Feasibility, Short and Mid-term Outcomes of Endovascular Management of Subclavian Artery Aneurysms

***Haitham A. Eldmarany*[1], *Amr Saleh El Bahaey*[2]**
Department of Vascular Surgery, Kasr Alaini Hospital, Cairo University

ABSTRACT

Introduction*: Recently, with the paradigm shift in vascular aneurysm repair, stent graft treatment has emerged as a less invasive option for management of subclavian artery aneurysms with lower rate of morbidity and mortality whenever acceptable proximal and distal landing zones available to help graft fixation.* ***Method****: Endovascular exclusion by covered stent was offered to all allegeable patients with Subclavian artery aneurysm presented to the vascular surgery department, Kasr Al-Aini hospital, Cairo University between March 2012 and April 2015. Our exclusion criteria included: active uncontrollable hemorrhage, critical upper limb ischemia and infected trauma wounds as well as excessive luminal discrepancy between the proximal and the distal arterial segments. Unilateral or bilateral femoral access was utilized and additional brachial access to aid stent graft crossability through supporting the wire was employed occasionally. Planned post-operative evaluation included clinical and duplex arterial evaluation after 1, 3 and 6 months respectively.* ***Results****: 15 patients with subclavian artery aneurysm were enrolled. Their age range was 14 - 47 years (mean, 32.1). All 15 patients (12 male; 3 female) had undergone stent graft exclusion. False aneurysms were encountered in 11 patients while true aneurysms were found in 4 patients. All stent grafts were placed via femoral approach except for one patient for whom the graft was placed through a trans brachial approach. A variety of stent graft diameters (7-9 mm) and lengths (60 - 100 mm) were used. The stent grafts used included 11 Wallgraft (Boston Scientific), 4 Fluency (Bard), and one Advanta V12 (Atrium medical). One patient required second stent grafts to repair type I endoleak caused by incorrect positioning and slipping of the first stent grafts. No conversion to open repair was necessary and no periprocedural blood transfusions were required. All stent graft devices were successfully deployed with total exclusion of the aneurysms. There was one procedure-related complication (6.6%), consisting of groin pseudoaneurysms requiring surgical repair 7 days after the procedure.* ***Conclusion****: Endovascular stent-graft placement is a promising and less invasive alternative to surgery and potentially carries a lower morbidity and mortality rate and result in shorter operative time and less blood loss.*

Key words: *Aneurysms, Subclavian, Endovascular*

INTRODUCTION

Subclavian artery aneurysms are rare clinical conditions occurring most commonly after blunt or penetrating trauma to the peri-clavicular region and represent a potentially life-threatening vascular problem due to the risk of rupture and the possible compromise of upper extremity perfusion from distal embolization or thrombosis [1, 2]. The optimal management of

Subclavian aneurysms still continues to be a challenge because of the close relation to vital intra-thoracic structures. Until recently, surgical repair was the standard management yet with considerable risk of morbidity and mortality especially for aneurysms of the proximal Subclavian segment which may necessitate thoracotomy or even sternotomy [3,4]. Recently, with the paradigm shift in vascular aneurysm repair, stent graft treatment has emerged as a less invasive option for management with lower rate of morbidity and mortality whenever technically feasible.

PATIENTS AND METHODS

Endovascular exclusion was offered to patients with subclavian artery aneurysm presented at vascular surgery department, Kasr Al-Aini hospital, Cairo University between March 2012 and April 2015. The preoperative data that were taken into consideration include: age, gender, the causative pathology, presenting symptoms, the imaging modality used for diagnosis (arterial duplex scan, contrast-enhanced multi-detector computed tomography angiography

CE-MD CTA), size and type of aneurysm (true or false), type of stents used and complications. Our exclusion criteria included any clinical contraindications to stent grafting like: active uncontrollable hemorrhage, critical upper limb ischemia and infected trauma wounds. Excessive luminal discrepancy between the proximal and the distal arterial segment as landing zones constituted another exclusion criterion. The procedures were performed in the angiography suite, in all procedures prophylactic broad spectrum antibiotics were routinely given before stent deployment and continued for 24 hours postoperative on empiric basis.

