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ORIGINAL ARTICLE / ARAŞTIRMA YAZISI

Radiology / Radyoloji

The Usage and Efficiency of Drug-Eluting Stents in Vertebral Ostial Stenosis

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ABSTRACT

Objectives: Extracranial vertebral artery atherosclerosis is an insidious and hazardous disease. With technological development and accumulating experience, antiproliferative drug-eluting stents became a viable option for reducing the in-stent restenosis of the origin of the vertebral artery. Here, we evaluated the technical success rates, efficiency, clinical and angiographic results of the usage of drug-eluting stents in vertebral ostial stenosis.

Patients and Methods: 28 stents were implanted in 24 patients with vertebral artery origin stenosis. Digital subtraction angiographic or CT angiographic follow-up was made at 6, 12 and 24 months.

Results: Paclitaxel-eluting stents were placed with high technical success for the treatment of vertebral artery origin stenosis. There was no procedure-related mortality. However, one patient succumbed to death due to aspiration pneumonia for a basilar artery stroke with successful stenting and thrombolysis procedure. There was only one limited subclavian artery dissection in a patient (%4.1) during the procedure which was managed conservatively. One stent (%3.7) had in-stent restenosis in the early period (6th month) and one patient (%4.1) had recurrent neurological symptoms on follow-up (9th month). In a median follow-up of 13 months (6-25 months), none of the patients had late stent thrombosis.

Conclusion: Vertebral artery ostial stenosis can be treated effectively and safely with high technical success and low in-stent restenosis rates with paclitaxel drug-eluting stents. With low restenosis rates, antiproliferative drug-eluting stents are an option for reducing the vertebral artery in-stent restenosis.

Keywords: Vertebral artery origin, stenosis, paclitaxel, drug-eluting stent

Vertebral Ostial Stenoz Tedavisinde İlaç Salınımlı Stent Uygulaması ve Etkinliği

ÖZET

Amaç: Ekstrakraniyal vertebral arter aterosklerotik hastalığı sinsi ve tehlikeli bir hastalıktır. Gelişen teknoloji ve artan tecrübelerle birlikte antiproliferatif ilaç salınımlı stentler vertebral arter orjininde stent içi stenozu azaltmaya alternatif oluşturmaktadır. Biz de çalışmamızda vertebral ostial stenozlarda ilaç salınımlı stent uygulamasının teknik başarısını, etkinliğini, klinik ve anjiyografik sonuçlarını değerlendirdik.

Hastalar ve Yöntemler: Vertebral arter orijin darlığı olan 24 hastaya toplam 28 adet stent yerleştirildi. 6, 12, 24. aylarda anjiyografi veya BT anjiyografi ile takip edildi.

Bulgular: Vertebral arter orijin darlıklarının tedavisinde paclitaxel salınımlı stent yüksek teknik başarı ile uygulandı. İşleme bağlı mortalite izlenmedi. Baziler arter inmesi nedeniyle başarılı stentleme ve tromboliz uygulanmış bir olgu aspirasyon pnömonisi nedeniyle kaybedildi. İşleme bağlı bir hastada (%4.1) subklavyen arterde sınırlı diseksiyon gelişti ve medikal tedavi ile takip edildi. Takipte bir adet stentte (%3.7) erken dönem (6.ay kontrol) stent içi restenoz gelişti, bir hastada (%4.1) rekürren nörolojik semptom izlendi (9.ay). Hastaların hiçbirinde geç dönem tromboz izlenmedi.

Sonuç: Vertebral arter ostial stenozlarında ilaç salınımlı stentler yüksek teknik başarı ve düşük stent içi restenoz oranları ile etkin ve güvenle kullanılabilir. Düşük restenoz oranları ile de antiproliferatif ilaç salınımlı stentler VA orjininde stent içi stenozu azaltmaya alternatif oluşturmaktadır.

Anahtar Sözcükler: Vertebral arter orijin, stenoz, paclitaxel, ilaç salınımlı stent

Vertebrobasilar infarcts are 25% of all cerebral infarcts (1). 5-year recurrent stroke rate is reported to be about 22-35% after a vertebrobasilar transient ischemic attack (TIA) or stroke (2). Ostium is the most common place for vertebral artery (VA) stenosis (3).

