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Original paper

Simultaneous vertebral and subclavian artery stenting

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Abstract

Introduction: Vertebrobasilar territory ischemia leads to disabling neurological symptoms and may be caused both by vertebral artery (VA) and subclavian artery (SA) stenosis. The coexisting symptomatic ipsilateral VA and proximal SA stenosis should be considered as a true bifurcation lesion for percutaneous treatment.

Aim: To evaluate the safety and efficacy of simultaneous angioplasty of vertebral and subclavian stenosis.

Material and methods: Fifteen patients (age 69.5 years, 46.7% men, all symptomatic from posterior circulation (history of stroke, transient ischemic attack, chronic ischemia symptoms)) were scheduled for simultaneous SA/VA angioplasty. Clinical and duplex ultrasound follow-up was conducted 1, 6 and 12 months after the procedure.

Results: The technical success rate was 100%. Single balloon-mounted stent angioplasty was performed for all VAs and for 13 (86.7%) SAs. In 4 cases a simultaneous radial and femoral approach was required. The mean North American Symptomatic Carotid Endarterectomy Trial (NASCET) VA stenosis was reduced from 88.7 ±9.7% to 5.7 ±6.8% and SA stenosis from 80 ±12.2% to 11 ±12.3% ($p < 0.01$). No periprocedural death, stroke, myocardial infarction or transient ischemic attack occurred. During follow-up (range: 6–107 months) in 10 of 15 (66.7%) patients relief of chronic ischemic symptoms was observed. No stroke/TIA occurred. One cardiovascular and 2 non-cardiovascular deaths were recorded. There was 1 symptomatic vertebral and 1 subclavian in-stent restenosis, and 2 cases of asymptomatic VA in-stent occlusion occurred.

Conclusions: Simultaneous vertebral and subclavian artery stenting is safe and effective. The restenosis rate remains at an acceptable level and it may be treated successfully with drug-eluting balloon angioplasty. In selected patients a dual radial and femoral approach may facilitate the procedure.

Key words: vertebral artery stenting, subclavian artery stenting, simultaneous angioplasty.

Introduction

The prevalence of subclavian artery (SA) stenosis in the general population is about 2% [1]. The real prevalence of extracranial vertebral artery (VA) stenosis generally is unknown, with estimates ranging from 7% to 40%. Approximately one-quarter of ischemic strokes involve the vertebrobasilar circulation, and stenosis of the proximal VA may account for up to 20% of these events [2, 3].

In 98% of cases, VA arises from the proximal segment of the SA; however, coexisting stenosis of these arteries is uncommon. The majority of subclavian artery stenoses occur proximally to the origin of the VA, leading to VA flow reversal. Most patients remain asymptomatic due to contralateral VA supply increase. This phenomenon also plays a role in VA stenosis. Incidental SA stenosis in the absence of symptoms rarely requires revascularization treatment even if 3rd degree VA flow reversal is present. However, in cases of inadequate collateral circulation supply or combination of vertebral and subclavian stenosis, typically symptoms occur mainly due to vertebrobasilar insufficiency [4, 5].

Surgical and endovascular approaches are available options of SA/VA stenosis treatment. However, it has been shown that endovascular intervention is much safer for this territory, and with advances in device technology, stent supported angioplasty has become the first line treatment [5, 6].

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Aim

The primary objective of this study is to evaluate the safety and efficacy of simultaneous subclavian and vertebral artery stenting.

Material and methods

Between February 2007 and July 2015 fifteen cases of patients with severe, symptomatic subclavian and vertebral artery stenosis were retrospectively extracted from the SA/VA angioplasty database in a single, high-volume center. The diagnosis of SA/VA stenosis was confirmed by Doppler ultrasound (DUS) and/or computed tomography angiography. Clinical symptoms, despite optimal medical therapy, were vertebrobasilar insufficiency (including vertigo, recurrent syncope) in all cases, prior posterior cerebrovascular incident in 5 (33.3%) cases, upper extremity exertional ischemia in 9 (60%) cases and subclavian-coronary steal syndrome in 1 (6.7%) patient after coronary artery bypass grafting. In the group with prior stroke/TIA 4 patients presented vertigo and 1 recurrent syncope.

