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Percutaneous endovascular therapy for symptomatic chronic total occlusion of the left subclavian artery

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ABSTRACT

Introduction: Percutaneous endovascular therapy is an accepted and preferred procedure for symptomatic subclavian artery disease. However, the technical feasibility and effectiveness of treating chronic total occlusion of the subclavian artery with this approach is uncertain. We aimed to evaluate the initial and mid-term results of endovascular therapy for patients with symptomatic chronic total occlusion of the left subclavian artery.

Methods: Consecutive patients who underwent balloon angioplasty and stenting for chronic total occlusion of the left subclavian artery between January 2010 and February 2014 were included.

Results: Overall, 16 patients (10 male, 6 female; mean age 56 ± 13 years) underwent balloon angioplasty and stenting for chronic total occlusion of the left subclavian artery – 6 (37.5%) had arm claudication, 8 (50.0%) had vertebrobasilar insufficiency and 2 (12.5%) had coronary steal. 18 balloon-expandable stents were implanted to 15 patients. The central luminal passage was not achieved in one patient because of the subintimal position of guidewire (procedural success rate 93.8%). There were no procedure-related complications. Mean preprocedural and postprocedural systolic blood pressure differences between the upper extremities were 37 ± 13 (range 25–60) mmHg and 11 ± 9 (range 5–38) mmHg, respectively; the improvement was statistically significant. Outpatient follow-up revealed one asymptomatic restenosis at two years. Patency rate at two years was 93.3%.

Conclusion: Balloon angioplasty and stenting for chronic total occlusion of the left subclavian artery is safe and effective, with good acute success rate and mid-term patency. Prospective randomised studies on larger patient populations would provide more precise results.

Keywords: angioplasty, stenting, subclavian artery, total occlusion

INTRODUCTION

Percutaneous transluminal balloon angioplasty (PTA) and stenting is an accepted treatment choice for subclavian artery (SA) occlusions.[1] Chronic total occlusion (CTO) of the SA is defined as complete occlusion of the SA, with no distal flow, present for an estimated duration of three months. CTO of the SA is encountered rarely and its precipitating factors are similar to that of atherosclerosis (e.g. smoking, diabetes mellitus, hypertension and hypercholesterolaemia).[2] Other causes include arteritis, compression of a mass and associated congenital heart disease.[3] Arm claudication is the most common symptom of SA stenosis.[4] SA steal syndrome, which is associated with vertebrobasilar insufficiency, is another condition (Fig. 1). Furthermore, SA occlusion may lead to coronary steal syndrome in patients with prior internal mammary coronary bypass surgery.[5]

Although revascularisation of subclavian occlusion in patients with symptomatic subclavian steal, carotid steal, arm claudication or coronary steal has been the traditional surgical approach,[6] with the evolution of endovascular techniques, SA occlusions can now be treated with balloon angioplasty and stenting.[7]

The present study was undertaken to examine the technical feasibility, effectiveness and reliability of treating CTO of the left SA as well as determine the mid-term results of balloon angioplasty and stenting by retrospective review of a series of 16 consecutive patients who had total occlusion of the left SA.

METHODS

A single-centre retrospective study was conducted of 16 consecutive symptomatic patients who were diagnosed with CTO of the left SA between January 2010 and February 2014. Chronicity of CTO was assessed based on the duration of symptoms and imaging documentation. We

included all patients who were symptomatic and underwent baseline colour duplex ultrasonography and/or angiography, which showed total occlusion of SA.

Informed consent from the patients and approval from the institutional review board were obtained. Preprocedural evaluations included patients' baseline characteristics, careful history-taking and physical examination. Technical and clinical determinants vis-à-vis the procedure, complications and follow-up were analysed using the institutional database.

All procedures were performed in the cardiac catheterisation laboratory and under local anaesthesia. All patients were receiving antiplatelet therapy with acetyl salicylic acid at the time of diagnosis (dose range 75–325 mg/day). In addition, clopidogrel was given orally (dose 75 mg/day) for at least one week before the procedure or administered as a loading dose (dose 300 mg) on the morning of the procedure. The dual antiplatelet therapy was maintained for four weeks.

