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# REAL-WORLD TREATMENT STRATEGIES AND EARLY OUTCOMES IN SUBCLAVIAN ARTERY OCCLUSIVE DISEASE: A SINGLE-CENTER EXPERIENCE

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REAL-WORLD TREATMENT STRATEGIES AND EARLY OUTCOMES IN SUBCLAVIAN ARTERY OCCLUSIVE DISEASE: A SINGLE-CENTER EXPERIENCE (Abstract): The **aim** of this study was to evaluate treatment strategies and early outcomes in patients undergoing revascularization for symptomatic subclavian artery occlusive disease. **Materials and methods:** A retrospective single-center study included 18 consecutive patients treated between January 2021 and December 2024. Demographic, clinical, imaging, procedural, and follow-up data were retrospectively analyzed. Early outcomes were compared according to lesion morphology (stenotic versus occlusive/thrombotic) and clinical presentation. **Results:** The mean patient age was 64.1 ± 8.5 years, and 55.6% were male. Endovascular treatment was performed in 72.2% of patients, whereas hybrid procedures were required in 44.4%. Overall technical success was achieved in 77.8% of cases. Primary patency and symptom improvement were documented in 66.7% of patients. Stent implantation was significantly more frequent in stenotic than in occlusive/thrombotic lesions (100.0% *vs*. 10.0%, $p$ = 0.001). Symptom improvement was also more common in stenotic lesions (100.0% *vs*. 50.0%, $p$ = 0.015). **Conclusions:** Endovascular treatment was the predominant revascularization strategy and provided favorable early outcomes in symptomatic subclavian artery occlusive disease. Lesion morphology significantly influenced treatment selection, technical success, and clinical improvement, supporting an individualized approach based on anatomical and clinical characteristics. **Keywords:** SUBCLAVIAN ARTERY, OCCLUSIVE DISEASE, ENDOVASCULAR TREATMENT, HYBRID REVASCULARIZATION, STENTING.

## INTRODUCTION

Subclavian artery occlusive disease is an uncommon manifestation of peripheral arterial disease, most often caused by atherosclerosis and associated with increased cardiovascular and cerebrovascular morbidity (1,2). It predominantly affects elderly patients with multiple cardiovascular risk factors, including hypertension, dyslipidemia, smoking, diabetes mellitus, carotid artery disease, coronary artery disease, and generalized peripheral arterial disease (3,4). Because it reflects diffuse systemic atherosclerosis, affected patients frequently have multiterritory vascular involvement and an increased cardiovascular risk profile (5, 6).

Clinical presentation ranges from asymptomatic disease to upper limb claudi-

cation, vertebrobasilar insufficiency, subclavian steal syndrome, and coronary-subclavian steal syndrome, depending on lesion severity and collateral circulation (1, 7, 8). Differences in systolic blood pressure between the upper extremities and diminished peripheral pulses are important diagnostic clues, although diagnosis is often delayed because symptoms may mimic orthopedic or neurological disorders (4,9-11).

Doppler ultrasonography is the first-line imaging modality, while computed tomography angiography (CTA) and digital subtraction angiography (DSA) are essential for lesion characterization and procedural planning (4, 12). Left-sided lesions are more common because of anatomical and hemodynamic factors related to the origin of the left subclavian artery from the aortic arch (12, 13).

Endovascular therapy has become the preferred first-line treatment for symptomatic subclavian artery disease because of its minimally invasive nature, lower perioperative morbidity, high technical success, and favorable patency rates (14-16). However, chronic total occlusions and thrombotic lesions remain technically demanding, and hybrid or surgical revascularization may still be required in selected patients (4, 14, 17-20).

The aim of this study was to evaluate real-world treatment strategies and early procedural outcomes in patients with subclavian artery occlusive disease treated at a tertiary vascular center, with particular emphasis on the influence of lesion morphology and clinical presentation on procedural success and early outcomes.

## MATERIALS AND METHODS

**Study design.** This retrospective single-center study was conducted in the Department of Vascular Surgery, Sf. Spiridon County Emergency Clinical Hospital, Iași, Romania, a tertiary referral center, and included consecutive patients treated for symptomatic subclavian artery occlusive disease between January 2021 and December 2024. Clinical presentation was classified as acute ischemia or chronic ischemia. Acute ischemia was defined as sudden symptom onset caused by arterial occlusion, whereas chronic ischemia referred to progressive symptomatic stenotic or occlusive disease.