Table I shows detailed patient characteristics.

The qualification for simultaneous vertebral and subclavian artery angioplasty was performed on the basis of non-invasive examinations, neurological, cardiological and radiological consultation, and finally on direct angiography. Non-invasive diagnostics also includes ECG Holter monitoring to exclude significant arrhythmias, and transthoracic/transesophageal echocardiography to exclude cardiac origin embolization.

All patients received pretreatment with aspirin (75 mg/day) and a 300 mg loading dose of clopidogrel before the procedure. After the angioplasty acetylsalicylic acid was maintained indefinitely, and 75 mg/day of clopidogrel was continued for the following 3 months for bare metal stents and 12 months for drug-eluting stents.

The percutaneous arterial approach was obtained via the femoral artery in 11 (73.3%) patients. A combined femoral and radial approach was required in 4 patients. The etiology of the obstructive lesions was atherosclerosis in all cases.

On the procedure day, the femoral artery was punctured and an 8 Fr short arterial sheath was introduced. In cases with combined access a 6 Fr sheath in the ipsilateral radial artery was used. Before angioplasty a weight-adjusted dose of unfractionated heparin was administered. Over a 0.035 inch diagnostic wire, an 8 Fr guiding catheter was advanced toward the stenosis. Subclavian lesions were crossed using a 0.018 inch wire or steerable 0.035 inch hydrophilic coated wire. At the distal segment of the vertebral artery a 0.014 inch coronary guidewire was positioned. In a case of total occlusion, a lesion was successfully crossed from radial access with a 0.035 inch hydrophilic-coated guidewire.

The VA neuroprotection was not used as the system retrieval might be problematic in case of the VA ostium being covered by the SA stent. Direct stenting was performed when possible. Before and after the procedure the degree of stenosis was evaluated by quantitative angiography (Figures 1 A–D, 2 A–E).

The study participants were evaluated at 1, 6 and 12 months and then at yearly intervals after the procedure. Clinical/neurological examination, blood pressure measurement in both arms and ultrasonography were performed. In patients with significant restenosis confirmed by computed tomography (CT) angiography, re-angioplasty with drug-eluting ballon (DEB) was performed.

Results

Coexisting subclavian and vertebral artery stenosis was diagnoses in 15 out of 401 patients with SA stenosis and out of 459 patients with VA stenosis; all cases were left-side. Of those, one left subclavian occlusion with left vertebral stenosis was successfully treated by stenting (Figures 3 A–E). In all cases, subclavian artery stenting

Table I. Baseline clinical characteristics of patients (*N* = 15)

Parameter	Result
Age [years]	69.5 ±9.3
Sex, male	7 (46.7%)
Vertigo	14 (93.3%)
Recurrent syncope	2 (13.3%)
Prior stroke/TIA	5 (33.3%)
TIA	1 (6.7%)
Pontine stroke	1 (6.7%)
Left sided cerebellar stroke	2 (13.3%)
Occipital lobe stroke	1 (6.7%)
Coronary subclavian steal	1 (6.7%)
Arm claudication	9 (60%)
Steal syndrome	6 (40%)
Hypertension	15 (100%)
Diabetes mellitus	2 (13.3%)
Dyslipidemia	15 (100%)
Coronary artery disease	8 (53.3%)
Previous percutaneous coronary intervention	5 (33.3%)
Previous myocardial infarction	3 (20%)
History of coronary artery bypass grafting	3 (20%)
Contralateral vertebral artery occlusion	1 (6.7%)
Coexisting carotid artery stenosis	6 (40%)

TIA – transient ischemic attack.