During the procedure, an 8F sheath was used for the right femoral artery whereas a 6F introducer was used for the left brachial artery. In patients with coronary steal, a 6F sheath was advanced to the femoral artery and a left Judkins diagnostic catheter was subsequently introduced over this sheath that engaged the left coronary artery ostia. The distal part of the left SA was confirmed and made guidance for intervention in this manner (Figs. 2 & 3).

During all procedures for totally occluded SAs, an 8F sheath was advanced over the 7F guiding internal mammary artery catheter to the stump of the left SA. Then, a 0.035-inch hydrophilic-coated guidewire (Glidewire; Medi-tech/Boston Scientific Corporation, Natick, MA, USA) was used to cross the CTO. In case the guidewire could not cross the lesion, a 0.018-inch Treasure wire (Asahi Intecc Co, Aichi, Japan) or CTO-dedicated wires were used. Guidewire was advanced to the brachial artery after crossing the lesion and the guiding catheter was introduced over the wire (Fig. 4).

Predilation was performed using an undersized PTA balloon (size 4–6 mm × 40–60 mm; GliderfleX; TriReme Medical, Pleasanton, CA, USA) (Fig. 5). Peripheral balloon-expanding stents (size 6–9 mm × 18–38 mm; Qualimed Propes) were used (Fig. 6). Aspirin (dose 300 mg/day) and clopidogrel (dose 75 mg/day) were continued after intervention.

The central luminal passage was not achieved in one patient because of the subintimal position of the guidewire. Angiographic control was performed after the procedure. Technical success was defined as residual stenosis of over 30% and clinical success was defined as technical success with resolution of symptoms.

All patients were followed up at one month, six months and 24 months after the procedure. At follow-up, in addition to history and physical examination, duplex ultrasonography was also performed. Restenosis was defined as recurrent symptoms accompanied by recurrent stenosis of over 60%, as confirmed by duplex ultrasonography.

For continuous variables values were given as mean ± standard deviation or data reported as number and percentages. For categorical and continuous variables, chi-square test and Student's *t*-test were used, respectively. A p-value < 0.05 was considered to be statistically significant. All statistical analyses were performed using SPSS version 16 (SPSS Inc, Chicago, IL, USA).

RESULTS

Overall, 16 patients with CTO of the left SA met the inclusion criteria. The clinical indications for percutaneous intervention in our study were arm claudication for 6 (37.5%) patients, vertebrobasilar insufficiency for 8 (50.0%) patients and coronary steal for 2 (12.5%) patients. Patients had some comorbidities and risk factors, such as coronary artery disease (31.3%), hyperlipidaemia (75.0%), hypertension (68.8%), diabetes mellitus (43.8%) and smoking (75.0%); 1 (6.3%) patient had renal insufficiency (Table I).

Table I. Demographic and clinical characteristics of patients (n = 16).

Variable	Subclavian stenting (no. [%])
Age (yr)*	56.2 ± 12.8
Male gender	10 (62.5)
Symptom	
Arm claudication	6 (37.5)
Vertebrobasilar insufficiency	8 (50.0)
Angina	2 (12.5)
Risk factor	
Coronary artery disease	5 (31.3)
Hyperlipidaemia	12 (75.0)
Hypertension	11 (68.8)
Diabetes mellitus	7 (43.8)
Smoking	12 (75.0)
Renal insufficiency	1 (6.3)

*Data presented as mean ± standard deviation.

Successful percutaneous angioplasty and stenting was achieved for 15 (93.8%) patients whereas the percutaneous intervention failed for the patient (n = 1, 6.3%) with arm claudication because of an inability to cross the lesion with wire despite multiple attempts. Consequently, the acute technical success for the entire group was 93.8%. Among the 15 patients with successful balloon angioplasty and stenting, 18 balloon-expandable stents were implanted (mean stent length 28.6 ± 11.4 mm; mean stent diameter 7.4 ± 2.2 mm). A single stent was placed in 12 patients while three patients received two stents each.

