

Percutaneous Transluminal Angioplasty for management of Chronic Total Occlusion of Subclavian Artery: A case series

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Abstract:-

Percutaneous transluminal angioplasty (PTA) and stenting have emerged as viable alternatives to surgical approaches for managing chronic total occlusion (CTO) of the subclavian artery (SA). This case series presents five instances of successful percutaneous interventions in patients with SA-CTO lesions, demonstrating technical feasibility, effectiveness, and reliability. The endovascular approach offers a minimally invasive option with outcomes comparable to traditional surgical methods, reducing the risks associated with anesthesia and postoperative morbidity. While literature supports percutaneous interventions in acute and subtotal occlusions, data on SA-CTO lesions remain limited. The reported cases emphasize the need for prospective trials to evaluate the efficacy of percutaneous interventions in managing SA-CTO lesions, highlighting their potential as a safe and effective alternative.

Keywords- Subclavian artery, Chronic total occlusion, Percutaneous transluminal angioplasty, Stenting, Endovascular treatment.

INTRODUCTION:

Percutaneous transluminal angioplasty (PTA) and stenting is a routinely done procedure for managing subclavian artery (SA) occlusions [1]. Occlusion of SA lasting for an estimated time of more than 3 months, with no distal flow on angiogram, is defined as chronic total occlusion (CTO). CTO of the SA has rare prevalence; however the risk factors overlap with those of coronary artery disease and atherosclerosis. The less common causes of SA-CTO lesions include arteritis (Takayasu Arteritis, or non-specific aorto-arteritis), extraluminal compression by a mass and associated congenital heart disease [2]. The most common symptom of SA stenosis is exertional pain in the ipsilateral arm, known as arm claudication [2]. The other symptoms include - subclavian steal syndrome, which is associated with vertebrobasilar insufficiency, and coronary steal syndrome leading to angina pectoris. The latter is even more common in patients with prior internal mammary coronary bypass surgery [3].

Routine management of symptomatic SA-CTO lesions has been using a surgical approach which involves creating bypass. With the evolution of percutaneous procedures, ease-of-access and availability of hardware, and operator experience, endovascular approach for management of SA-CTO lesions offer a safe and effective alternative. These percutaneous procedures are minimally invasive and have clinical outcomes similar to surgical methods. The risks of anaesthesia, post operative morbidity and mortality associated with surgical treatment are reduced to a great extent with endovascular procedures [4]. There is adequate literature to support the use of percutaneous interventions in acute and sub-total occlusions of SA, however, the data on using endovascular approach for the management of SA-CTO lesions instead of surgery remains limited. CTO lesions are considered a challenging subset as they are harder to break through than non-occlusive stenosis, thus associated with high failure rates [5]. We report 5 cases which elicit the technical feasibility, effectiveness and reliability of treating SA-CTO lesions with a percutaneous approach, thus indicating the need for prospective trials evaluating this technique.

Case 1 (Figure 1):

