Zagazig University Medical Journal
www.zumj.journals.ekb.eg

Manuscript ID ZUMJ-2102-2149 (R2)
DOI 10.21608/zumj.2021.65011.2149

ORIGINAL ARTICLE

Surgical treatment of subclavian artery aneurysms

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Submit Date 2021-02-24
Revise Date 2021-03-31
Accept Date 2021-04-11

ABSTRACT

Background: Subclavian artery aneurysms (SAAs) are uncommon aneurysms.SAA is potentially serious disease due to complications.

Objective: to evaluate the surgical treatment of SAAs and its complications.

Methods: Fifteen patients with SAAs: 13 patients (86.67%) had extrathoracic (ET) aneurysms and two patients (13.33%) had intrathoracic (IT) aneurysms. Thoracic outlet syndrome (TOS) was presented in 8 patients (53.33%), while, atherosclerosis was presented in 7patients (46.67%). Laboratory & radiological studies were done. All patients were treated surgically.

Results: In 13 patients with extrathoracic aneurysms, a supraclavicular approach to the subclavian artery was used in (6/13, 46.15%), supraclavicular and infraclavicular approach was used in (7/13, 53.85%) cases. After excision of the aneurysm, graft interposition using (PTFE) and saphenous vein graft bypass were done in (6/13, 46.15% & 5/13 , 38.46 %) patients respectively. In two patients (2/13, 15.38 %), aneurysmal excision and end to end anastomosis were done. While in two patients with intrathoracic aneurysms, a combined left thoracotomy and supraclavicular approach was used. Common carotid-subclavian bypass using Dacron graft was done. In (6/8, 75 %) of patients with TOS, decompression was performed before arterial reconstruction. In three (37.50 %) patients with cervical rib, the cervical rib was resected. In three patients (37.50 %) with scalene syndrome, scalenectomy of the scalenus anterior muscle was done. In two patients (2/8, 25 %) with brachial artery embolism, embolectomy was done.

Conclusions: Early intervention was needed, especially in distal SAAs, because of the risk of thrombo-embolic complications. Open repair is sill the gold standard intervention for SAA.

Keywords: Subclavian artery aneurysm(SAA), thoracic outlet syndrome, intrathoracic SAA, extrathoracic SAA, open surgical repair.

INTRODUCTION

Subclavian artery aneurysms (SAAs) are uncommon in comparison to aneurysms involving other peripheral arteries. They represent about 1% of all peripheral artery aneurysms.[1] There are cases of intrathoracic and extrathoracic subclavian artery involvement.[2] SAA is potentially serious disease because of distal embolization, compression of surrounding structures, the risk of rupture, as well as thrombosis. [2,3]

Subclavian artery (SA) is divided into three parts: proximal, middle and distal part. [3] Bahnson in 1953, reported the first successful resection and reconstruction of SAAs. [4] In 1956, Schein did the same operation using an arterial homograft for reconstruction. [5]

The etiology of an SAA is mostly related to thoracic outlet syndrome, atherosclerosis, traumatic and iatrogenic causes. Most of SAAs (39%) were existed in the proximal segment of the SA. While, 25% and 24% were existed in the middle and distal segment respectively. [3]

Clinically, patients with SAAs present with a pulsating mass, shoulder pain and/or non-specific chest pain. Other symptoms include local compression, thrombosis, embolization and rupture. Symptoms of local compression are: compression of the stellate ganglion induced Horner syndrome or facial anhydrosis. While, recurrent laryngeal nerve compression caused hoarseness of voice. Dyspnea and dysphagia due to compression of trachea and esophagus were reported . Subclavian vein compression, causing venous congestion, was described. The most frequent sign of local compression was brachial plexopathy. [3,6-10]

Diagnosis of SAA is mainly dependant on symptoms & localization. The diagnosis of SAAs in the middle and distal segment of the SA is mainly clinical .Aneurysms of proximal segment of SA are mainly diagnosed by plain chest X-ray which was confirmed by Duplex ultrasound. A suspicion of SAA was often confirmed by angiography. Magnetic resonance angiography (MRA) and computed tomography angiography (CTA) are more often used nowadays . [3,11]