Access site complications, neurologic events, distal embolisation or death was not encountered during the periprocedural period in any of our patients. The mean preprocedural systolic blood pressure difference between the upper extremities was 37 ± 13 (range 25–60) mmHg while the corresponding postprocedural difference was 11 ± 9 (range 5–38) mmHg; improvement following the intervention was statistically significant ($p < 0.05$).

After the procedure, all patients were followed up at one month, six months and 24 months using duplex ultrasonography. During the follow-up period, restenosis occurred only in one patient. This patient was asymptomatic, and was treated by exercise rehabilitation and

medical therapy. Among the remaining 14 patients, there were no complications or restenosis noticed at 24 months (Table II).

Table II. Procedural data and result of subclavian artery BA and stenting at initial and two-year follow-up (n = 16).

Variable	Subclavian stenting (no. [%])
Stent length (mm)*	28.6 ± 11.4
Stent diameter (mm)*	7.4 ± 2.2
Successful BA and stenting	15 (93.8)
Unsuccessful BA and stenting	1 (6.3)
Procedural complication (major or minor)	0 (0)
Total restenosis (occlusion) at two-year follow-up	1 (6.3)

*Data presented as mean ± standard deviation. BA: balloon angioplasty

DISCUSSION

Although the conventional treatment of SA occlusion involves surgical procedures with good outcomes, many serious complications have been reported, and associated mortality and morbidity remain high.[8] Due to such reasons, the treatment of subclavian stenosis has shifted toward percutaneous procedures during the last decade. However, controversy regarding the safety, feasibility and outcomes of percutaneous intervention for CTO of the SA persists.[9]

In the present study, there were no minor or major complications with balloon angioplasty and stenting in patients with CTO of the SA. Our technical success rate was 93.8% and restenosis occurred only in one patient during 24 months of follow-up. Previous reports have also showed high rates of technical success and low complication rates, similar to our study.[10]

Symptoms are the main indications for percutaneous intervention for CTO of the SA. In our study, the most common indications were vertebrobasilar insufficiency (n=8, 50.0%), arm claudication (n = 6, 37.5%) and coronary steal (n = 2, 12.5%). Revascularisation options for symptomatic CTO of the SA include percutaneous and surgical treatments. During surgery, a variety of bypass techniques can be performed, such as carotid-subclavian bypass, carotid-

subclavian transposition, and axillo-axillary or subclavian-subclavian bypass. These approaches have been shown to have good long-term patency rates (range 82%–100%).[11,12] However, extensive dissections and manipulations during the surgery can result in serious injuries to adjacent tissues. Thus, mortality rates for surgery can be as high as 10% whereas related morbidity can be nearly 25%.[13] Even with extrathoracic techniques, mortality rates remain in the range of 2%–5%.[14]

Major surgical complications include injuries of the brachial plexus, vagal nerve, laryngeal nerve and phrenic nerve. Cerebral ischaemia, Horner syndrome and chylothorax are other main complications.[13] Qi et al evaluated the surgical treatment of SA occlusion in a series involving 39 patients. In their study, although the initial and long-term patency rates were very good, the complication rate was 13.5%.[15] Schardey et al also found similar results in a series of subclavian carotid transposition for subclavian occlusion treatment and reported a complication rate of 15%.[16] It is difficult to express an opinion about the comparison between surgical and endovascular approaches for patients with subclavian occlusion because of a lack of randomised studies. Still, endovascular treatment for symptomatic occlusive disease of the SA has increasingly become the preferred option and is suggested as the first line of treatment.[17]

Balloon angioplasty alone for the treatment of cervical occlusive arterial disease was introduced in the 1980s.[18] However, only balloon angioplasty for CTO was not as effective.[19] In studies involving series of patients undergoing pure balloon angioplasty, patency rates have been around 50% or as low as 15% at follow-up.[20] While comparing the patency rates of PTA for SA stenosis between the stenting and only balloon angioplasty groups, Henry et al found significantly better results among patients for whom stenting was done.[6] Sixt et al also recommended stenting for CTO of the SA.[21] In contrast to only balloon angioplasty, stenting for CTO of the SA has provided durable outcomes.[22] By using stents, procedural success rates

were shown to increase to 70%–100% for CTO.[23] In our cohort, a combination of balloon angioplasty and stenting was achieved for all patients by using balloon-expandable stents.