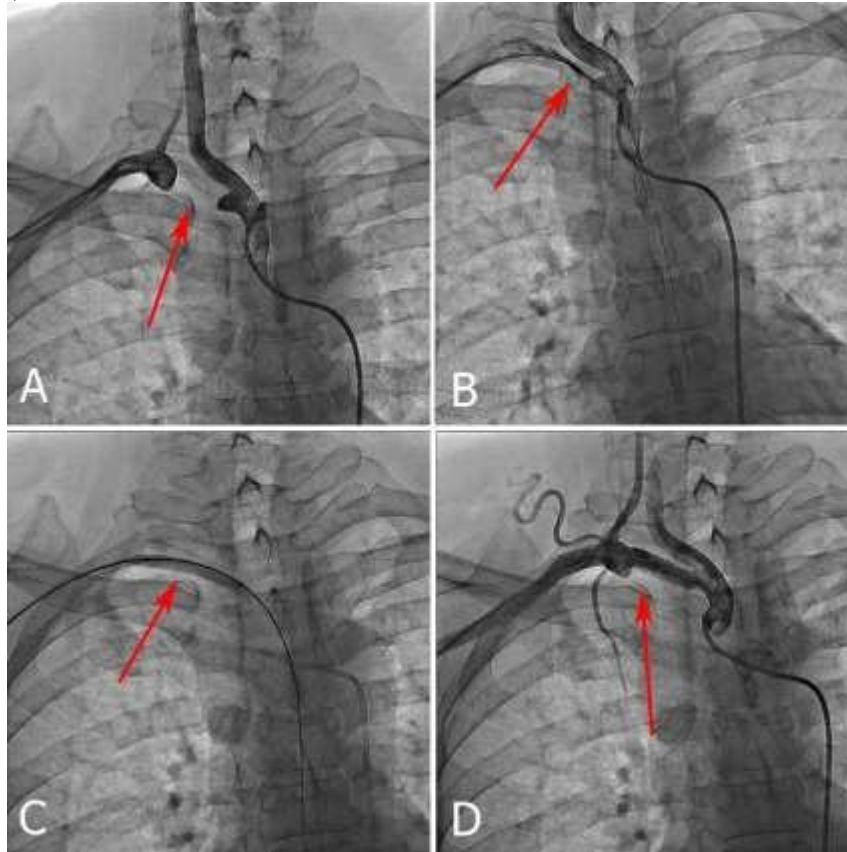


Figure 1: Fluoroscopic projections demonstrating: **A-** chronic total occlusion of ostio-proximal right SCA; **B-** lesion crossed with stiff end of a 0.035” 150cm Terumo guidewire; **C -** bare metal stent of size 7 x 25 mm being deployed in the proximal right SCA; **D -** complete revascularization achieved in the right SCA with no residual stenosis

A 60 year old diabetic male, known smoker presented with complaints of right upper limb claudication for the last 2 years. On examination, the pulse was palpable in all limbs except the right upper limb. Blood pressure was 126/84 mmHg in the left upper limb but could not be recorded in the right upper limb. Other systemic examination was within normal limits. A computed tomography (CT) angiography was done which showed complete occlusion of ostio-proximal right SCA. After obtaining written informed consent, the patient was planned for peripheral transcatheter angioplasty. Loading dose of oral aspirin (325 mg) and clopidogrel (600 mg) was given. After giving local anesthesia, an ultrasound guided right femoral and right brachial artery access was taken with 6Fr and 7Fr sheaths respectively. Unfractionated Heparin at a dose of 100U/kg was administered intravenously. A 6Fr 100cm 0.071 inch Judkins Right (JR) guiding catheter was advanced through the right brachial sheath, through which the stiff end of a 0.035” 150cm Terumo guidewire was inserted, and was used to cross lesion in right SCA. The JR diagnostic catheter was exchanged with a 0.035” 145cm Amplatz super-stiff wire on which semi-compliant balloon of size 4 x 20 mm was crossed to predilate the lesion at a pressure of 14 atmosphere (atm). One bare metal stent of size 7 x 25 mm was deployed in the proximal right SCA at 14 atm. Complete revascularization was achieved in the right SCA with no residual stenosis. Right radial pulse could be palpated immediately after the procedure. Over the next 48 hours the patient got significant symptomatic relief and was discharged in stable condition.