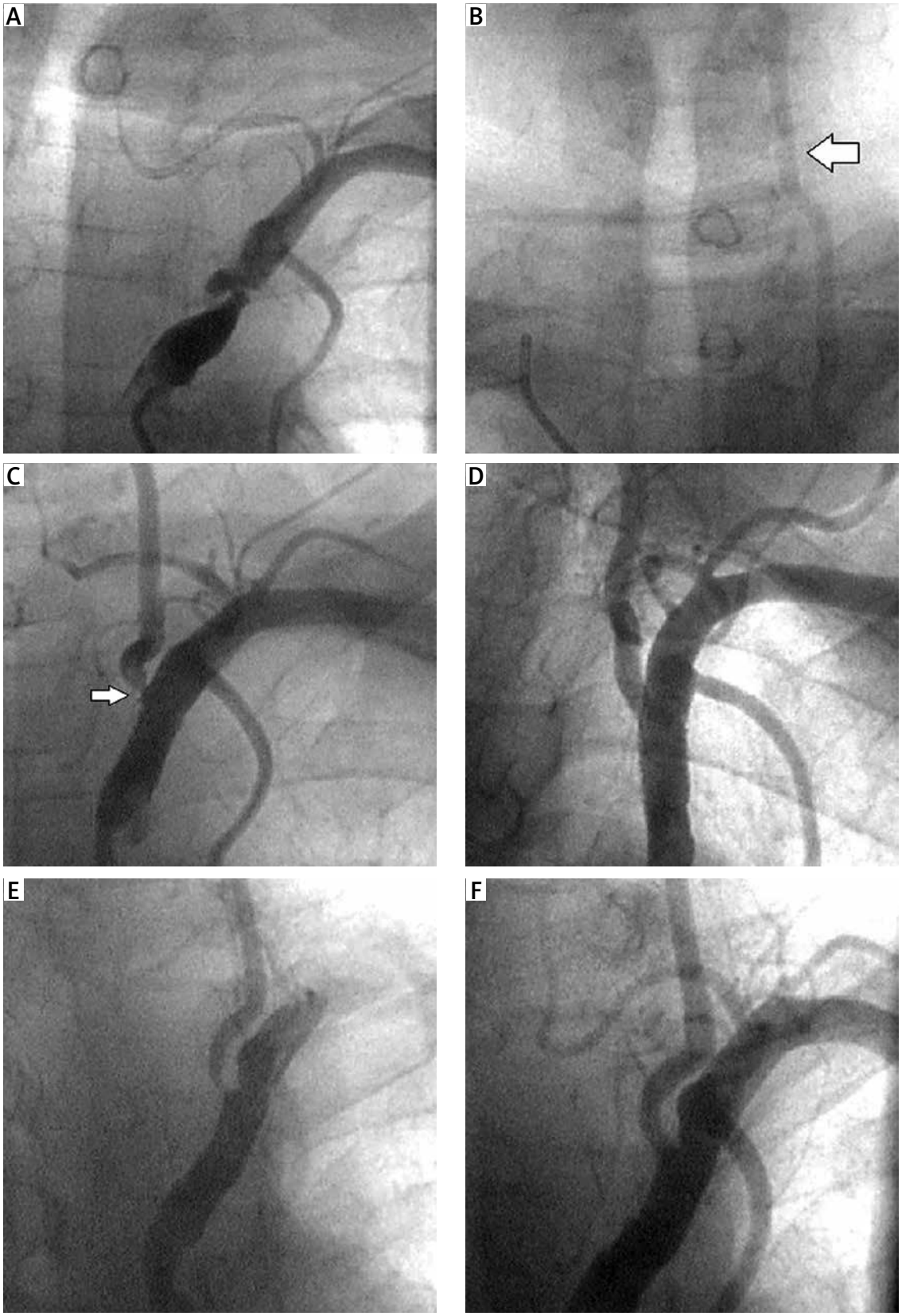

Figure 1. A – Selective angiography confirming left subclavian stenosis. **B** – Subclavian steal syndrome – flow reversal in the left vertebral artery (large arrow). **C** – Vertebral artery stenosis after subclavian stenting (small arrow). **D** – Final angiography showing optimal effect on VAS and SAS. **E** – Bare metal stent restenosis in the vertebral artery. **F** – Final effect after Dior 3.0 × 15 mm drug-eluting balloon dilatation