All procedure were done under local anesthesia, intravenous sedation was occasionally used once the patients started felling discomfort. Access was gained under local anesthesia through a single or bilateral trans-femoral arterial route, with or without additional ipsilateral brachial access to aid stent graft crossability through supporting the wire by snaring. The exact anatomical location of the aneurysm together with proximal and distal artery diameters were determined with routine initial angiography at the start of the procedure, and a final decision regarding stent graft treatment was then determined. As part of this procedure, the inability to pass a guide wire and marked luminal discrepancy between the proximal and distal involved arterial segments that would not allow for proximal adequate oversizing of 1 mm without compromising the much smaller distal artery were considered barriers against stent graft management. Trans-femoral and/or trans-brachial access (5F to 6F introducer sheaths) was obtained. No long-term anticoagulation was followed just antiplatelet drugs (clopidogrel 75 mg once daily for 3 months) were prescribed. Planned post-operative evaluation included clinical and duplex arterial evaluation after 1, 3 and 6 months respectively and yearly thereafter. Our primary endpoints were: graft patency, arm ischemia, limb amputation, the need for open surgical intervention, the presence or absence of other endovascular-related complications, and death.

RESULTS

During the study period, 15 patients with subclavian artery aneurysm were eligible and enrolled. Their age range was 14 - 47 years (mean, 32.1). All 15 patients (12 male; 3 female) underwent stent graft treatment. Etiology and types of the aneurysms are shown in **table 1.**

Table 1: causes and types of the aneurysms

Gunshot injuries	*6 (40%)*
Atherosclerosis	4 (26.6%)
Stab injuries	2 (13.3%)
Behcet's disease	2 (13.3%)
Road traffic accidents (blunt trauma)	1 (6.6%)
False aneurysms (pesduoaneurysms)	11 (73.3%)
True aneurysms	4 (26.6%)

Access was gained under local anesthesia through a bilateral trans-femoral arterial route in 8 patients, brachial and femoral routes in 6 patients to aid stent graft cross ability through wire snaring in cases of tortuous anatomy and single trans-femoral route in one patient. All stent grafts were placed via a trans-femoral approach except for one patient for whom the graft was placed through trans brachial approach. Trans-femoral and/or trans-brachial access (5F or 6F introducer sheaths) was obtained; surgical unilateral femoral artery exposure was done in all cases. The appropriate stent graft was introduced via an 8For 9F sheath (11 cm in length) over a super stiff guide wire. Crossing the lesion and angiographic control for precise deployment was provided by a diagnostic catheter from the contra lateral femoral access or from the ipsilateral brachial access positioned in aortic arch or the proximal part of subclvain artery. Long introducer sheath (90 cm in length) was used in only 1 case; it has the advantage of providing access for stent graft and angiographic control of the graft at the same time, but in very proximal injuries achieving a stable position for the long introducer sheath was difficult. A variety of stent graft diameters (7-9 mm) and lengths (60 - 100 mm) were used. One patient required second stent grafts to repair type I endoleak caused by incorrect positioning due to slipping of the first stent grafts. In all patients, the aneurysms were successfully treated initially with technical success rate of 100%. Success was defined as total exclusion of the aneurysm without any type of endoleaks, as confirmed by post deployment completion angiography.(**Figures 1-3**)