Therapeutic modalities involve conservative treatment, open surgical repair, endovascular exclusion and several hybrid techniques. [3, 12,13] Surgical repair by combined supra- and infraclavicular approach was mandatory. After decompression procedure of thoracic outlet syndrome (TOS), vascular reconstruction was done. It includes aneurysm sac excision and end-to-end anastomosis, or interposition artificial graft 8 mm and infrequent bypass procedure may be used from the subclavian to the axillary artery. Some patients require additional brachial thrombectomy. [1]

Surgery for the proximal SA included right and left thoracotomy or sternotomy with and without supraclavicular or transclavicular access, axillary access and anterior thoracotomies in combination with mini-sternotomy and supraclavicular access. A supraclavicular access approach is usually used to reach the middle segment of the SA which may be combined with an infraclavicular incision.[3,12,14] For revascularization of the arm after exclusion of the SAA, carotid subclavian bypass was mandatory. [1-3]

This study aimed to evaluate the surgical treatment of SAAs and its complications.

PATIENTS AND METHODS

Patients

This prospective study occurred within 3 years period from January 2018 to December 2020. Fifteen patients with subclavian artery aneurysms SAAs were included.

All patients were admitted to The Vascular Surgery Unit in Alexandria Main University Hospital, Faculty of Medicine and Department of Experimental and Clinical Surgery, Medical Research Institute, Alexandria University, Egypt. After approval of The Ethical Committee of the Faculty of Medicine, Alexandria University, an informed consent was taken from every patient. The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Inclusion criteria

Presence of pulsating mass in supraclavicular region. Partial or complete thrombosis in the aneurysm. Hand ischemia due to distal embolization. The presence of vascular (TOS) as cervical rib and scaline syndrome.

Exclusion criteria:

Fracture clavicle with severe fibrosis and infection. Fracture cervical spine. Severe cervical disk prolapse.

Methods

- **All patients were subjected to:**
  History, clinical examination, routine laboratory tests & radiological studies including plain x- ray chest, duplex ultrasound, angiography and CT angiography.
- **Treatment modalities:**
  All patients were treated surgically.

Thoracic outlet syndrome (TOS) was presented in 8 patients (8/15, 53.33%), while, atherosclerosis was presented in 7patients (7/15 ,46.67%). thirteen patients had extrathoracic aneurysms (13/15 , 86.67 %) . While, two patients had intrathoracic aneurysms (2/15 ,13.33 %).

In 13 patients with extrathoracic aneurysms, a supraclavicular approach to the subclavian artery was used in (6/13, 46.15%). While, supraclavicular and infraclavicular approach was used in (7/13, 53.85%) cases. Graft interposition using (PTFE) after excision of the aneurysm was done in 6/13(46.15%) patients. Saphenous vein graft bypass after excision of the aneurysm was done in 5/13 (38.46 %) patients. In two patients (2/13, 15.38 %), aneurysmal excision and end to end anastomosis were done.

While in two patients with intrathoracic aneurysms (2/15,13.33 %), a combined left thoracotomy and supraclavicular approach were used. Common carotid-subclavian bypass using Dacron graft was done.

In (6/8, 75 %) of patients with TOS, decompression was performed first then arterial reconstruction was done. In three (3/8, 37.50 %) patients with cervical rib, the cervical rib was resected. In three patients (3/8, 37.50 %) with scalene syndrome, scalenectomy of the scalenus anterior muscle was done. In two patients (2/8, 25 %) with brachial artery embolism as a complication of thrombosis of SAA, embolectomy was done and the upper limb ischemia disappeared.

Statistical analysis of the data:

Data was analyzed using version 20.0 of IBM SPSS software package (Armonk, NY: IBM Corp) Qualitative data were described using number and percent. Quantitative data were described using range (minimum and maximum), mean and standard deviation.

RESULTS

Demographic data, localization, etiology and clinical presentation of the patients with SAAs are shown in table I. Fifteen cases of subclavian artery aneurysms were included in the present study. The mean age was 40±20.81 years with a range from 22 to 64 years. Most of patients were males (9/15, 60%). The majority of patients (13/15, 86.67%) had aneurysms in the extrathoracic (ET) segment of the subclavian artery. While, two patients (2/15,13.33%) had aneurysms in the intrathoracic (IT) segment of the subclavian artery. Eight patients (8/15,53.33%) with SAAs were related to TOS. While, seven patients (7/15,46.67%) with SAAs were due to atherosclerosis.

