed an asymptomatic 5.3-cm pseudoaneurysm originating from the proximal RSCA.

Patient 4. A 72-year-old right-handed man presented with a right upper chest abnormality on a chest x-ray. He had previously undergone endovascular abdominal aortic aneurysm repair. A CTA showed a 5.3-cm proximal RSCA.

DISCUSSION

The hybrid technique used in this series has been previously described[3,4] with one or more variations in several case reports.[5-7] Indications include lesions involving the proximal subclavian artery or the innominate bifurcation. Patients with innominate arteries that are too large and/or short (<20 mm) for available endografts should be excluded. Advantages of the current technique over conventional repair include: 1) avoidance of a median sternotomy and dissection of the proximal arch, especially in patients with a hostile or redo mediastinum as in two of the patients in this series, and 2) use of the carotid-axillary bypass graft as a conduit, which allows a less traumatic delivery of the endograft through the artery than a direct puncture. The technique does not compromise any future surgeries of the aorta or the arch as might be required in patient 1 with Marfan syndrome. In good-risk patients, however, direct reconstruction remains the standard of care.

A standard transfemoral insertion of the endovascular delivery system has several limitations. The delivery system of an iliac limb is not long enough to reach the innominate-carotid artery. A super-stiff 0.035″ guidewire must be placed into the carotid artery in order to support the delivery system. Both of these can increase the risk vessel injury or neurologic complication.

Two of the four cases suffered minor strokes. This likely represents intraoperative embolic events that likely occurred during the introduction of the delivery system and/or endograft deployment. Temporary clamp occlusion during this portion of the procedure would be well tolerated and may mitigate the risk of these embolic events.

In conclusion, the current case series shows the feasibility of a hybrid approach to these difficult pathologies. Meticulous technique is important for optimal device selection and avoidance of neurologic complications. Late outcomes in terms of endograft integrity and carotid-axillary graft patency remain to be determined.

AUTHOR CONTRIBUTIONS

Conception and design: KB, WL
Analysis and interpretation: KB, WL
Data collection: KB, RF
Writing the article: KB, RF, WL
Critical revision of the article: N/A
Final approval of the article: KB, RF, WL
Statistical analysis: N/A
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Overall responsibility: WL

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