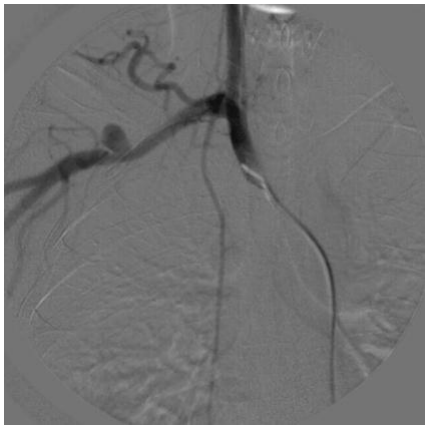

Fig 1: Right subclavian artery aneurysm

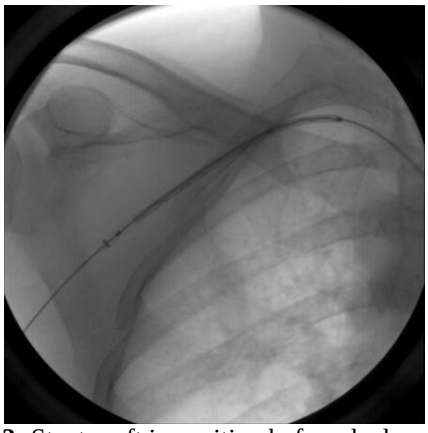

Fig 2: Stent graft in position before deployment

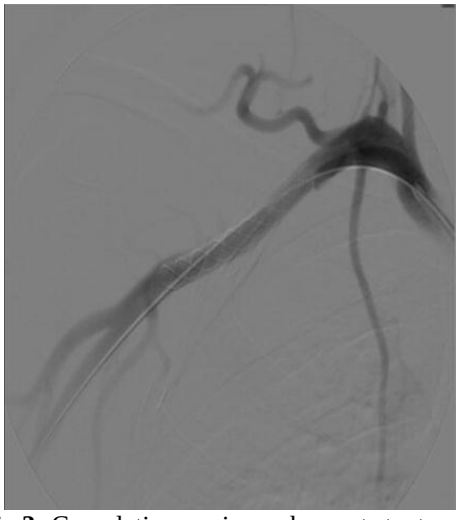

Fig 3: Completion angiography post stent graft deployment

The stent grafts used included 11 Wallgraft® (Boston Scientific), 4 Fluency® (Bard), and one Advanta V12® (Atrium medical). No conversion to open repair was necessary and no periprocedural blood transfusions were required. All stent graft devices were successfully deployed with total exclusion of the aneurysms. There was one procedure-related complication (6.6%), consisting of femoral pseudoaneurysms requiring surgical repair 7 days after the procedure. No long-term anticoagulation just antiplatelet drugs were prescribed (clopidogrel 75 mg once daily for 3 months). Patency rates (at the most available follow up data) are shown in **table 2.**

Table 2: patency rates at 3, 6 and 10 months

	At 3 months	***At 6 months***	***At 10 months***
Primary patency rate	15 (100%)	15 (100%)	14 (93.3%)
Secondary patency rate	------	-----	100%

One patient developed in-stent stenosis at 10 months follow up, which required angioplasty and stenting using a bare metal self-expandable stent.

DISCUSSION

Subclavian artery injury can be life-threatening.[1,2] The prehospital mortality rate with subclavian trauma has been estimated at approximately 75%.[2] Surgical repair has long been considered the first-line therapy for this vascular problem. However, mortality rates during and after surgical treatment are not low, with reported postsurgical mortality rates ranging from 5% to 30%[3,4] also, the close proximity of the subclavian artery, clavicle and brachial plexus puts barriers against the surgical treatment with a high risk of vascular and or neurological complications. Covered stent treatment for subclavian artery diseases is feasible because of the low morbidity and mortality risk.[5, 6, 7]

The first case of subclvain artery stenting was reported by Becker et al., it was a 43-year-old man who underwent stenting with a balloon-expandable metallic stent for left subclavian injury [8], while du Toit et al. reported a high clinical success rates for covered stent management of subclavian artery injuries with

low complication rates.[9] However, stent grafts are liable for compression by the first rib or the clavicle in case of deployment in the third part of subclvain artery.[10]

In addition, du Toit et al. reported stent graft stenosis (20%) and occlusion of the subclavian artery (12%) after stent graft deployment during 48 months of follow-up.[9] on the other hand, the clinical results of covered stent management of brachiocephalic or proximal subclavian artery traumatic aneurysms have not been well documented; reports of using endovascular management of vascular injuries in this region have been limited only to some case reports.[11, 12, 13] Patients with multiple co-morbidities who are unfit for general anesthesia or those with decreased life expectancy may benefit from this minimally invasive approach.