Seven patients (7/13,53.85%) with ET SAAs had shoulder pain and pulsating mass, Seven patients (7/13,53.85%) had chronic upper limb ischemia, two patients (2/13,15.38%) had acute upper limb ischemia and one of the ET SAA (1/13,7.69%) was asymptomatic.

One of the two patients with aneurysms in IT segment of the subclavian artery (1/2,50%) was a symptomatic and the second one (1/2,50%) presented with dyspnea.

In all 13 cases of ET SAAs, open repair was performed. A supraclavicular approach to the subclavian artery was used in (6/13, 46.15%), while, supraclavicular and infraclavicular approach was used in (7/13, 53.85%) cases. Vascular reconstruction was performed. It consisted of aneurysmal sac excision and arterial reconstruction with tube 8mm (PTFE) interposition graft in 6 cases (6/13,46.15 %), Case **1**,Fig1 A,B,C & D, saphenous vein graft bypass after excision of the aneurysm in5cases (5/13 ,38.46 %) . In two patients (2/13, 15.38 %), aneurysmal excision and end to end anastomosis were done.

For eight patients with TOS: In (6/8, 75 %) of patients, decompression was performed first then arterial reconstruction was done. In three (3/8, 37.50 %) patients with cervical rib, the cervical rib

was resected. In three patients (3/8, 37.50 %) with scalene syndrome, scalenectomy of the scalenus anterior muscle was done. Two patients (2/8, 25.00 %) required additional brachial reconstruction; embolectomy due to acute hand ischemia.

Two left subclavian artery intrathoracic aneurysms (atherosclerotic) were treated by a combined left high postrolateral thoracotomy and supraclavicular approach. Excision of the aneurysm and left common carotid-subclavian bypass using 8 mm tube Dacron graft, Table II, Case **2**,Fig2 A,B,C & D.

Table 1: Demographic data, localization, etiology and clinical presentation of the patients with SAAs (total N0.=15)

Item	No	%
Age:	15	100
Mean± SD	40±20.81 years	
Range	22-64 years	
Sex		
Males	9	60
Females	6	40
Localization		
Extrathoracic (ET)		
Intrathoracic(IT)	13	86.67
	2	13.33
Etiology		
Thoracic outlet syndrome (TOS)	8	53.33
Atherosclerosis	7	46.67
Clinical presentation		
Extrathoracic SAAs (No.=13)		
Shoulder pain and pulsating mass	7	53.85
Chronic upper limb ischemia	7	53.85
Acute upper limb ischemia	2	15.38
Asymptomatic	1	7.69
Intrathoracic SAAs(No=2)		
Asymptomatic	1	50
Dyspnea	1	50

All patients were operated under general anesthesia.

Table II: Intraoperative data & early post-operative complications of patients with SAAs (total N0.=15)

Intraoperative data	N0	%
Extrathoracic open approach	13/15	86.67
Supraclavicular approach	6/13	46.15
Combined supra and infraclavicular approach	7/13	53.85
Types of open reconstruction for extrathoracic subclavian aneurysm	13/15	86.67
Graft interposition (PTFE)	6/13	46.15
Saphenous bypass graft	5/13	38.46
Aneurysmal resection and end to end anastomosis	2/13	15.38
Additional vascular procedure for TOS (8 patients):		
Decompression procedure in cervical rib or scaline muscle resection	6/8	75.00
Combined decompression procedure and brachial embolectomy	2/8	25.00
Intrathoracic open approach left high posterolateral thoracotomy& supraclavicular approach Intrathoracic aneurysm excision and left common carotid to left SA bypass using Dacron graft.	2/15	13.33
Early post-operative complications	2/15	13.33
Superficial supraclavicular wound infection	1/15	6.67
Transient brachial plexus injury	1/15	6.67

Case I

Figure1A: Photograph of right gaint subclavian artery aneurysm, complicated by thrombosis and distal brachial artery embolism showing right hand ischemia (arrow).