Medical treatment is classically the initial treatment in VA stenosis (4). In cases where medical treatment is inadequate, angioplasty and stenting are preferred options for symptomatic vertebrobasilar atherosclerotic disease to avoid surgical-related morbidity (4-6). Primary stenting with balloon-expandable coronary stents is reported to be applied safely with high technical success in VA origin stenosis (OS). Nevertheless, relative in-stent restenosis (ISR) is still a problem to be solved. Antiproliferative drug-eluting stents (DES) offer an alternative for decreasing the ISR in VA origin. In our study, we assessed the technical success, efficiency, clinical and angiographic results of DESs in vertebral ostial stenosis.

Methods

The institutional review board approved this retrospective study and waived informed consent.

Patient Information

Patients who had VAOS with percutaneous endovascular Paclitaxel eluting stenting procedure in our institution between 2006 to 2008 were included in this retrospective study.

Age, gender, medical histories, clinical findings of the subjects and administered stent diameter were collected from medical records.

Stenting procedure

Endovascular treatment was indicated for the patients that had vertebrobasilar insufficiency or a history of TIA or stroke with 50% and higher VAOS which was determined by vertebral angiography. VAOS rates were measured with modified NASCET (North American Symptomatic Carotid Endarterectomy Trial) criteria (7), which was used for carotid stenosis, using diagnostic digital subtraction angiograms (DSA). All patients had pre and post-neurological examinations. Before the procedure, all patients were informed of the procedure and complications, and all patients signed the informed consent form. All procedures were performed by experienced interventional neuroradiologists in a DSA system (Artis, Siemens Medical Solutions, Erlangen, Germany).

In our procedure, all elective patients were medicated with clopidogrel bisulfate 75 mg/day, acetylsalicylic acid (ASA) 300 mg/day, starting 5 days before the procedure. In emergency situations, 300 mg clopidogrel bisulfate and 300 mg ASA were administered before the procedure as a loading dose.

During the procedure after 70-100 U/kg bolus heparin infusion, 7- 10 U/kg/hour heparin infusion was given to keep the activated clotting time level between 250-300 seconds.

Stent diameter was chosen according to the distally normal VA diameter, stent length was chosen to cover the entire atherosclerotic plaque.

After the procedure, we recommended ASA, 100 mg/day, lifelong, and clopidogrel, 75 mg/day, for two years.

In our clinic, we keep the patients under a control schedule at 6,12, 24 months. Stents were evaluated with DSA at 6^{th} and 24^{th} months, with computed tomography angiography (CTA) at 12^{th} months.

Evaluation

The location of the lesion and stenosis rates were reviewed from the pre-procedure DSA. Stenting procedure of the vertebral ostial stenosis and other necessary locations, additional findings and complications were reviewed and noted. The pre and post-procedural Magnetic Resonance imaging (MRI) were reviewed if available.

Follow-up DSA and CTA findings were evaluated from Picture Archiving and Communication System (PACS®) and noted retrospectively. For CTA datasets, the axial 0.5 mm thin slices, coronal and sagittal reformatted images with maximum intensity projections obtained by dual source CT scanner (SOMATOM Definition, Siemens Medical Solutions, Erlangen, Germany) were reviewed. Hemodynamically significant ISR is considered in >50% stenosis. Morbidity and mortality rates as well as restenosis rates in 6,12 and 24 months were noted.

Results

Four patients were lost to follow-up after discharge, so they were excluded from the final analysis. Twenty-four patients (M: F= 20:4, mean age 60, range 47-81) who had VAOS with a total of 28 Paclitaxel eluting stents (PES) (Taxus- Boston Scientific) implanted by percutaneous endovascular procedure, were included in the study.

The majority of the patients were referred to our clinic from neurology clinics for a previous cerebrovascular event or persistent ischemic symptoms of posterior circulation despite optimal medical treatment. Three patients were diagnosed during cardiovascular evaluations (case 8, 10, 23).