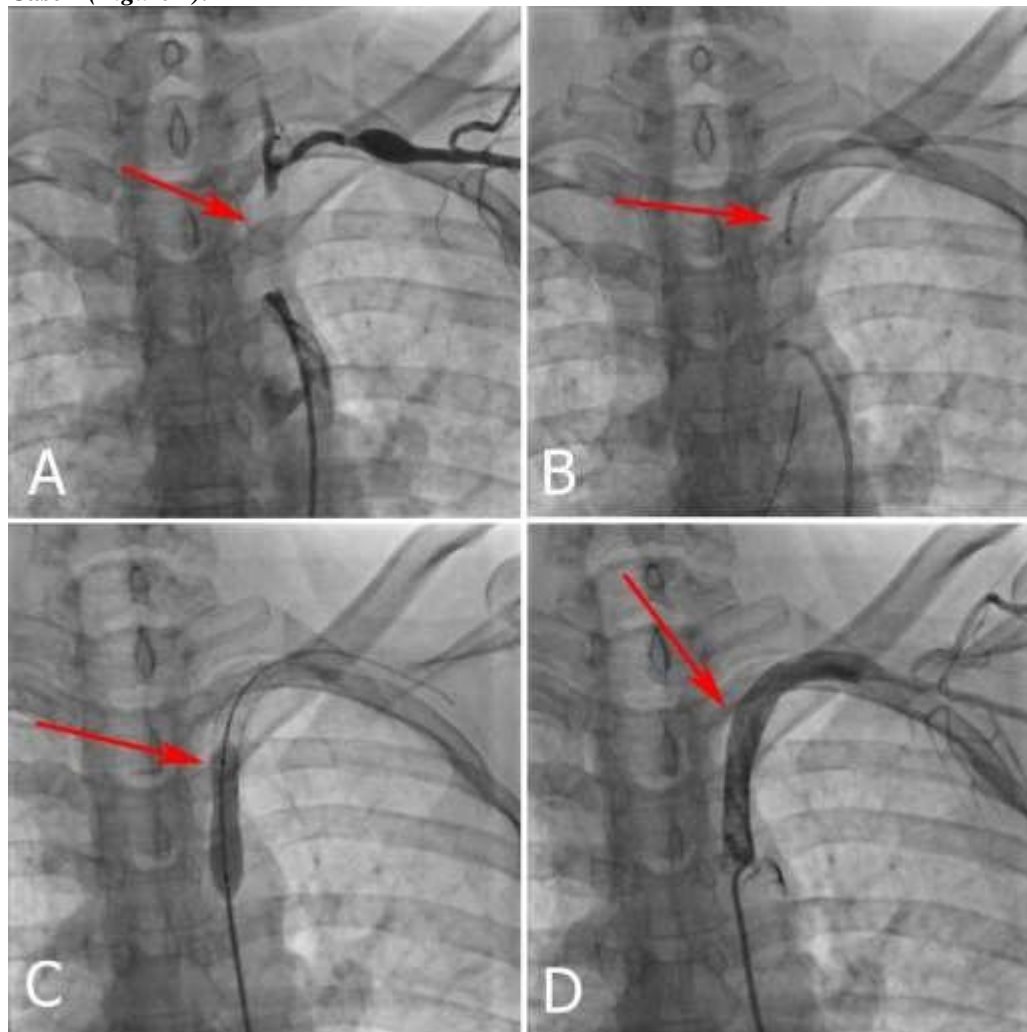
Case 2 (Figure 2):

Figure 2: Fluoroscopic projections demonstrating: **A-** chronic total occlusion of ostio-proximal left SCA, with presence of aneurysmal dilation; **B-** predilation with a non-compliant balloon over 0.014" Asahi Gaia 2 guidewire; **C** – last bare metal stent of size 7 x 15 mm being deployed in the proximal left SCA; **D** - complete revascularization achieved in the left SCA with no residual stenosis

A 52 year old female with type 2 diabetes and dyslipidemia, presented with symptoms of left upper limb claudication, numbness in left arm, and vertebrobasilar insufficiency for the last 1 year. On examination, the left radial pulse was not palpable. Blood pressure was 130/90 mmHg in the right upper limb and not recordable in the left upper limb. Other systemic examination was normal. CT Angiography showed 100% occlusion of ostio-proximal left subclavian artery, with presence of aneurysmal dilation distally. Patient was planned for peripheral transcatheter angioplasty and informed consent was taken. Loading dose of oral aspirin (325 mg) and clopidogrel (600 mg) given. After giving local anesthesia, right femoral and left brachial artery access was obtained with 6Fr and 7Fr sheaths respectively. Intravenous Unfractionated Heparin at a dose of 100 IU/kg was given. As per initial pre-procedure planning a 6Fr 100cm 0.071 inch JR guiding catheter was advanced through the right femoral sheath. However, a 0.035" 150cm Terumo guidewire advanced through the JR diagnostic catheter could not cross the lesion in the left ostio-proximal SCA stump. A 6Fr 100cm 0.071 inch JR guiding catheter was now inserted in the left brachial sheath, through which a 0.014" Asahi Gaia 2 wire was used to successfully cross the lesion. Serial predilation done was done with non-compliant balloon of sizes 2 x 10 mm, followed by 3 x 15 mm at 6-10 atm pressure, after which minimal flow through the left SCA could be visualised. Now, the lesion was crossed with a 0.035" 260cm exchange length Terumo guidewire, which was further exchanged with 0.035" 260cm Amplatz super-stiff wire. One bare metal stent 6 x 12 mm deployed in proximal left SCA at 13 atm followed by another bare metal stent of size 6 x 15 mm proximal to the previous stent. Post stent deployment it was observed that lesion was missed, and hence another bare metal stent of size 7 x 15 mm was deployed in ostio-proximal left SCA. Complete revascularization achieved in left SCA with no residual stenosis. Left radial pulse was palpable immediately after the procedure, and the patient was discharged in an asymptomatic state post procedure. Patient is on regular follow-up without any fresh symptoms.

