

# Utility of Preoperative 3D CT Angiography and Proximal Balloon Occlusion to Minimize Morbidity of Open Repair of a True Subclavian Artery Aneurysm

Salvatore T. Scali<sup>\*1</sup>, Adam W. Beck<sup>1</sup>, Thomas S. Huber<sup>1</sup> and Eva M. Rzcudlo<sup>2</sup>

<sup>1</sup>Division of Vascular Surgery and Endovascular Therapy, University of Florida, Gainesville, Florida, USA

<sup>2</sup>Section of Vascular Surgery, Dartmouth-Hitchcock Medical Center, Lebanon, New Hampshire

**Abstract:** This report highlights the utility of three dimensional (3D)-CT angiography, in conjunction with combined endovascular and open surgical management, to treat a degenerative subclavian artery aneurysm. The patient presented with an incidentally discovered right subclavian artery aneurysm and underwent surgical reconstruction without complication. Although a variety of case reports in the literature document repair of various subclavian artery pathologies including those associated with aberrant subclavian artery anatomy (Kommerel's diverticulum), iatrogenic pseudoaneurysm, and thoracic outlet compression with post-stenotic dilatation, post-inflammatory and infectious aneurysms; true fusiform degenerative aneurysms of the subclavian artery remain a rare clinical entity. These lesions present with variable anatomic configurations, which can be clearly defined with pre-operative CT or MR angiography. Defining the anatomy with 3D imaging can facilitate clinical decision-making and allow potential application of hybrid approaches to surgical management.

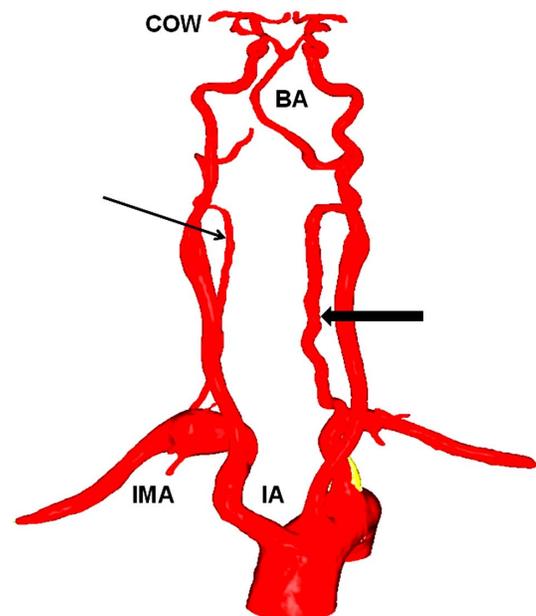
**Keywords:** Computed tomography, subclavian aneurysm, balloon occlusion.

## CASE REPORT

A 54 year old woman presented with an incidentally discovered right subclavian artery aneurysm after work-up for dizziness and vertigo. Her history was notable for lower extremity superficial venous insufficiency that was treated with greater saphenous vein ablation and stab phlebectomy. There was no history of antecedent trauma and no associated right upper extremity symptoms such as numbness, tingling, pain, or evidence of peripheral embolization. Additionally, there was no personal or family history of aneurysms or connective tissue disorders and her work-up was negative for inflammatory conditions such as arteritis. Clinical examination was remarkable for a prominent pulse in the right supraclavicular fossa and a normal vascular exam distally, with no stigmata of Marfan syndrome.