All patients' medical histories were investigated and summarized in table 1. 22 patients had a history of TIA, stroke or vertebrobasilar insufficiency. Nine patients had a previous stroke history (3 of them from posterior circulation) and 2 patients had cerebrovascular events meanwhile. Basically, vertebrobasilar insufficiency was evaluated by clinical information. Four patients had pre-procedural CTA.

There were 2 asymptomatic patients, diagnosed during the cardiovascular work-up (case 10) and angiography investigation for the leg angina (case 8). These patients were treated for the diagnosis of high stenosis (>90%) rates of the VA with accompanying cerebrovascular occlusions and/or stenosis.

Nineteen patients had pre-procedural MRI and 3 of them (case 6, 11, 17) had acute ischemic lesions (15.7%).

The VAOS rates were subclassified as >90% (n=13), 90-70% (n=8) and 69-50% (n=6) when measured with modified NASCET. There was one unclassified intervention which was a broken stent (case 12), previously installed in another institution.

Nineteen patients had predisposing factors for atherosclerotic disease (79.1%). Nine patients had one or more findings of hemiparesis, loss of sensation, cerebellar ataxia, dysphasia, during the neurological examination (37.5 %).

In our study, all vessels were stented successfully with the percutaneous endovascular method. During the stenting procedure, none of the lesions needed predilatation balloon angioplasty. A DSA example of a case with pre and post-stenting images is shown in Fig. 1.

After the procedure, none of the control angiograms showed either an intracranial missing branch or an intraluminal filling defect suggestive of distal embolization. One patient (case 19) among 24 patients (4.1%) was diagnosed with a limited proximal subclavian artery dissection on post-procedure control angiogram. The patient was only anticoagulated without additional intervention. One week later the control CTA revealed the findings as stable.

None of the patients developed permanent neurological symptoms or any deficit on post-procedure neurological examinations. Two patients with temporary neurological symptoms had post-procedural MRI performed. One patient with a complaint of numbness on the left hand developed two millimetric lesions in the right postcentral gyrus with restricted diffusion (case 3) and another patient with the clinical finding of emotional indifference-agitation had a millimeter sized hemorrhagic lesion in the corpus of the left caudate nucleus (case 6). The clinical findings of both were disappeared during early follow-up (within one week).

Fig. 1: A DSA example of a case with pre (a) and post-stenting (b) images. The left VA origin stenosis was treated with a paclitaxel-eluting stent.

Table 1. Patients demographics, findings and treatments

Case No	Sex	Age	Symptoms	Clinical Findings	Imaging finding-pre	Imaging findings-post	Comorbidity	Lesion location	Stenosis %	Stent Taxus (mm)	6th Month Control Angio	1st Year Control CTA	2nd Year control Angio	Other stented area/ stenosis Additional findings	Complication
1	W	53	V, NV, At	-	MRI: No acute ischemic lesion. A couple millimetric nonspesific lesion	-	Ht	RVA LVA	70-90 70-90	2.5x12 4.5x12	P MIH	P P	P MIH	-	-
2	M	66	V, Hd, Wk temporary D, Di	-	-	-	Ht, DM,HL, C	LVA	50-70	5x12	P	-	MIH	L ICA %50-70 L Renal A	-
3	W	48	Vd	-	MRI: A couple milimetric chronic ischemic lesion	MRI: Peripheral and median milimetric acute ischemic lesion on R postcentral gyrus	DM, Ht, RA,Hs	RVA LVA	>90 >90	4x12 4.5x16	MIH MIH	P P	P P	R ICA>%90 (L ICA stenosis-follow-up)	-
4	M	61	Vd, L Hp	(Previous CVE) LUE 3/5, LLE 4/5	MRI: Chronic ischemic lesion on R putamen, centrum semiovale Wallerian degeneration, large R lateral ventricule	-	-	LVA	50-70	5x12	P	MIH	-	L ICA %70-90 (R subclav, brakiocef occlusion, steal) (L subclav stenosis-follow-up)	-
5	M	60	R H	(Previous CVE- L PCA) Loss of sensation Incompetant cerebellar examination	MRI: Chronic ischemic lesion on left occipital, posterior talamus, bilateral cerebellar	-	HT	LVA	50-70	4.5x12	MIH	P	-	(Hypoplastic RVA) (L ICA stenosis-follow-up	-
6	M	48	L Hp	(Previous CVE) LUE 4/5	MRI: RMCA area large chronic infarct, volume loss. Front nearby-5 mm acute ischemic lesion	MRI: Milimetric new hemorrhagic lesion on the corpus of left caudat nucleus	-	RVA	70-90	3.5x12	p	p	p	R ICA>%90 L ICA %70-90	-
7	M	54	L Hp, Fp	(Previous CVE) Indistinct L nasolabial sulcus, LUE 3/5, LLE 4/5 L hyperactive DTR	MRI: Chronic ischemic gliotik lesion on R temporal lobe CTA: Saccular aneurism on arcus aorta	-	C	LVA	>90	4.5x12	MIH	p	p	R ICA >%90 (RVA stenosis-follow-up)	-
8	M	70	EA	-	MRI: Chronic ischemic gliotic lesions on bilateral centrum semiovale, posterior periventricular area	-	CAD	RVA LVA	>90 >90	4x12 4.5x12	P MIH	P P	MIH P	R ICA >%90	-