Typically, balloon-expandable stents should be used for ostial lesions. In comparison to self-expanding stents, balloon-expandable stents have a higher radial force and offer more precise placement. If the lesion is non-ostial, the use of a self-expanding stent can be considered, with the knowledge that predilation and postdilation would likely be mandatory.

Some critical anatomical details must be considered, including the relationship of the stenosis to the vertebral and left internal mammary arteries.[24] A stenosis that is close to the origin of the vertebral artery may require complex interventions. This can lead to vertebral artery dissections and catastrophic complications. The left internal mammary artery is also in close proximity to the distal endpoint of the stent, and its origin must be addressed as well, so that its present or future use as a conduit for coronary bypass surgery would not be hindered.

In our study, we used balloon-expandable stents with emphasis on correct placement and high radial force. Balloon-expandable stents have been the main stents in many previous studies.[25] Although self-expanding stents do provide good results, these stents are contraindicated for ostial lesions. Stent dislocation into the aorta may be provoked by using self-expanding stents for ostial lesions, and therefore the use of such or undersized stents should be avoided for these lesions. But, as reported by Sixt et al, it should be borne in mind that self-expanding stents support better long-term prevention of restenosis.[21]

Recanalisation failure is common in CTO of the SA. This failure may be related to calcification, density and length of the occluded segment.[26] In our study, in one patient, all attempts to pass the lesion were unsuccessful. In such cases, aggressive efforts to traverse the lesion may produce severe complications. The other complications of PTA, such as stent dislocation, thrombosis, dissection and infection, were not seen in our study. In-stent restenosis is another concern with endovascular procedures. Some studies have found that short-term and

mid-term results, at least during the first two years, for in-stent restenosis were very low.[27] Although there is paucity of long-term results, it has been shown that stenting for symptomatic SA stenosis had 83% primary and 96% secondary patency rates on long-term follow-up.[28] In-stent restenosis can be treated with balloon angioplasty or repeat stenting for symptomatic patients. In our patient with restenosis, however, we did not perform further intervention, as the patient remained symptom-free.

There were some limitations to our study. As this was a retrospective single-centre study, with small sample size, further extensive and prospective studies are warranted to corroborate our findings. This notwithstanding, our series of patients with symptomatic CTO of the left SA who were treated with balloon angioplasty and stenting showed remarkable procedural success rate, satisfactory initial and mid-term patency rates, and a very low complication rate.