**Clinical and Imaging Assessment.** All patients underwent clinical vascular examination, including pulse assessment and bilateral blood pressure measurement whenever feasible. Imaging evaluation included Doppler ultrasonography, computed tomography angiography (CTA), and/or digital subtraction angiography (DSA), according to clinical indications. Significant stenosis was defined as ≥50% luminal narrowing associated with symptoms. Lesions were classified according to location, laterality, morphology (stenotic or occlusive/thrombotic), and associated vascular findings. Vertebral artery flow reversal, vertebrobasilar insufficiency, and concomitant carotid artery disease were also recorded.

**Treatment Strategy.** Treatment was individualized according to clinical presentation, lesion morphology, vascular anatomy, and technical feasibility. Endovascular treatment consisted of percutaneous transluminal angioplasty (PTA) with or without stent implantation. Stents were implanted in cases of significant residual stenosis, vessel recoil, flow-limiting dissection, or suboptimal angiographic results. Surgical treatment included thromboembolectomy, bypass procedures, or other open revascularization techniques. Hybrid procedures

combined open and endovascular interventions during the same procedure or hospitalization. Vascular access (femoral, brachial, or combined) was selected according to lesion characteristics.

**Data Collection.** Demographic, clinical, imaging, procedural, and follow-up data were retrospectively collected from electronic medical records, imaging databases, operative reports, and discharge summaries. Variables included age, sex, cardiovascular risk factors, clinical presentation, lesion morphology, treatment modality, technical success, symptom improvement, primary patency, and reintervention.

The primary outcome was technical success, defined as restoration of antegrade blood flow after revascularization. Secondary outcomes included stent implantation, failed endovascular recanalization, surgical bypass, symptom improvement, primary patency, and reintervention. Follow-up consisted of outpatient evaluation and vascular imaging (Doppler ultrasonography and/or CTA), when available.

**Statistical Analysis.** Data management was performed using Microsoft Excel and XLSTAT, while statistical analyses were conducted using IBM *SPSS Statistics version 27.0* (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Fisher's exact test was used for comparisons because of the small sample size. Comparative analyses were performed according to lesion morphology (stenotic versus occlusive/thrombotic) and clinical presentation (acute versus chronic ischemia). A two-sided $p$ value $<0.05$ was considered statistically significant.

**Ethics approval.** The study was approved by the Ethics Committee of the Sf. Spiridon Clinical County Emergency Hospital, Iași, Romania (Approval No. 89/12 June 2026) and was conducted in accordance with the Declaration of Helsinki and institutional ethical standards.

## RESULTS

**Baseline characteristics**. The study included 18 patients with a mean age of 64.1 ± 8.5 years, with a predominance of male patients (55.6%). Hypertension and dyslipidemia were the most frequent cardiovascular risk factors. Chronic ischemia was more commonly observed than acute ischemia.

Lesion and imaging characteristics are presented in second table. Most lesions involved the left subclavian artery (77.8%), while occlusive/thrombotic lesions were more frequent than stenotic lesions. Angio-CT evaluation was performed in 61.1% of patients, and associated carotid stenosis was identified in 27.8% of cases.

Procedural characteristics are summarized in third table. Endovascular treatment was performed in most patients (72.2%), with stent implantation in 44.4% of cases. Surgical brachial access was frequently used (83.3%), while hybrid procedures combining open surgical and endovascular techniques were performed in 44.4% of patients.

Early outcomes are summarized in the next. Technical success was achieved in 77.8% of patients, while primary patency during follow-up and symptom improvement were documented in 66.7% of cases. Reintervention was required in only one patient (tab. IV.)

Procedural outcomes according to lesion type and clinical presentation are presented in fifth table. Stent implantation was significantly more frequent in stenotic lesions compared with occlusive/thrombotic lesions (100.0% *vs*. 10.0%, p = 0.001).