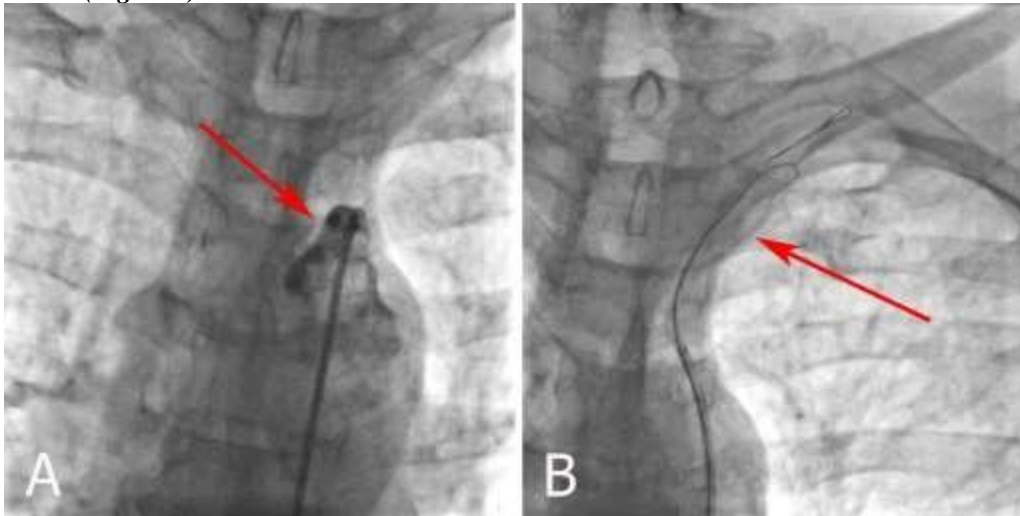
Case 3 (Figure 3):

Figure 3: Fluoroscopic projections demonstrating: **A-** chronic total occlusion of ostio-proximal left SCA; **B-** two 0.014'' Asahi Gaia 2 wires which failed to cross the lesion

A 68 year old hypertensive and diabetic male, known smoker presented with complaints of left upper limb claudication and numbness for the last 3 years. On examination, the pulse was palpable in all limbs except in the left forearm. Blood pressure was 140/90 mmHg in the right upper limb but couldn't be recorded in the left upper limb. Systemic examination was normal. CT Angiography showed 100% occlusion of ostio-proximal left SCA. Patient was planned for peripheral transcatheter angioplasty and informed consent was taken. Loading dose of oral aspirin (325 mg) and clopidogrel (600 mg) given. After giving local anesthesia right femoral access was taken with 6Fr sheath. Unfractionated Heparin at a dose of 100U/kg was administered intravenously. A 6Fr 100cm 0.071 inch JR guiding catheter was introduced through the right femoral sheath. Angiography showed 100% chronic total occlusion of ostial left SCA. The initial attempt to cross the lesion with the stiff end of a 0.035'' 150cm Terumo guidewire was unsuccessful. We attempted to cross the lesion with two 0.014'' Asahi Gaia 2 wires but failed to cross the lesion. Thus the procedure was abandoned and the patient was referred to cardio-thoracic and vascular surgery for aorto-subclavian bypass.