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FIGURES

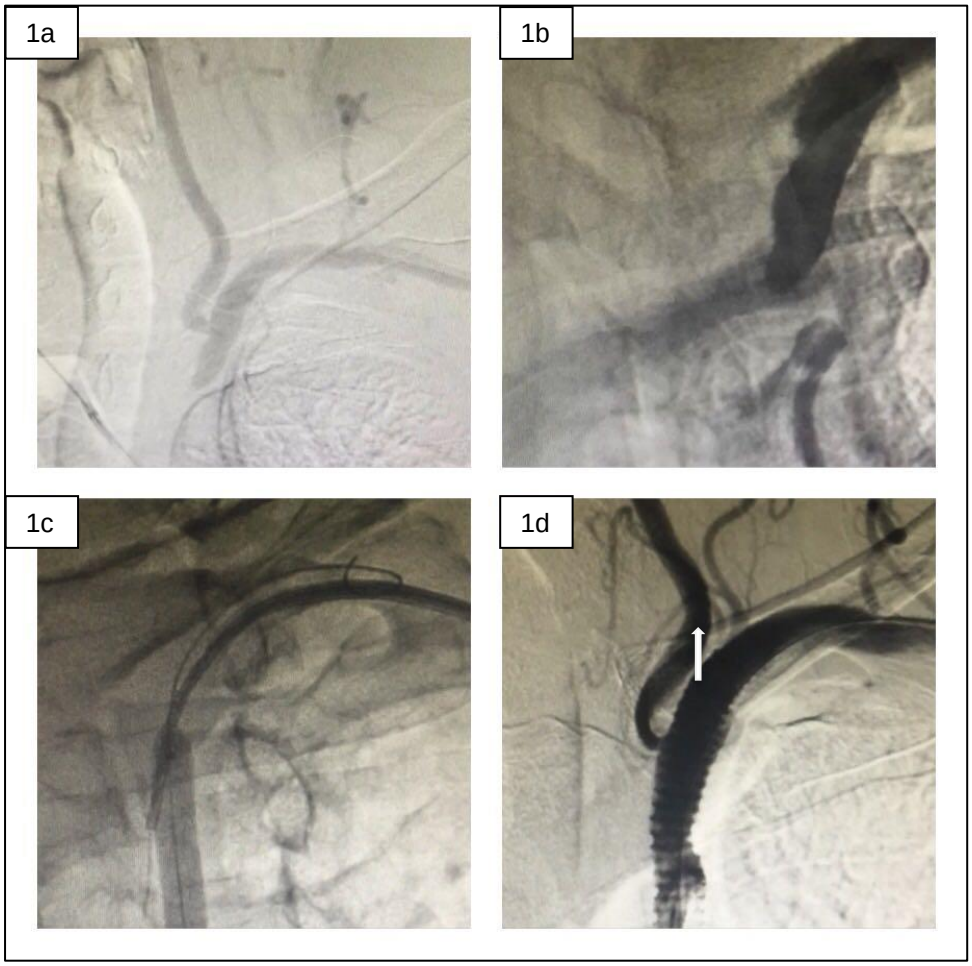

Fig. 1 Angiographs show (a) subclavian steal syndrome; (b) total occlusion of the proximal left subclavian artery; (c) percutaneous transluminal balloon angioplasty; and (d) stent deployment and anterograde flow in the left vertebral artery (arrow).

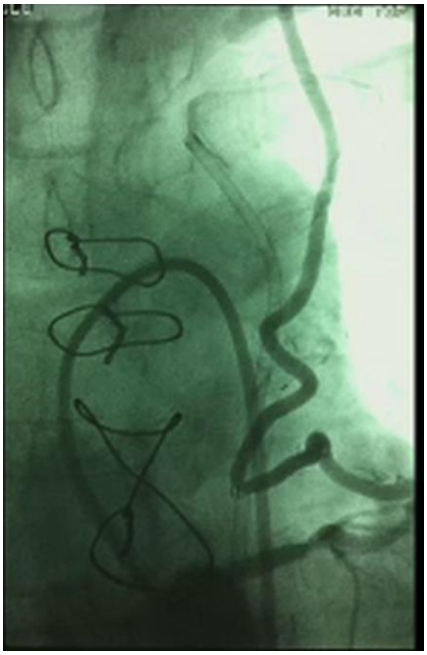

Fig. 2 Coronary angiograph shows retrograde flow in the internal mammary artery with filling of the left subclavian arteries.

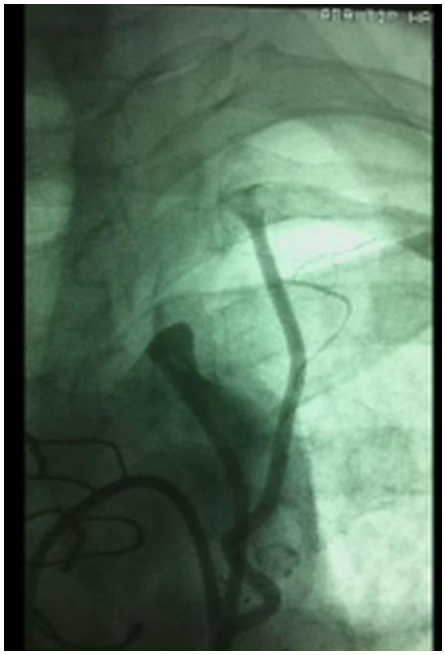

Fig. 3 Angiograph shows total occlusion in the ostial lesion of the left subclavian artery.