Figure1B: Plain x-ray of the neck showing right cervical rib (arrow)

Figure1C: Arch aortography showing gaint aneurysm of the right subclavian artery 58mm in diameter and brachial artery embolism due to (TOS) (cervical rib) (arrow)

Figure1D: Postoperative picture showing two Supraclavicular and infraclavicular scars after decompression and excision of the aneurysm and reconstruction by interposition PTFE graft 8mm. After brachial artery embolectomy, the pallor of the ischemic hand was disappeared. (arrows)

Case II

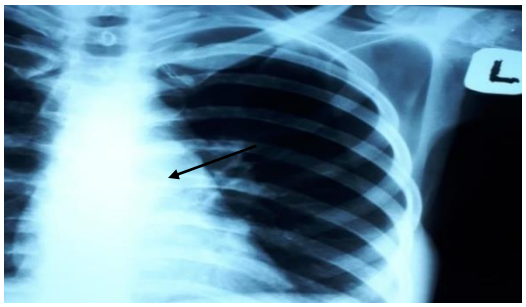

Figure 2 A: **P**reoperative arch aortography showing left subclavian artery aneurysm (arrow)

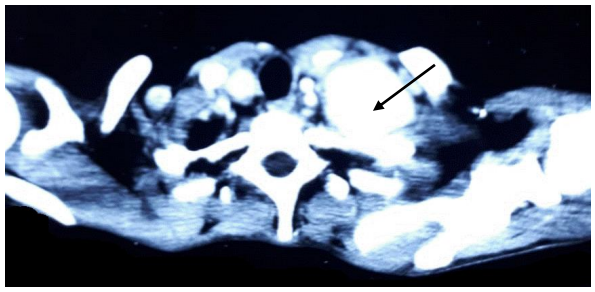

Figure 2 B: Computed tomography arteriography (CTA) showing left subclavian artery aneurysm (arrow)

Figure 2 C: Arch aortography showing aneurysm of the second and distal segment of left subclavian artery (the arrow)

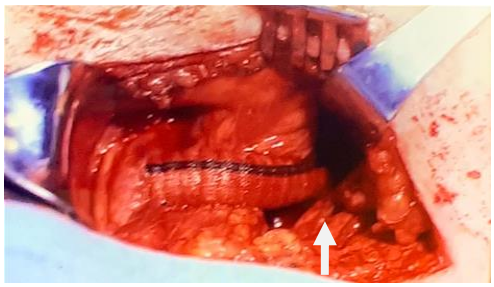

Figure2 D : Intra operative photograph showing excision of left subclavian artery aneurysm and common carotid to distal subclavian artery interposition bypass graft was done using Dacron graft 8mm in diameter.

DISCUSSION

Subclavian artery aneurysms constitute less than 1% of peripheral aneurysmal disease. Although they are uncommon and without consensus on size warranting intervention, there are hazerds of debilitating distal embolization and fatal rupture. [1,15-17]

Aneurysms are classified as intrathoracic and extrathoracic depending on the site. Atherosclerosis is the first etiology of intrathoracic aneurysms then injuries, infection, cystic medial degeneration, Marfan's syndrome and Takayasu arteritis, while extrathoracic aneurysms are due to thoracic outlet syndrome (TOS) or iatrogenic injuries. [16,17]

In the present study, regarding the localization, the majority of the cases were extrathoracic aneurysms (86.67%), while only (13.33%) were intrathoracic aneurysms. This was in agreement with Davidovic et al [1] who dedicated that (80%) of SAAs from their study affected extrathoracic (ET), while (20%) affected intrathoracic (IT) segment of the subclavian artery.

In the current study, regarding the etiology, eight (53.33%) SAAs were related to TOS, while seven (46.67%) to atherosclerosis. Davidovic et al [1] stated that eighteen (72%) SAAs were due to TOS, five (20%) to atherosclerosis.