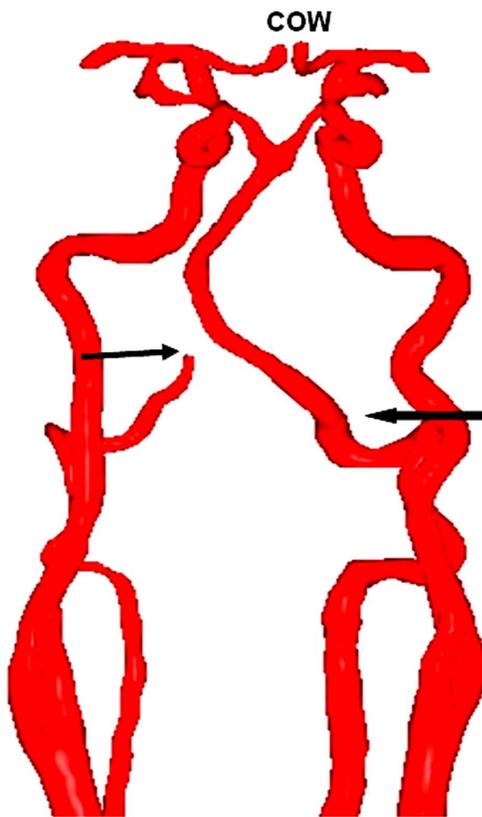
An MR angiogram performed as part of her vertigo work-up discovered a 2.2 x 2.5 cm, proximal right subclavian artery aneurysm. Imaging with CT angiography (CTA) and 3D reconstruction revealed a fusiform, proximal right subclavian artery aneurysm with no associated mural thrombus. No additional aortic or peripheral arterial pathology was detected and there was no evidence of cervical rib or proximal subclavian artery stenosis. Multiple branch vessels, including the vertebral artery, thyrocervical trunk and internal mammary arteries were documented to arise from the aneurysm (Fig. 1A). The CTA demonstrated

that the right vertebral artery did not fill the basilar circulation and a larger, dominant left vertebral artery was present (Fig. 1B).



**Fig. (1A).** 3D (M2S, Inc., West Lebanon, NH) reconstruction of the Right subclavian artery aneurysm. Several vessels are noted to arise from the aneurysm including the vertebral (small arrow) and internal mammary arteries (IMA). The proximal extent of the aneurysm extends to the innominate bifurcation (IA). Pre-operative CT angiography demonstrated a dominant Left vertebral artery (block arrow) filling the basilar artery (BA) and a complete Circle of Willis (COW) with normal aortic arch anatomy.

\*Address correspondence to this author at the Shands Hospital at the University of Florida, Gainesville, Florida, NG-45, 1600 SW Archer Road, Division of Vascular Surgery and Endovascular Therapy, Gainesville, Florida, 32610, USA; Tel: 352-273-5484; Fax: 352-273-5515; Email: salvatore.scali@surgery.ufl.edu

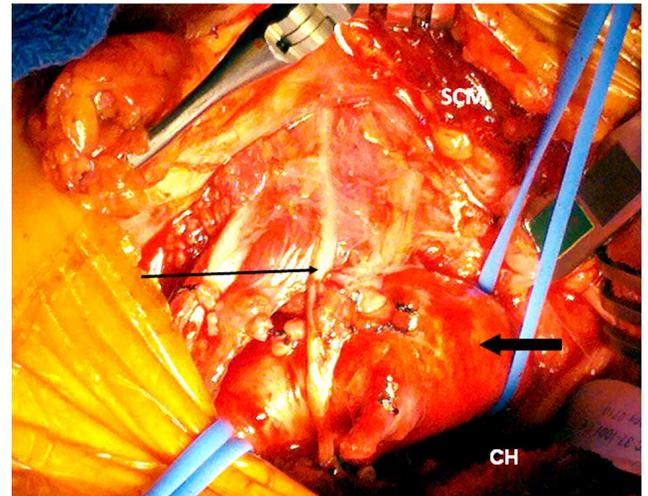


**Fig. (1B).** CT angiogram with M2S reconstruction demonstrating the occluded, terminal Right vertebral artery (arrow) and remaining contribution of the dominant, contralateral Left (block arrow) vertebral artery to the posterior circulation. A complete COW was present with no evidence of additional extra- or intra-cranial arterial pathology.