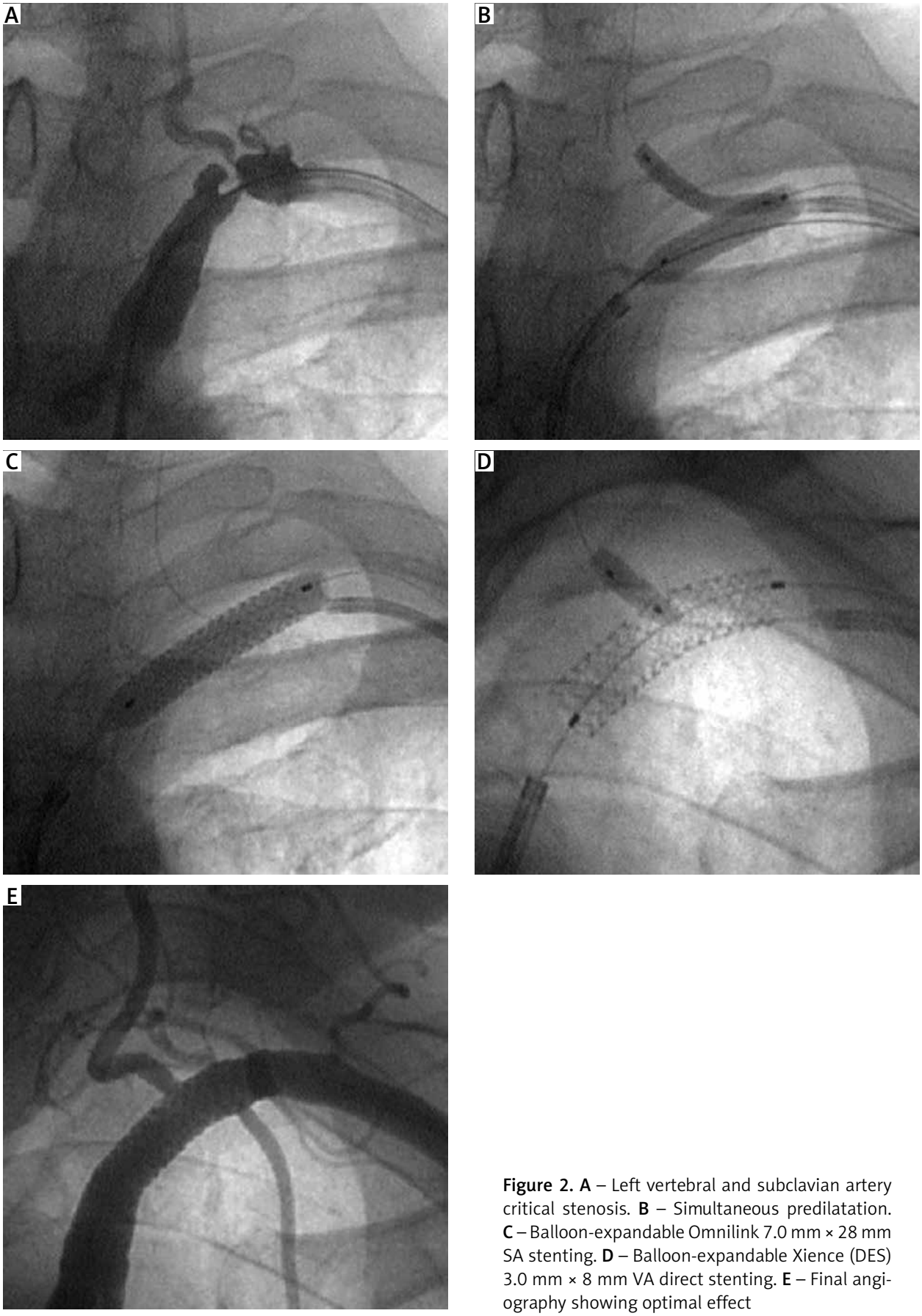

Figure 2. A – Left vertebral and subclavian artery critical stenosis. **B** – Simultaneous predilatation. **C** – Balloon-expandable Omnilink 7.0 mm × 28 mm SA stenting. **D** – Balloon-expandable Xience (DES) 3.0 mm × 8 mm VA direct stenting. **E** – Final angiography showing optimal effect