Clinical picture ranges from asymptomatic mass to compression of the neighboring anatomical structures or distal embolization. Dyspnea, dysphagia, and hoarseness of voice from tracheal, phrenic, esophageal, and right recurrent laryngeal nerve compression have been reported. Compression of the stellate ganglion leads to Horner's syndrome , as well as brachial plexus compression leads to sensory and motor sign's. [1,2,17] Thoracic CTA is the imaging technique of choice since it aids to diagnosis and operational approach to SAA. [17]

In the present study, regarding the clinical presentation , Seven (53.85%) of our patients with ET SAA suffered from shoulder pain and pulsatile mass, seven (53.85%) suffered from chronic limb ischemia, while two (15.38%) suffered from acute limb ischemia, One extrathoracic SAA was asymptomatic (7.69%). Out of two IT SAAs, one patient was asymptomatic (50%), one patient presented with dyspnea (50%).

In a recent study 2020 done by Davidovic et al, [1] they mentioned that Seven (35%) of their patients with ET SAA suffered from shoulder pain and pulsatile mass, seven (35%) suffered from chronic limb ischemia, while , five (25%) suffered from acute limb ischemia. One extrathoracic SAA was asymptomatic (5%). Of the five cases with IT SAAs, two (40%) had no symptoms, one (20%) suffered from dyspnea, while hematothorax caused by rupture occurred in two cases (40%).

As subclavian artery aneurysms (SAAs) are uncommon, there is a paucity of literature regarding surgical repair technique. [18] Since the natural history of SAAs is unknown and no guidelines regarding the timing of intervention are available, early treatment is necessary in order to prevent potential complications. [19] The indication for exclusion of an SAA depends on prevention of upper limb thrombosis, embolisation and rupture. The risk of development of these complications may based on several aneurysm-related features, involving its cause and site. Therapeutic options include conservative treatment, open surgical repair, endovascular exclusion and various hybrid techniques. [3] The choice of procedure should be tailored to the patient, based on comorbidities, clinical picture and anatomical criteria. An open approach is advised when compressive symptoms exist. [20]

Up till now, open surgical repair is done via an ipsilateral thoracotomy or supraclavicular incision with adequate long-term patency results up to 9.2 years.[1,15] Davidovic et al, [1] 2020 stated that in series of patients in their study, two cases with IT SAAs were treated with open surgery (OS). Other three patients underwent hybrid procedure. One patient with ET SAA was treated endovascularly due to hostile anatomy, while in all other 19 patients of ET SAAs open repair was done, which involved: graft interposition in 10 (52.63%), end-to-end anastomosis in 7 (36.84%) patients, while bypass procedure in 2 (10.52%) cases. Davidovic et al, [2] prefered a combined supraclavicular and infraclavicular approach because it allows complete exposure of the subclavian artery, cervical and first ribs, and all soft tissue anomalies in SAAs due to thoracic outlet syndrome (TOS). The surgical procedures in the current study were more or less similar to Davidovic et al, [1] 2020.

No postoperative deaths occurred in the current study. Early two complications were noted (13.33%). One superficial supraclavicular wound infection which was successfully treated with antibiotics after two weeks (6.67%) and one transient brachial plexus injury (6.67%). The duration of follow-up was 3 months. In this follow-up period all reconstructed arteries in all patients remained patent. In all patients, a complete resolution of symptoms and return to full activity was observed.

On the contrary of the present study, Davidovic et al, [1] 2020 dedicated that in series of patients in their study, pneumothorax occurred in two patients (8%) with ET SAAs as an early postoperative complication.It was treated successfully by thoracic drainage. Two patients (8%) suffered from hemothorax after open repair of IT SAA and was treated with several pleural punctions, while one after open repair of ET SAA and the treatment was conservative. After open repair of ET SAA's, three cases suffered from acute limb ischemia which was treated successfully by transbrachial embolectomy.

Conclusion

SAA is an uncommon vascular disease with life and limb threatening complications. Early intervention was indicated, especially in distal SAAs, because of the risk of thrombo-embolic complications. The site, size, clinical picture and co morbidity affect the choice of treatment. Although they are infrequent, the potential for serious complications (thrombosis, embolization and rupture) needs surgical intervention. Open repair remains the gold standard modality for SAA.

Conflict of interest statement: The authors report no conflict of interest.

Funding source: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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TO CITE THIS ARTICLE

Salem, A., Salem, M., Salem, S., Moustafa, S. Surgical treatment of subclavian artery aneurysms. *Zagazig University Medical Journal*, 2021; (1582-1591): -. doi: 10.21608/zumj.2021.65011.2149