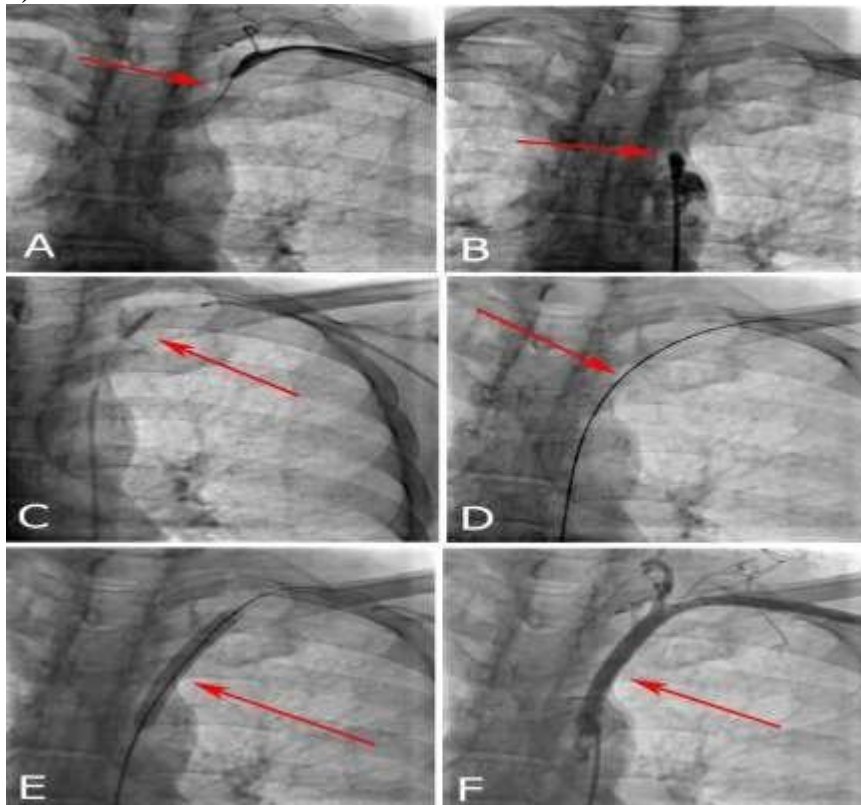
Case 4 (Figure 4):

Figure 4: Fluoroscopic projections demonstrating: **A-** chronic total occlusion of ostio-proximal left SCA; **B-** 0.014" Asahi Gaia 2 guidewire inserted through right brachial route failed to cross the lesion; **C-** predilation with a non-compliant balloon over 0.014" Asahi Gaia 2 guidewire inserted via right femoral route; **D-** 0.014" guidewire exchanged with exchange-length Terumo guidewire, and finally JR exchanged 0.035" 260cm Amplatz super-stiff wire; **E-** bare metal stent of size 6 x 35 mm being deployed in the proximal left SCA; **D** - complete revascularization achieved in the left SCA with no residual stenosis.

A 56 year old male, known smoker presented with symptoms of left upper limb claudication for the last 2 years. On examination, the left radial pulse was not palpable. Blood pressure was 136/90 mmHg in the right upper limb but not recordable in the left upper limb. Systemic examination was normal. CT Angiography showed 100% occlusion of ostio-proximal left SCA. Patient was planned for peripheral transcatheter angioplasty and informed consent was taken. Loading dose of oral aspirin (325 mg) and clopidogrel (600 mg) given. After giving local anesthesia, right femoral and left brachial artery access was obtained with 6Fr and 7Fr sheaths respectively. Intravenous Unfractionated Heparin was given at a dose of 100 U/kg. Right brachial approach to the lesion was planned initially, however 0.014" Asahi Gaia 2 wire, taken across a 6Fr 100cm 0.071 inch JR guiding catheter could not cross the left ostio-proximal SCA stump. To avoid complications, an alternative approach was attempted. A 6Fr 100cm 0.071 inch JR guiding catheter was inserted through the left brachial sheath through which 0.014" Asahi Gaia 2 wire was inserted. This wire, along with support of a 2 x 12 mm noncompliant balloon successfully crossed the lesion. Predilation was done serially along the lesion with the same balloon at 8-10 atmosphere pressure following which minimal flow through left SCA could be visualised. This 0.014" Gaia 2 guidewire was then exchanged with 0.035" 260cm Terumo guidewire across the lesion. Finally, the JR guide was exchanged with a 0.035" 260cm Amplatz super-stiff wire over which a self expandable bare metal stent of size 6 x 35 mm was deployed proximal left SCA at 14 atm. Complete revascularization achieved in left SCA. Left radial pulse could be palpated immediately after the procedure. Patient's symptoms were relieved significantly and he was discharged in stable condition. Patient is on regular follow-up without any residual symptoms.