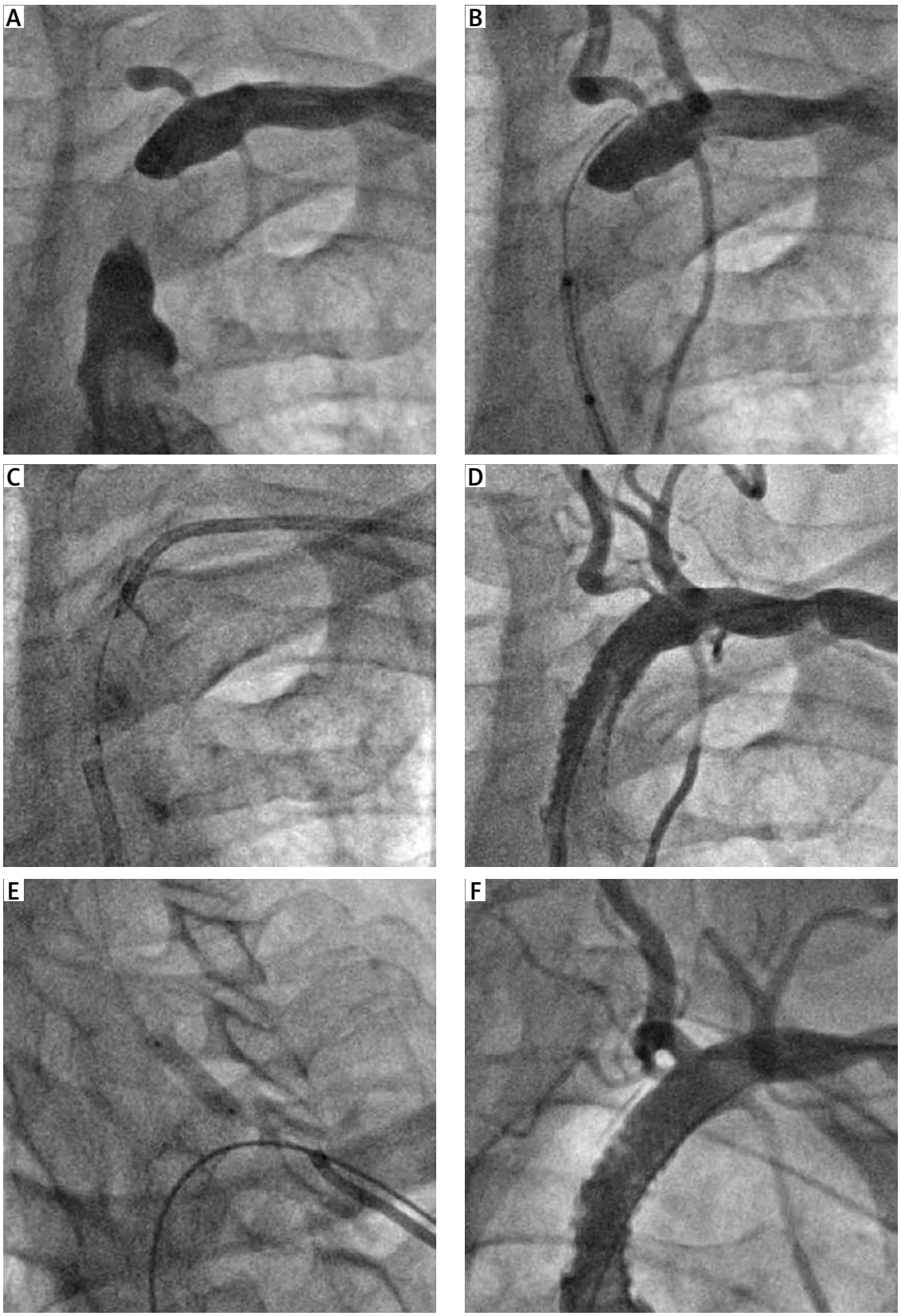

Figure 3. A – Selective angiography from combined approach. **B** – Unsuccessful attempt at crossing through occluded subclavian artery from femoral approach. **C** – Successful crossing via radial approach. **D** – After balloon-expandable Omnilink 9.0 mm × 39 mm stent implantation. **E** – Balloon-expandable Omega (BMS) 4.0 mm × 12 mm VA direct stenting. **F** – Final angiography

was the first procedure, and VA stent-supported angioplasty was performed after rewiring. In 2 of these 15 patients VA stenting was necessary due to severe plaque shift after subclavian artery stenting (SAS). Final kissing was performed with a non-compliant balloon in VA when needed. Technical success defined as stent implantation with residual stenosis < 20%, no significant dissection and normal flow was achieved in all 15 (100%) cases of vertebral and in 13 (86.7%) cases of subclavian artery stenting. In 2 cases of SA self-expandable stent-supported angioplasty, the nominal stent diameter was not achieved due to increasing local pain during post-dilatation and the risk of artery perforation; thus 30% and 40% residual stenosis were measured. In all cases of VA angioplasty and in 12 cases of SA angioplasty single balloon-mounted stents were used. The mean North American Symptomatic Carotid Endarterectomy Trial (NASCET) VA stenosis was reduced from 88.7 ±9.7% to 5.7 ±6.8% and SA stenosis from 80 ±12.2% to 11 ±12.3% ($p < 0.01$). The preprocedural discrepancy in systolic blood pressure between the upper extremities ranged from 15 to 57 mm Hg with a mean of 32.5 mm Hg. The postprocedural differences ranged from 0 to 20 mm Hg with a mean of 5.5 mm Hg ($p < 0.01$). Procedural data are summarized in Table II.