Table 1. Patients demographics, findings and treatments (continued)

Case No	Sex	Age	Symptoms	Clinical Findings	Imaging finding-pre	Imaging findings-post	Comorbidity	Lesion location	Stenosis %	Stent Taxus (mm)	6th Month Control Angio	1st Year Control CTA	2nd Year control Angio	Other stented area/ stenosis Additional findings	Complication
9	M	54	R Hp, D	(Previous CVE) RUE, RLE 2/5, LUE, LLE 3/5, dysphasia	MRI: Left MCA area- chronic large hemorrhagic infarct, Wallerian degeneration	-	DM, C	RVA	50-70	3x12	MIH	P	BTA: P	(L ICA occlusion RVA stenosis-follow-up	-
10	M	63	Hd	-	-	-	CAD	LVA	>90	4.5x12	ISR	-	-	L ICA >%90 (R ICA, RVA occlusion)	-
11	M	81	N, Hd, R Hp	CVE; Opens his eyes to verbal stimulus, head movements to the questions, localizes the pain with L hand, L arm, leg spontaneous movement, R extremity extantion???	MRI: Bilateral cerebellar, tectal, R hipocampal, bilateral occipital acute ischemic lesions	-	-	LVA	50-70	4.5x12	-	-	-	(BA thrombolysis)	-
12	M	66	V, D, At	(Previous CVE) Ataxic walk, bilateral intantional tremor, Romberg+	MRI: A couple milimetric noncpesific lesion in L frontal subcortical white matter CTA: Intimal hyperplasia and mechanical complication (broken stent) likely to cause hemodynamically significant stenosis in L vertebral ostial stent	-	DM	LVA Broken stent	-	4.5x16	P	-	-	RVA occlusion	-
13	W	54	NV, V, At	(Previous CVE) Ataxic walk, RUE movement and cerebellar examination awkward	CT, CTA: R cerebellar enfarct, L ICA >50% stenosis	-	DM	RVA LVA	>90 >90	5x12 5x16	P MIH	P MIH	-	(L ICA stenosis-follow-up)	-
14	M	64	Temporary D	(Previous CVE) -	-	-	DM, Ht, C, CAD	LVA	50-70	5x12	MIH	MIH	-	(L ICA occlusion R ICA stenosis-follow-up)	-
15	M	67	S, temporary visual, hearing loss	(Previous CVE) -	-	-	Ht	LVA	>90	4.5x12	MIH	P	-	(R ICA, L ICA stenosis-follow-up)	-
16	M	66	N-L arm	-	MRI: bulbus posterior R sided hyperintense milimetric lesions possibly due to chronic ischemia CTA: Soft plaques that do not cause stenosis in bilateral carotid bifurcation, L distal CCA	-	Ht, DM	LVA	>90	4x16	MIH	P	-	RVA>90	-

Table 1. Patients demographics, findings and treatments (continued)