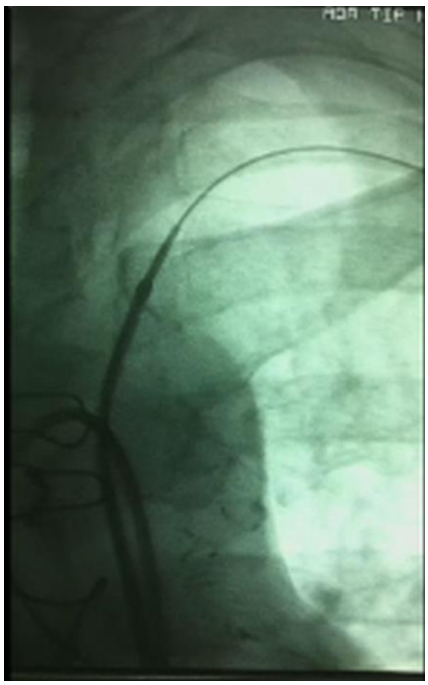

Fig. 4 Angiograph shows lesion crossing with the wire.

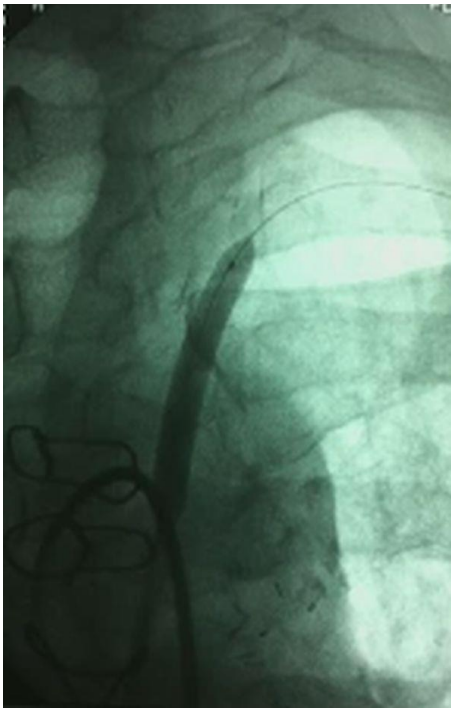

Fig. 5 Angiograph shows predilation during balloon angioplasty.

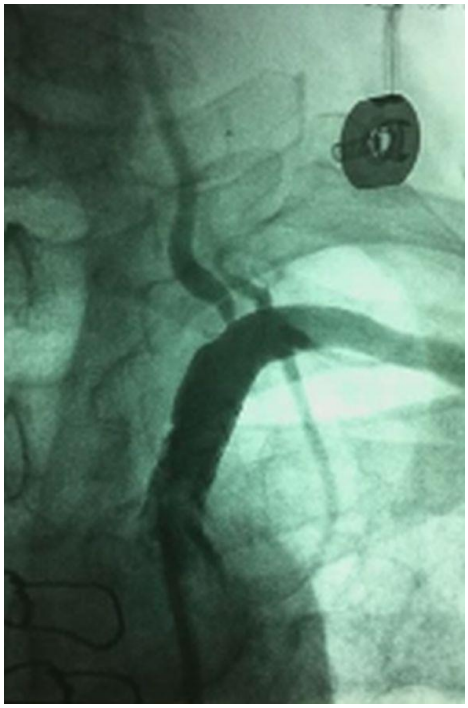

Fig. 6 Angiograph shows post-angioplasty control, with the stent implant showing good patency of the left subclavian artery and maintenance of the vertebral and internal mammary arteries.