No periprocedural death, stroke, myocardial infarction or transient ischemic attack occurred. In 11 patients with symptomatic coronary artery disease, coronary angiography was performed. Three of these patients underwent successful percutaneous coronary angioplasty 2–6 weeks after VA/SA stenting. During follow-up (range: 6–107 months) in 10 of 15 patients release of chronic ischemia symptoms was observed. No new posterior circulation stroke/transient ischemic attack (TIA) occurred. In 2 out of 3 patients with recurrent symptoms, critical restenosis was revealed – one in a VA stent (at 31 months of follow-up; Figure 1 E) and the second in an SA stent (13 months after the initial procedure). Both were successfully redilated with a drug-eluting balloon – Freeway 7.0 × 20 mm (Eurocor) and Dior 3.0 × 15 mm (Eurocor) (Figure 1 F). In 1 patient, borderline (50%) left VA in-stent restenosis occurred 11 months after angioplasty and the patient was qualified for pharmacological treatment. In duplex ultrasound follow-up asymptomatic in-stent occlusion of the VA was revealed in 2 cases, the first after 5 months, the second 8 months after the procedure. During the follow-up 3 deaths were recorded, the first due to acute kidney failure (26 months follow-up), the second due to myocardial infarction (30 months follow-up) and the third due to liver cancer (49 months follow-up).

Periprocedural and follow-up Duplex ultrasound data are summarized in Table III.