TABLE I.
**Baseline Characteristics of the Study Cohort**

| Variable | Total Cohort (n = 18) |
|---|---|
| Age, mean ± SD (years) | 64.1 ± 8.5 |
| Male sex, n (%) | 10 (55.6) |
| Female sex, n (%) | 8 (44.4) |
| Hypertension, n (%) | 7 (38.9) |
| Dyslipidemia, n (%) | 6 (33.3) |
| Smoking history, n (%) | 4 (22.2) |
| Diabetes mellitus, n (%) | 1 (5.6) |
| Peripheral arterial disease, n (%) | 5 (27.8) |
| Carotid stenosis, n (%) | 5 (27.8) |
| Chronic ischemia, n (%) | 9 (50.0) |
| Acute ischemia, n (%) | 6 (33.3) |
| Other/unspecified presentation, n (%) | 3 (16.7) |

Data are presented as mean ± standard deviation or number (%). Percentages were calculated according to the total study cohort.

TABLE II.
**Lesion and Imaging Characteristics**

| Variable | n (%) |
|---|---|
| Left-sided lesions | 14 (77.8) |
| Right-sided lesions | 1 (5.6) |
| Unspecified/bilateral lesions | 3 (16.7) |
| Stenotic lesions | 7 (38.9) |
| Occlusive/thrombotic lesions | 10 (55.6) |
| Vertebral steal syndrome | 2 (11.1) |
| Associated carotid stenosis | 5 (27.8) |
| Angio-CT evaluation performed | 11 (61.1) |

Data are presented as number (%). Angio-CT = computed tomography angiography.

TABLE III.
**Procedural Characteristics**

| Variable | n (%) |
|---|---|
| Endovascular treatment | 13 (72.2) |
| Percutaneous transluminal angioplasty (PTA) | 7 (38.9) |
| Stent implantation | 8 (44.4) |
| Balloon-expandable stents | 7 (38.9) |
| Failed endovascular attempt | 4 (22.2) |
| Surgical brachial approach | 15 (83.3) |
| Surgical bypass/embolectomy | 8 (44.4) |
| Hybrid procedures | 8 (44.4) |

Data are presented as number (%). PTA = percutaneous transluminal angioplasty. Hybrid procedures included combined open surgical and endovascular approaches.

TABLE IV.

**Early Outcomes**

| Outcome | n (%) |
|---|---|
| Technical success | 14 (77.8) |
| Failed endovascular attempt | 4 (22.2) |
| Documented primary patency during follow-up | 12 (66.7) |
| Symptom improvement | 12 (66.7) |
| Reintervention required | 1 (5.6) |

Data are presented as number (%). Technical success was defined as successful revascularization with restoration of antegrade blood flow. Primary patency was defined as maintained vessel permeability during follow-up without additional intervention.

In addition, symptom improvement was more frequently observed in patients with stenotic lesions (100.0% *vs.* 50.0%, p = 0.015) (tab. V.)

TABLE V.

**Procedural Outcomes According to Lesion Type and Clinical Presentation**

| Variable | Acute Ischemia | Chronic Ischemia | Stenotic Lesions | Occlusive/ Thrombotic Lesions | p-value |
|---|---|---|---|---|---|
| **Stent implantation, n (%)** | 4 (66.7) | 4 (44.4) | 7 (100.0) | 1 (10.0) | 0.001 |
| **Failed procedure, n (%)** | 0 (0.0) | 4 (44.4) | 0 (0.0) | 4 (40.0) | 0.088 |
| **Surgical bypass, n (%)** | 4 (66.7) | 3 (33.3) | 1 (14.3) | 6 (60.0) | 0.145 |
| **Primary patency, n (%)** | 4 (66.7) | 7 (77.8) | 6 (85.7) | 6 (60.0) | 0.350 |
| **Symptom improvement, n (%)** | 5 (83.3) | 7 (77.8) | 7 (100.0) | 5 (50.0) | 0.015 |

Data are presented as number (%). Comparisons between groups were performed using Fisher's exact test. Acute ischemia included patients with sudden symptomatic arterial occlusion, whereas chronic ischemia included patients with progressive stenotic or occlusive disease. Bold p-values indicate statistical significance.