Case 5 (Figure 5):

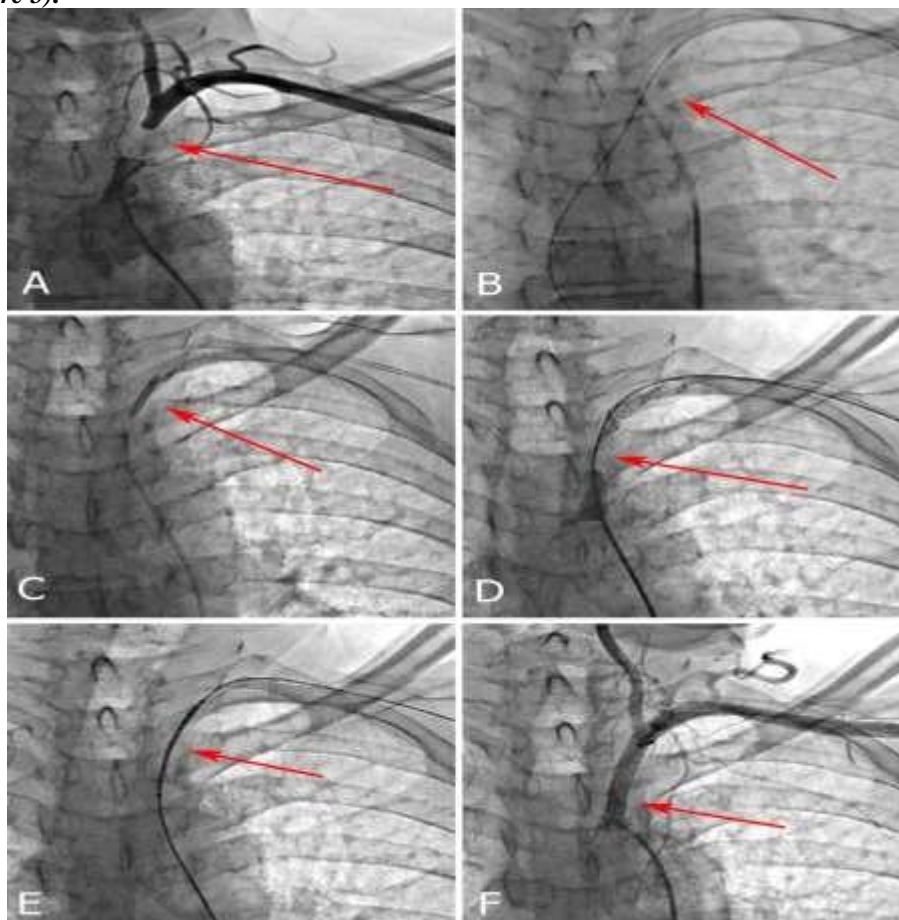


Figure 5: Fluoroscopic projections demonstrating: **A-** chronic total occlusion of ostio-proximal left SCA; **B-** lesion crossed with stiff end of 0.035" 260cm Terumo guidewire; **C-** predilation with a non-compliant balloon over 0.014" Asahi Gaia 2 guidewire inserted via right femoral route; **D-** 0.014" guidewire exchanged with

0.035" 260cm Terumo guidewire; **E**- bare metal stent of size 6 x 25 mm being deployed in the proximal left SCA; **D** - complete revascularization achieved in the left SCA with no residual stenosis.

A 60 year old male, known diabetic, smoker with dyslipidemia presented with symptoms of left upper limb claudication, numbness in left upper limb and fatigue in left arm for 3 years. On general examination, the left forearm pulses were not palpable. Pulse was present in other limbs. Blood pressure was 144/86 mmHg in the right upper limb but not recordable in the left upper limb. Other systemic examination was within normal limits. CT Angiography revealed 100% occlusion of proximal left subclavian artery. Patient was planned for peripheral transcatheter angioplasty and informed consent was taken. Loading dose of oral aspirin (325 mg) and clopidogrel (600 mg) given. After giving local anesthesia, right femoral and left brachial artery access was obtained with 6Fr and 7Fr sheaths respectively. Intravenous Unfractionated Heparin was given at a dose of 100 U/kg. Initially a retrograde left brachial approach was planned, and a 6Fr 100cm 0.071 inch JR guiding catheter taken through right femoral access was parked near SCA occlusion site. A 0.014" Asahi Gaia 2 wire taken along a JR guiding catheter through brachial access could not cross the lesion in left ostio-proximal SCA. The lesion was successfully crossed with a stiff end of 0.035" 260cm Terumo guidewire across the lesion, however no semi compliant balloons could be crossed over the Terumo guidewire. Hence, another 0.014" Asahi Gaia 2 guidewire inserted through right femoral sheath was used to cross the lesion with Terumo guidewire in situ. Successful serial predilation was then done over 0.014" guidewire along the lesion with a non-compliant balloon of size 2 x 10 mm at 6-10 atm. Minimal flow through left SCA could now be visualised. Both the Terumo guidewire and 0.014" guidewire were exchanged with a 0.035" 260cm Terumo guidewire across the lesion, and the JR guide was withdrawn. A self expandable bare metal stent of size 6 x 25 mm was deployed over the exchange length Terumo guidewire in proximal left SCA at 15 atm. Complete recanalization was achieved in the left SCA. Left radial pulse could be palpated immediately after the procedure. Patient's symptoms improved and he was discharged in stable condition. Patient is on regular follow-up and has no recurring symptoms.