Because of the patient's relatively good health and young age, an open approach was planned after considering the options of both endovascular and open operative repair. Due to the proximal location of the aneurysm, a combined endovascular and open approach was chosen to limit the necessary exposure for proximal control. A transverse, supraclavicular incision was performed to expose the right subclavian artery (Fig. 2). The clavicular head of the sternocleidomastoid muscle was divided. Once identified, the phrenic nerve was isolated and protected. Trans-femoral balloon occlusion was employed until adequate mobilization of the lesion could be achieved by utilizing a 0.035 inch stiff glide wire, 5 French Shuttle sheath, and a 12x40mm non-compliant balloon with a three-way stopcock. The balloon was positioned at the level of the innominate bifurcation and the wire was retracted inside the balloon shaft once insufflated to facilitate end-to-end anastomosis. No common carotid shunting or EEG monitoring were utilized due to the presence of a normal ipsilateral carotid bifurcation and contralateral carotid system.

The side branches of the aneurysm were sequentially ligated, including an atretic right vertebral artery, prior to opening the aneurysm. It has been our practice that if patients have an intact Circle of Willis with either co-dominant or contralateral vertebral artery dominance, that vertebral artery revascularization is not routinely undertaken and is based on previously published data from our

institution on thoracic aortic endografting and the management of the left subclavian artery (and by extension the vertebral artery) [1]. Endoaneurysmorrhaphy was then performed using an 8mm, non-ringed heparin coated PTFE graft (Fig. 3). The patient tolerated the procedure well without complication and the remainder of her hospitalization was unremarkable. One and twelve month follow-up revealed symmetric brachial pressures and a patent graft on duplex examination.



**Fig. (2).** Supraclavicular exposure of the Right SAA. The clavicular head of the sternocleidomastoid muscle (SCM) has been divided to gain maximal medial exposure of the aneurysm which extends under the clavicular head (CH). The upper, smaller arrow denotes the location of the phrenic nerve and the lower (block) arrow demonstrates the proximal extent of the aneurysm.



**Fig. (3).** Completed interposition bypass graft using an 8mm non-ringed Gore® Propaten® graft (W.L. Gore & associates, Inc., Newark, DE) with preservation of the phrenic nerve (arrow). The proximal and distal extent of the repair is highlighted by the relationship to the phrenic nerve and the clavicular head (block arrow).

## DISCUSSION

Subclavian artery aneurysms (SAA) are a relatively unusual clinical entity in contemporary practice [2, 3]. These

aneurysms are often (30-60%) found in conjunction with other aneurysms located in the aortoiliac distribution or other peripheral arterial beds [4]. A variety of etiologies, including atherosclerotic, congenital, mycotic, mixed connective tissue, and inflammatory arteritides can predispose patients towards true aneurysm formation. Intra- thoracic SAAs are typically caused by atherosclerosis, infection, medial degeneration or are found in association with *arteria lusoria*. Extra-thoracic lesions are frequently associated with thoracic outlet syndrome, trauma with resultant pseudoaneurysm formation or inflammatory arteritis.

To date, there is little consensus about indications for treatment of SAA. Some reports have advocated an aggressive posture due to the devastating complications these lesions may have [5]. Historically, size greater than 2cm, evidence of peripheral embolization, rupture, thrombosis, or local compressive symptoms with or without associated brachial plexopathy have been cited as indications for intervention [2, 3]. Open operative management has traditionally involved ligation, endoaneurysmorrhaphy or resection with arterial reconstruction. The reconstruction may be performed using interposition, transposition or carotid-subclavian bypass techniques depending on the location and extent of the lesion. Purely endovascular techniques have become increasingly popular [6, 7], but the long-term durability is not clear.

The approach to both open and endovascular SAA repair depends greatly on the anatomic location and involvement of the cerebrovascular circulation [8]. Anticipation of posterior circulation adequacy post-intervention is paramount to good outcomes and may have direct implications on the revascularization strategy employed [8, 9]. Because of the dominance of the contra lateral vertebral artery, this patient's right vertebral was ligated without revascularization. This decision was made based on previous published reports [1, 10, 11] describing the management of the subclavian artery (and by extension the vertebral artery) in the management of thoracic aortic disease.