Discussion

The majority of subclavian artery stenoses occur proximally to the ostium of the vertebral artery. The left subclavian artery is involved more often than the right. The proposed potential mechanism is that the acute angle of the origin of the left SA increases flow turbulence and accelerates atherosclerosis at the subclavian-aortic junction [7, 8]. Despite VA flow reversal, only the minority of the patients become symptomatic. However, the risk of stroke and TIA recurrence in symptomatic patients may be three times higher compared with patients without stenosis [9]. The endovascular procedure, which is less invasive and shorter as compared to surgery, may be more beneficial, especially in patients with serious comorbidities [6, 10].

In our study all lesions were treated with stents as primary stenting has been shown to improve long-term

Table II. Procedural data

Procedure	Result
Left vertebral	15 (100%)
Left subclavian	15 (100%)
Vertebral:	
Balloon-expandable bare-metal stent	9 (60%)
Balloon-expandable drug-eluting stent	6 (40%)
Stent diameter [mm]	2.5–5.0
Stent length [mm]	8–14
Direct stenting	11 (73.3%)
Angiographic stenosis evaluation:	
Pre-intervention	88.7 ±9.7%
Post-intervention	5.7 ±6.8%
Subclavian:	
Occlusion	1 (6.7%)
Balloon-expandable stent	12 (80%)
Self-expandable stent	3 (20%)
Stent diameter [mm]	6–9
Stent length [mm]	17–39
Direct stenting	10 (63.7%)
Angiographic stenosis evaluation:	
Pre-intervention	80 ±12.2%
Post-intervention	11 ±12.3%
Inter-arm systolic blood pressure difference [mm Hg]:	
Pre-intervention, mean ± SD	32.5 ±13.5
Post-intervention, mean ± SD	5.5 ±6.1
Access:	
Femoral	11 (73.3%)
Combined	4 (26.7%)

Table III. Periprocedural and follow-up Duplex ultrasound data

No.	SA stent	VA stent	SA PSV before procedure [m/s]	Ostium VA PSV/ EDV before procedure [m/s]	SA PSV after procedure [m/s]	VA V2 PSV/ EDV after procedure [m/s]	Follow-up (5–65 months) SA PSV [m/s]	Follow-up (5–65 months) VA V2 PSV/EDV [m/s]
1	Omnilink[1] 6.0/18 mm	BMS Volo[6] 3.0/11 mm	6.5	4.2/1.1	2.2	1.24/0.4	3.0	0.4/0.2
2	Acculink[1] 7.0/30 mm	BMS Zeta[1] 3.0/13 mm	5.5	Flow reversal, plaque shift	1.2	0.46/0.12	1.2	0.5/0.2
3	Express[2] 7.0/17 mm	BMS Skylor[6] 3.0/13 mm	4.0	Occlusion suspected	1.86	0.41/0.13	1.4	0.39/0.09
4	Nefro[3] 7.0/18 mm	BMS Skylor[6] 3.5/10 mm	Unknown	Flow reversal	1.46	0.56/0.16	2.2	0.5/0.2 – **restenosis**
5	Omnilink[1] 8.0/18 mm	BMS Chopin[3] 4.5/8 mm	5.5	Unknown	2.0	1.02/0.23	2.2	0.85/0.19
6	Nefro[3] 7.0/16 mm	BMS Liberte[2] 4.0/8 mm	5.75	4.5/0.9	1.8	1.3/0.31	1.8	0.15/0.05 – **borderline restenosis**
7	Visi-Pro[4] 9.0/37 mm	BMS Gazelle[7] 4.0/8 mm	5.5	Plaque shift	3.5	1.02/0.21	3.7	1.1/0.3
8	Absolute Pro[1] 8.0/30mm	BMS Vision[1] 4.0/8 mm	4.0	4.0/1.7	1.8	0.45/0.11	1.4	0.27/0.12
9	Omnilink[1] 9.0/39 mm	BMS Omega[2] 4.0/12 mm	Occlusion	Flow reversal	2.1	0.27/0.11	2.0	Asymptomatic occlusion
10	Omnilink[1] 9.0/39 mm	DES Nefro[3] 5.0/8 mm	4.6	Occlusion suspected	2.1	0.38/0.11	2.5	0.4/0.1
11	RX Herculink Elite[1] 6.5/18 mm	DES Endeavor Resolute RX[8] 2.5/14 mm	Unknown	Flow reversal	2.7	0.61/0.15	2.0	Asymptomatic occlusion
12	Zilver[5] 8.0/30 mm	DES Endeavor[8] 3.5/12 mm	4.5	Flow reversal	2.0	0.56/0.2	4.5 – **restenosis**	0.25/0.08
13	Omnilink[1] 7.0/28 mm	DES XienceV[1] 3.0/8 mm	8.6	Flow reversal	2.8	0.54/0.12	3.2	0.15/0.05
14	Neptun[3] 7.0/20 mm	DES Biomatrix[7] 4.0/8 mm	CT angiography	CT angiography	2.2	0.7/0.2	2.7	0.76/0.25
15	Omnilink Elite[1] 7.0/19 mm	DES Resolute Integrity[8] 2.75/14 mm	CT angiography	CT angiography	1.6	0.45/0.12	2.4	0.3/0.1