In our series, which was primarily a feasibility study, we attempted to offer patient this less invasive option to outline the short and mid-term outcomes as well as the necessary technical aspects needed to successfully perform the endovascular aneurysm exclusion in that particular vascular territory. A Wallgraft endoprosthesis was used in 11 patients; this was the only covered stent available in our hospital during the early study period. The Wallgraft® is a self-expanding stent formed of braided steel covered with a Dacron graft. Fluency® is a self-expanding nitinol Stent encapsulated with e.PTFE (expanded Polytetrafluoroethylene) graft and was used in 4 patients; Advanta V12® is a balloon-expandable nitinol stent covered with e.PTFE graft and was used in 1 patient. Patency and other outcomes may be different with Dacron- covered stents versus e.PTFE-covered stents; however this variable was not significant during analysis; furthermore the study being a feasibility study with main concern on success of aneurysm exclusion. Technically, one must pay attention for shortening of the stent that might occur after deployment especially in tortuous vessels that have been straightened by the stiff wire. In one patient where the wire was snared from the brachial access to achieve body floss technique in order to provide more support for the stent graft and more precise deployment to cover the proximally located true Subclavian aneurysm, the graft slipped down inside the aneurysm sac after releasing the wire, the flossing wire was stretching the tortuous artery giving false dimensions and after wire release the artery returned back pushing the graft up more distally, this case required another graft to cover the aneurysm. For that reason we recommend accurate preoperative planning as obtained from constructed CT- angiography images, the same like what is routinely followed in AAA (Abdominal Aortic Aneurysm) endovascular therapy.

During stent placement, care must be taken to not occlude the ostium of vertebral artery. The femoral approach was used in 9 patients, while combined femoral and brachial access was used in 6 patients. The brachial approach provides better control of the guide wire and a more direct access to a lesion in which most of the circumference of the subclavian artery may have been disrupted. We did not find the size of the vessel to be a main factor in determining our choice of open repair or endovascular repair. Another important issue is the possibility of stent graft compression between the clavicle and the first rib which might results in stent fracture.

Phipp et al[14] reported 3 patients in whom bare metal stents or covered stents were placed in the subclavian vessels (artery or vein) to manage problems of thoracic outlet syndrome, and 6 months to 2 years later had stent fracture. Although, we should consider that, the pathophysiology of atherosclerotic occlusive diseases or thoracic outlet syndrome is different from that of aneurysms or pesudoaneurysms.

We have not found any case of stent fracture in our patients. Short-term results of endovascular repair, as reported by Patel et al[15] and du Toit et al[16] are encouraging, but long-term durability has not been established. Nevertheless, in case of stent thrombosis, future revascularization is still possible, this, if necessary, can be done under less emergent circumstances after the risk of rupture has been resolved. Subclavian and axillary vessel injuries occur infrequently, and it is unlikely that a prospective randomized trial with enough number of patients can be carried out comparing the endovascular and open approaches. A potential bias in our series was that the selection between open repair and endovascular repair was determined by surgeon preference. The purpose of our study is not to express superiority of one approach over the other, but, we believe that, in some selected patients, stent grafts offer an additional way of dealing with these problems.

Limitations of our study include the relatively small number of patients; although the largest retrospective series to date reported 79 patients[17] and most series include 21 to 28 patients. [18, 19, 20] another limitation is the relatively short period of follow up. A large series with long-term follow-up comparing endovascular stent grafting with surgical options is still needed to safely confirm the widespread adaption of endovascular management in such lesions.

CONCLUSIONS

Endovascular stent-graft placement in Subclavian artery aneurysm is a promising and less invasive alternative to surgery and potentially carries a lower morbidity and mortality rate and result in shorter operative time and less blood loss.

Funding:

This work received no funding.