Open repair for aneurysms with intra-thoracic involvement frequently requires sternotomy or lateral thoracotomy [3], and hybrid techniques can often decrease the extent of exposure required for repair<sup>9</sup>. Although excellent long-term patency of direct arterial reconstruction of subclavian aneurysms has been reported, the resultant peri-operative morbidity can be prohibitive for selected patients [12]. Endovascular adjuncts such as that utilized in this patient can simplify the repair and decrease the exposure required for the procedure, thus decreasing the associated morbidity. For providers with even rudimentary endovascular skill sets, proximal balloon tamponade of the supra-aortic trunk vessels can facilitate anatomic exposures, minimize blood loss and reduce patient morbidity in elective

and emergent situations [13]. The ability to incorporate pre-operative 3D CTA with endovascular adjuncts can further expand the treatment armamentarium of interventional radiologists, vascular, cardiothoracic, and acute care/trauma surgeons alike [14].

## CONCLUSION

Isolated true degenerative aneurysms of the subclavian artery are a rare and sometimes challenging clinical problem. A variety of potential etiologies and anatomic configurations make preoperative 3-dimensional CT or MR angiography very useful when choosing the approach to repair. While the use of purely endovascular therapy is attractive, conventional surgical reconstruction remains the mainstay of therapy. Endovascular adjuncts to open operation can often simplify the repair and decrease the morbidity associated with extensive exposure for arterial reconstruction.

## REFERENCES

- [1] Feezor RJ, Lee WA. Management of the left subclavian artery during tevar. *Semin Vasc Surg* 2009; 22: 159-64.
- [2] Van Leemput A, Maleux G, Heye S, Nevelsteen A. Combined open and endovascular repair of a true right subclavian artery aneurysm without proximal neck. *Interact Cardiovasc Thorac Surg* 2007; 6: 406-8.
- [3] Resch TA, Lyden SP, Gavin TJ, Clair DG. Combined open and endovascular treatment of a right subclavian artery aneurysm: A case report. *J Vasc Surg* 2005; 42: 1206-9.
- [4] Davidovic LB, Markovic DM, Pejic SD, Kovacevic NS, Colic MM, Doric PM. Subclavian artery aneurysms. *Asian J Surg* 2003; 26: 7-11; discussion 12.
- [5] Motoki M, Fukui T, Shibata T, *et al.* Right subclavian artery aneurysm: Report of a case. *Osaka City Med J* 2010; 56: 1-4.
- [6] Bowman JN, Ellozy SH, Plestis K, Marin ML, Faries PL. Hybrid repair of bilateral subclavian artery aneurysms in a patient with marfan syndrome. *Ann Vasc Surg* 2010; 24: 114 e111-5.
- [7] Franz RW. Delayed treatment of a traumatic left subclavian artery pseudoaneurysm. *Vasc Endovascular Surg* 2008; 42: 482-5.
- [8] Criado FJ. Endovascular techniques for supra-aortic trunk intervention. *Perspect Vasc Surg Endovasc Ther* 2007; 19: 231-7.
- [9] Bruen KJ, Feezor RJ, Lee WA. Hybrid management of proximal right subclavian artery aneurysms. *J Vasc Surg* 2011; 53: 528-30.
- [10] Feezor RJ, Martin TD, Hess PJ, *et al.* Risk factors for perioperative stroke during thoracic endovascular aortic repairs (tevar). *J Endovasc Ther* 2007; 14: 568-73.
- [11] Matsumura JS, Lee WA, Mitchell RS, *et al.* The society for vascular surgery practice guidelines: Management of the left subclavian artery with thoracic endovascular aortic repair. *J Vasc Surg* 2009; 50: 1155-8.
- [12] Salo JA, Ala-Kulju K, Heikkinen L, Bondestam S, Ketonen P, Luosto R. Diagnosis and treatment of subclavian artery aneurysms. *Eur J Vasc Surg* 1990; 4: 271-4.
- [13] Alexander JR, Weeks SM, Sandhu J, Mauro MA, Jaques PF. Balloon tamponade for the treatment of inadvertent subclavian arterial catheter placement. *J Vasc Interv Radiol* 2000; 11: 875-7.
- [14] Desai M, Baxter AB, Karmy-Jones R, Borsa JJ. Potentially life-saving role for temporary endovascular balloon occlusion in atypical mediastinal hematoma. *AJR Am J Roentgenol* 2002; 178: 1180.