DISCUSSION:

The estimated prevalence of SA stenosis is about 2% in general population, however in patients with coexisting peripheral arterial disease of the lower extremity it extends to 9% [6].

Before the refinement of percutaneous transluminal angioplasty techniques and hardware, surgical management was the mainstay treatment of SA-CTO lesions. Surgical management of subclavian lesions is associated with significant complications which include injury to the brachial plexus, vagal nerve, laryngeal nerve or phrenic nerve, cerebral ischaemia, Horner syndrome and chylothorax [7]. The conventional balloon-only angioplasty for the treatment of cervical occlusive arterial disease was introduced in the 1980s [8]. The major challenge with balloon-only intervention was poor patency rates, which were around 50% or as low as 15% at follow-up [9]. However, with the use of metallic-stents, percutaneous interventions offer a durable alternative with higher procedural success rates, and adequate patency rates on follow up. According to European Society of Cardiology 2017 Guidelines, symptomatic stenosis or occlusion of SA, acute limb ischemia, asymptomatic SA stenosis/occlusion with subclavian steal are indications for percutaneous angioplasty [6].

The success rate of SA stenting are better in non-occlusive or thrombotic lesions, ranging from 98-100%, however, the percutaneous intervention of SA-CTO lesions is associated with reduced acute technical success [10]. In our case series, we had a success rate of 80% (4 out of 5 patients) which is comparable with rates reported in the literature, which ranges from 46-76%. In a series of 17 patients described Rodriguez-Lopez et al, a success rate of 94% was observed [11]. Babic et al. reported a acute technical success rate of 82.1% (46 out of 56 patients) with 76% patency at a follow up duration of 40 ± 26 months [5]. In another case series of 16 patients a procedural success rate of 93.8% was reported, with a two year patency rate of 93.3% [12]. Similarly, in another subset of 23 patients with SA-CTO lesions the success rate of percutaneous intervention was 91.3% with a five year patency rate of around 75% [10].

During percutaneous intervention, some critical anatomical details are important. The assessment of relationship of stenosis to the vertebral and left internal mammary artery is critical during stent placement. Procedural complications include vertebral artery dissections leading to spinal infarction, and occlusion of left internal mammary artery thus abolishing the present or future use as a conduit for coronary bypass surgery [13].

Revascularization failure and in-stent restenosis (ISR) are not uncommon with SA-CTO percutaneous interventions. These complications are related to calcification, density and length of the lesion. Aggressive efforts to cross such lesions may lead to untoward complications, hence must be dealt with utmost caution. The other complications include stent fracture and dislocation, thrombosis, dissection and local site infection. We encountered no such complications in our cases. Although, as described above, some case reports describe very

good short-term and mid-term results, with good patency rates, and minimal ISR, there is a paucity of long term data [14]. ISR can be managed with balloon-only angioplasty or re-do stenting in patients who continue to be symptomatic.

There are a few limitations to our case series. We report only five cases from a single centre tertiary centre, performed by two operators. The long term follow up of these patients is not reported in this report.

CONCLUSION:

Endovascular treatment of SA-CTO lesions with percutaneous balloon angioplasty and stenting has a high technical success rate with an acceptable long-term patency rate, thus is a safe and effective treatment option. It is associated with significantly reduced morbidity and risk of complications as opposed to the routine surgical approach. Hence, further extensive and prospective well-designed studies are warranted to corroborate the limited data available on percutaneous interventions in such lesions.

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