## DISCUSSION

The present study evaluated real-world treatment strategies and early procedural outcomes in patients with symptomatic subclavian artery occlusive disease treated at a tertiary vascular center. Three principal findings emerged: (1) endovascular treatment was feasible and associated with favorable early outcomes in most patients; (2) lesion morphology significantly influenced procedural strategy and technical success; and (3) stenotic lesions achieved better procedural and clinical outcomes than occlusive or thrombotic lesions. These findings support an individualized, lesion-oriented approach to subclavian artery revascularization.

Most patients presented with multiple cardiovascular risk factors and concomitant carotid or peripheral arterial disease, confirming that subclavian artery stenosis is usually part of diffuse systemic atherosclerosis rather than an isolated vascular disorder. The predominance of left-sided lesions and the spectrum of ischemic and vertebrobasilar symptoms observed in our cohort

are consistent with previous reports. Delayed diagnosis remains common because symptoms may mimic orthopedic or neurological disorders, highlighting the importance of bilateral blood pressure measurement and careful pulse examination.

Endovascular treatment was performed in more than two-thirds of patients, with an overall technical success rate of 77.8%. Although lower than the 90-98% success rates reported in larger series, this likely reflects the inclusion of complex lesions, including chronic total occlusions, acute thrombotic lesions, and patients requiring hybrid procedures (15, 21-24).

Lesion morphology was the main determinant of procedural success. Stent implantation was significantly more frequent in stenotic lesions, whereas occlusive and thrombotic lesions were associated with higher failure rates and more frequent surgical bypass. These findings agree with previous studies showing that chronic total occlusions remain technically challenging because of severe calcification, longer lesion length, and guidewire crossing difficulty (23-25). In contrast, focal stenoses usually allow easier recanalization and better clinical outcomes (26).

In-stent restenosis remains an important limitation of endovascular therapy, with reported rates ranging from 8% to 25%, particularly in patients with extensive atherosclerosis, long lesions, and chronic occlusions (27, 28). Covered stents may provide superior mid-term patency in selected patients (29,30). Likewise, complex occlusions often require retrograde brachial access or hybrid techniques after failed antegrade recanalization (31,32), consistent with our experience. Surgical or hybrid procedures therefore remain valuable alternatives for heavily calcified lesions or failed endovascular treatment (33-35).

Patients with vertebrobasilar insufficiency represent a particularly important subgroup because successful revascularization may restore antegrade vertebral flow and improve neurological symptoms (36,37). Preprocedural CTA was essential for lesion characterization, procedural planning, and assessment of carotid and vertebral artery involvement, while Doppler ultrasonography remains an effective modality for diagnosis and follow-up (38).

The main novelty of this study is the comparison of procedural strategies and early outcomes according to lesion morphology in a heterogeneous real-world cohort that included stenotic, thrombotic, chronic occlusive, and hybrid-treated lesions. Our findings emphasize that treatment selection should be individualized according to lesion complexity, vascular anatomy, symptom severity, and patient comorbidities.

The strengths of this study include its real-world design, inclusion of both acute and chronic ischemic presentations, and comparative analysis according to lesion morphology, providing clinically relevant information for procedural planning. However, several limitations should be acknowledged. The retrospective single-center design and the small sample size (18 patients) limit the generalizability and statistical power of the study. In addition, follow-up was relatively short and heterogeneous, precluding reliable assessment of long-term patency and restenosis. Finally, treatment selection was individualized according to lesion characteristics and operator judgment, introducing potential selection bias. Despite these limitations, the study provides useful real-world evidence supporting individualized manage-

ment of symptomatic subclavian artery occlusive disease

## CONCLUSIONS

Endovascular and hybrid treatment strategies provided favorable early technical and clinical outcomes in patients with subclavian artery occlusive disease. Lesion morphology significantly influenced procedural planning and therapeutic success, with stenotic lesions being more suitable for stent implantation and associated with better symptomatic improvement compared with occlusive/thrombotic lesions. These findings highlight the importance of individualized and lesion-oriented treatment strategies adapted to lesion characteristics and clinical presentation in real-world vascular practice.

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## CONFLICT OF INTEREST AND FUNDING

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