Case No	Sex	Age	Symptoms	Clinical Findings	Imaging finding-pre	Imaging findings-post	Comorbidity	Lesion location	Stenosis %	Stent Taxus (mm)	6th Month Control Angio	1st Year Control CTA	2nd Year control Angio	Other stented area/ stenosis Additional findings	Complication
17	M	47	V, NV, Vd, Di, At	CVE: double vision at left glance, nistagmus, quadranopsia, obliterated L nasolabial fold, At to the L, minimally awkward knee heel test	MRI: LPCA area, bilateral talamic, upper pons, bilateral serebellar acute infact areas CTA: LVa occlusion 4 cm distal to the origin, no prebasilar segment, thin, irregular basilar artery, LPCA occlusion	-	C	LVA	70-90	4.5x16	MIH	P	-	(Hypoplastic RVA)	-
18	M	70	EA, V	-	MRI: No acute ischemic lesion	-	Ht	RVA	>90	4x16	P	-	-	R ICA>90 (LVA, L subclav, L ICA stenosis-follow-up)	-
19	M	53	V, NV, S	-	MRI: A couple milimetric nonspesific gliotic lesion in bilateral subcortical area	-	C	LVA	70-90	4x16	MIH	P	-	(RVA stenosis-follow-up)	L subclav dissection
20	W	72	Hd, V, D, N-L arm	-	MRI: L cerebellar chronic ischemic lesion. Milimetric ischemic gliotic lesions in cerebral subcortikal white matter	-	Ht	RVA	>90	4x12	MIH	-	-	R ICA %70-90 RVA cervical %50-70 (LVA occlusion)	-
21	M	62	V	-	MRI: No acute ischemic lesion. Bilateral milimetric chronic ischemic lesions	-	DM	RVA	70-90	4x12	P	P	-	(RVA intradural stenosis Milim ACoA aneurism-follow-up)	-
22	M	55	V, Vd, N-L face	-	MRI: No acute ischemic lesion	-	Ht, HL, COPD	LVA	>90	4.5x16	MIH	-	-	L ICA occlusion-reconstruction with cervical collateral	-
23	M	65	Previous TIA, V	-	MRI: No acute ischemic lesion. L frontal chronic enfarct. Lacunar enfarct in L caudat nucleus	-	C, CAD	RVA	70-90	4x16	P	-	-	RVA intracran stenosis stent, R PICA origin aneurism coil emb	-
24	M	44	V, N-L arm- lip	-	MRI: No acute ischemic lesion. A couple millimetric nonspesific lesion	-	Ht, renal artery stent	RVA	70-90	4x16	MIH	-	-	-	-

ACoA, anterior communicating artery; At, ataxia; BA, basilar artery; C, smoker; CAD, coronary artery disease; CCA, common carotid artery; COPD, chronic obstructive pulmonary disease CVE, cerebrovascular event; Di, diplopia; D, dysarthria; DM, diabetes mellitus; DTR, deep tendon reflex; EA, lower extremity angina; Fp, facial paresis; H, hypoesthesia; Hd, headache; HL, hiperlipidemi; Hp, hemiparesis; Hs, Hashimoto Tiroiditi; Ht, hypertension; ICA, internal carotid artery; ISR, instent restenosis; L, left; LLE, left lower extremity; LUE, left upper extremity; M, man; MIH, minimal intimal hyperplasia; N, numbness; NV, nausea-vomiting; P, patent; PICA, posterior inferior cerebellar artery; R, right; PCA, posterior cerebral artery; RA, Romatoid Arthritis; RLE, right lower extremity; RUE, right upper extremity; S, syncope; V, vertigo; VA, vertebral artery; Vd, visual disturbance; TIA, transient ischemic attack; U, unconscious; W, woman; Wk, weakness

During the early postoperative period within the seven days, one patient (case 1) had vomiting twice with a fifteen seconds long asystole. ECG and cardiac enzymes were normal with no additional problems.