REFRENCES

1. D. Demetriades, D. Theodorou, E. Cornwell, T. V. Berne, J. Asensio, et al., "Evaluation of Penetrating Injuries of the Neck: Prospective Study of 223 Patients," World Journal of Surgery, Vol. 21, No. 1, 1997, pp. 41-48.
2. G. McKinley, A. T. Carrim and J. V. Robbs, "Management of Proximal Axillary and Subclavian Artery Inju-ries," British Journal of Surgery, Vol. 87, No. 1, 2000, pp. 79-85.
3. N. M. Rich, R. W. Hobson, B. S. Jarstfer and T. M. Geer, "Subclavian Artery Trauma," The Journal of Trauma, Vol. 13, No. 6, 1973, pp. 485-496.
4. S. M. George Jr., M. A. Croce, T. C. Fabian, E. C. Man- giante, K. A. Kudsk, et al., "Cervicothoracic Arterial In-juries: Recommendations for Diagnosis and Manage- ment," World Journal of Surgery, Vol. 15, No. 1, 1991, pp. 134-140.
5. E. S. Xenos, M. Freeman, S. Stevens, D. Cassada, J. Pacanowski, et al., "Covered Stents for Injuries of Sub- clavian and Axillary Arteries," Journal of Vascular Sur-gery, Vol. 38, No. 3, 2003, pp. 451-454.
6. de V. Odendaal, et al., "Endovascular Management of Traumatic Cervicothoracic Arteriovenous Fistula," British Journal of Surgery, Vol. 90, No. 12, 2003, pp. 1516-1521.
7. S. C. Wheeler, K. M. Zinn and T. W. Hughes, "Endovas-cular Covered Stent Repair of an Iatrogenic Subclavian Artery-to-Pulmonary Artery Fistula and Pseudoaneurysm," Journal of Vascular and Interventional Radiology, Vol. 18, No. 6, 2007, pp. 775-779.
8. G. J. Becker, J. F. Benenati, G. Zemel, D. S. Sallee, C. A. Suarez, et al., "Percutaneous Placement of a Balloon- Expandable Intraluminal Graft for Life-Threatening Subclavian Arterial Hemorrhage," Journal of Vascular and Interventional Radiology, Vol. 2, No. 2, 1991, pp. 225-229.
9. D. F. du Toit, A. V. Lambrechts, H. Stark and B. L. War-ren, "Long-Term Results of Stent Graft Treatment of Subclavian Artery Injuries: Management of Choice for Stable Patients?" Journal of Vascular Surgery, Vol. 47, No. 4, 2008, pp. 739-743.
10. L. H. Phipp, D. J. Scott, D. Kessel and I. Robertson, "Subclavian Stents and Stent-Grafts: Cause for Concern?" Jour- nal of Endovascular Surgery, Vol. 6, No. 3, 1999, pp. 223-226.
11. E. J. Miles, A. Blake, W. Thompson, W. G. Jones and E. L. Dunn, "Endovascular Repair of Acute Innominate Artery Injury Due to Blunt Trauma," The American Journal of Surgery, Vol. 69, No. 2, 2003, pp. 155-159.
12. F. Lennox, D. R. Logan, R. C. Waugh and J. May, "Endovascular Management of an Innominate-Caval Fistula Secondary to Insertion of a Cardiac Pacemaker," Circulation, Vol. 102, 2000, pp. E124-125.
13. K. Takasaki, K. Enatsu, M. Nakayama, T. Uchida and H. Takahashi, "A Case with Tracheo-Innominate Artery Fistula. Successful Management of Endovascular Emboliza-tion of Innominate Artery," Auris Nasus Larynx, Vol. 32, No. 2, 2005, pp. 195-198.
14. Phipp LH, Scott JA, Kessel D, Robertson I. Subclavian stents and stent-grafts: cause for concern? J Endovasc Surg 1999; 6:223-6.
15. Patel AV, Veith FJ, Kerr A, Sanchez LA. Endovascular graft repair of penetrating subclavian artery injuries. J Endovasc Surg 1996; 3:382-8.

16. Du Toit DF, Strauss DC, Blaszzyk M, de Villers R, Warren BL. Endovascular treatment of penetrating thoracic outlet arterial injuries. Eur J Vasc Endovasc Surg 2000; 19:489-95.
17. Demetriades D, Chahwan S, Gomez H, Peng R, Velmahos G, Murray J, et al. Penetrating injuries to the subclavian and axillary vessels. J Am Coll Surg 1999; 188:290-5.
18. Sullivan MT, Bacharach MJ, Perl MD, Gray B. Endovascular management of unusual aneurysms of the axillary and subclavian arteries. J Endovasc Surg 1996;3:389-95.
19. Hoff SJ, Reilly MK, Merrill WH, Stewart J, Frist WH, Morris JM. Analysis of blunt and penetrating injury of the innominate and subclavian arteries. Am Surg 1994; 60:151-4.
20. Kalakuntla V, Vijaykumar P, Tagoe A, Weaver W. Six-year experience with management of subclavian artery injuries. Am Surg 2000;65:927-31.