**Velocity measurements were made at 60° insonation angle. PSV/EDV – peak systolic velocity/end-diastolic velocity, SA – subclavian artery, VA V2 – V2 segment of vertebral artery, BMS – bare metal stent, DES – drug-eluting stent. [1]Abbott, [2]Boston Scientific, [3]Balton, [4]ev3, [5]Cook Medical, [6]Invatec, [7]Biosensors, [8]Medtronic.*

patency compared with balloon procedures alone [11, 12]. Despite higher rates of restenosis as compared to other treatment options, balloon angioplasty may be considered in patients who are unable to tolerate open surgery and/or with contraindications to dual-antiplatelet therapy.

In subclavian artery angioplasty, we preferred balloon-expandable stents, especially for ostial lesions. They offer higher radial force and more precise deployment, which allows one to avoid incidental coverage the origin of the vertebral or internal mammary artery. On the other hand, self-expanding stents are easier to deliver through a tortuous lesion.

It is well known that small caliber arteries are more prone to restenosis as compared to larger arteries. The use of drug-eluting stents (DES) in these arteries might be of benefit [13–15]. In our study 6 DES were used in the vertebral lesions with 1 in-stent occlusion. There was 1 case of restenosis and 1 case of occlusion in bare-metal stents (Table III).

Simultaneous vertebral and subclavian artery stenting is a technically demanding endovascular procedure which should be performed in high-volume centers. In some cases wiring of the vertebral artery may be challenging due to tortuosity of the vessel and multiple views may be required to adequately visualize the VA ostium. For this reason a radial approach may be beneficial especially when proximal SA stenosis displaces the wire away from the artery ostium (Figure 2 A) [16].

Vertebrobasilar ischemia may be provoked both by vertebral and subclavian artery stenosis. Therefore simultaneous artery stenting seems to be the optimal solution. There is also no need for subsequent hospitalization for a second procedure, which decreases the risk of possi-

ble access complications and reduces costs. On the other hand, the larger amount of contrast medium used during the procedure requires optimal patient hydration and kidney function evaluation.

Conclusions

Simultaneous vertebral and subclavian stenting is a safe and effective procedure with regard to the initial success rate and long-term patency. Despite severe limitations due to retrospective analysis and a small cohort of 15 patients, the restenosis and occlusion rate remained at an acceptable level and, if possible, it may be treated successfully with drug-eluting balloon angioplasty. In selected patients a dual radial and femoral approach may facilitate the procedure.

Conflict of interest

The authors declare no conflict of interest.

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