One patient (case 11) succumbed to death due to aspiration pneumonia 11 days after the procedure. The patient was brought to the hospital unconscious with a basilar artery stroke. Additional left VA stenosis was diagnosed and treated with PES during the same session of angiography for intraarterial thrombolysis. The patient benefited from intraarterial thrombolysis, neurological symptoms regressed and was extubated. Nevertheless, he couldn't survive.

Follow-up

The mean follow-up was 447 days, the median follow-up was 399 days.

The follow-up findings are summarized in table 2. Twenty-three of the 24 patients with a total of 27 PES were evaluated at the 6th month (median 187 days) with DSA. Only one stent (case 10) out of 27 stents was diagnosed with hemodynamically significant ISR (3.7%). The patient was a 63-year-old male, diagnosed with a right VA and ICA occlusion with 90% stenosis of left VA and ICA during cardiology controls. Left VA and left ICA stenoses were treated with endovascular stenting. At the 6th month follow-up, there was MIH in the left ICA stent but hemodynamically significant (>50%) ISR in the left VA stent (Fig. 2). Meanwhile, the patient stopped using the ASA but continued to use clopidogrel due to stomach bleeding. We planned a treatment session of balloon angioplasty, unfortunately, the patient refused the treatment due to an additional recent diagnosis of lung carcinoma. Furthermore, he didn't continue follow-ups and died of complications of lung carcinoma.

At the first and second-year evaluations, no other hemodynamically significant ISR were investigated.

Table 2. Follow-up findings

Month	Median day	Patient (n)	Stent (n)	DSA/CTA	Patent (n)	Patent (%)	MIH (n)	MIH (%)	ISR (n)	ISR (%)
6	187	23	27	27/-	10	37%	16	59%	1	3.7%
12	370	17	22	2/20	18	81.80%	4	18.20%	-	-
24	736	7	11	8/3	8	72.72%	3	27.30%	-	-

n: number

Only one patient (4.1%) had recurrent neurological symptoms during the follow-ups (case 12). The patient had recurrent complaints of balance and speech problems. Two months before being referred to our clinic, he was treated with left vertebral ostial stenting in another clinic. The patient had a broken stent and was treated with PES through both segments of the fragmented stent (Fig. 3). The 6th month follow-up after this procedure yielded a normal DSA. 9 months after the second procedure there was worsening of the cerebellar symptoms. Nevertheless, the left VA ostial stent was patent at angiographic controls. No lesion that had restricted diffusion on MRI. No other findings on spinal MRI explained the symptoms. The cerebellar findings were recovered and the patient was discharged after 10 days of hospitalization.

In a median follow-up of 13 months (6-25 months), none of the patients had late stent thrombosis. The procedural and post-procedural events are collected in table 3.

Fig. 2: Case 10: Stenosis (a) and paclitaxel-eluting stent implantation (b) of the left vertebral artery are seen. In-stent restenosis is observed at the sixth-month control angiogram (c, d).

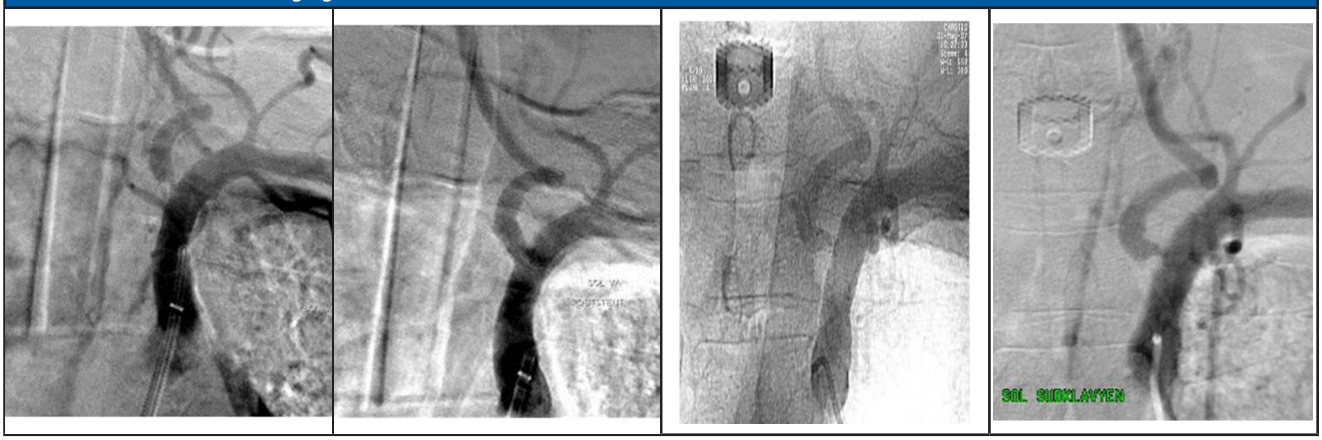
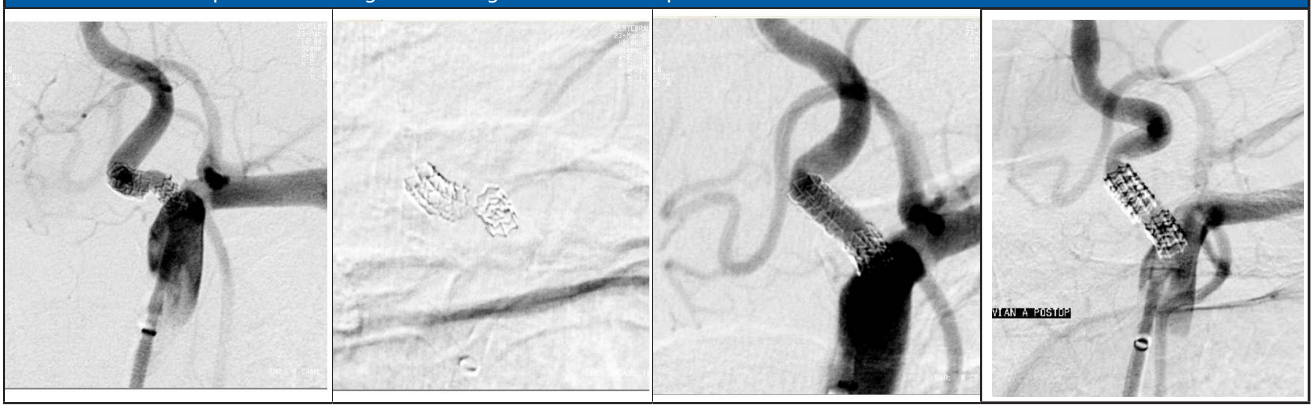


Table 3. Procedural, post-procedural events						
	Major event	n	%	Minor event	n	%
Procedure related complications	-	-	-	Limited proximal subclavian artery dissection	1	4.1
30 days adverse events	Exitus due to aspiration pnomonia	1	4.1	Temporary numbness on left hand/ Two milimetric acute ischemic lesion- R postcentral gyrus Emotional indifference- agitation/ Milimetric hemorrhagic lesion- L caudate nucleus Vomiting- vagal stimulation, 15 seconds asystole	3	12.5
Long period events	-	-	-	Worsening of cerebellar symptoms	1	4.1

Fig. 3: Case 12 : It was observed that the stent, previously placed on the VA origin, was broken (a, b). Angiography images (c, d) obtained after insertion of the paclitaxel-eluting stent through the broken components are observed.



Discussion

Proximal extracranial VA is the second most common stenotic area after carotid artery bifurcation. The origin of the VA is a difficult region to display (8).

Currently, catheter angiography is the gold standard in the evaluation of the VA origin and plaque, the detection of ulceration and thrombus, and the evaluation of extra and intracranial blood flow (9). However, it includes the risks of invasiveness, hospitalization, ionizing radiation, contrast agent allergy and nephropathy. Therefore, DSA is not the first method of choice in the diagnosis of extracranial VA atherosclerotic disease. Color Doppler Ultrasonography (US) and MRI have some technical and anatomical limitations in VA origin imaging. Spiral and multislice CTA can display extracranial VA without the risks of DSA (10).

We included DSA for the diagnosis of VA stenosis in the study. CTA was alternated with DSA to decrease the risks of DSA for the follow-up of the cases.

Classically the VA ostial atherosclerotic disease is treated with antiplatelet medication and anticoagulation. The benefit of an intervention over medical treatment alone is unclear. Various small trials were conducted to determine the efficiency of endovascular treatment modality relative to medical therapy alone. Nevertheless, these trials failed to demonstrate the superiority of stenting over the best medical therapy (11-13). Large randomized controlled trials are required to elucidate this question.

The generally accepted interventional indications are symptomatic VA stenosis, persistent posterior system ischemic symptoms despite optimal medical therapy, or intolerance to medical therapy. However, published studies may justify attempts without a medical treatment with symptomatic disease (14). The severity of stenosis, angiographic appearance (vulnerability, presence of ulceration), adequacy of collateral flow and patient age are the effective factors for decisions (14).

In embolic posterior circulation ischemia when cardiac causes are eliminated, the embolic event should be considered primarily due to VA origin disease. In these cases, treatment is recommended even the degree of stenosis is less than 50%, as it is a source of embolism (15).

Asymptomatic patients with significant stenosis in the origin of VA are controversial. Although most of the asymptomatic patients don't require, some researchers suggest endovascular treatment to high grade (more than 70%) stenosis in dominant VA or single VA origin for the increased risk of embolism (16). In a young asymptomatic patient, endovascular treatment is also recommended for severe ulcerated stenosis without good collateral flow. Another group of researchers argues that asymptomatic patients should be treated in cases where collateral circulation is necessary and is of great importance, such as carotid occlusion (8).

In our hospital, endovascular treatment is recommended for patients with posterior circulation ischemic symptoms despite optimal medical treatment, and those with more than 50% stenosis in the origin of VA in DSA. In addition, endovascular treatment is recommended to patients with an ulcerated plaque in the origin of VA, regardless of whether they are symptomatic or asymptomatic.

The ostial VA stenoses are highly elastic lesions due to the well-developed muscular layer of VA origin like coronary arteries. Thus, for successful treatment, it is necessary to use stents with high radial force (17). In the SSYLVIA trial, the increased restenosis rates in VA origin lesions compared to the lesions in intracranial vessels and VA segments prior to posterior inferior cerebellar artery have been associated with the lesions' high elastic nature and the stent's design (18).

Primary stenting with balloon-expandable coronary stents were reported to be applied safely with high technical success in VAOS (17). Although percutaneous stenting decreases the rate of procedural complications such as failed balloon dilatation or risk of dissection, the high ISR-rates remain as a problem to be solved (17, 19).

In parallel with the data of the decreased ISR-rates of antiproliferative DES in coronary arteries (20), DES were started to be used in VAOS as an alternative. The first-generation DES is sirolimus and PES. It is known that paclitaxel and sirolimus-eluting stents decrease the neointimal hyperplasia by inhibiting the induced smooth muscle proliferation by mitogens (21).

Although some studies revealed no differences in the ISR-rate between DES and bare-metal stents (BMS) (22) the results of two metanalyses showed a reduction of the ISR-rate and a lower rate of recurrent symptoms- symptomatic restenosis for DES compared with the BMS group (23, 24). It is indicated that the relative ISR problem remains relevant (24, 25). The prospective randomized STOVAST trial revealed no evidence for ISR reduction with DES versus BMS group (26). In this trial, cobalt-chromium stents in the BMS group were observed to have the lowest ISR-rates (8.3%, 1/12 patients) whereas the PES in the DES group was observed to have the highest ISR-rate (50%, 2/4 patients). Our data differ from the STOVAST trial significantly. We have found only 3.7% (only one asymptomatic case among 27 stent applications) hemodynamically significant (which is >50%) ISR-rate occurred in about 6 months after stenting with PES in our retrospective study within a mean of 447 days of follow-up. The patient had a combined contralateral ICA and VA occlusion. In a recent study, the contralateral VA occlusion at the time of stenting is postulated as an increased risk factor for ISR (27). The differences between the reported restenosis rates may be connected with the number of patients, the median interval follow-up time and the differences of the evaluation methods as well as application-related differences.

Although DESs are being used in the supra-aortic and intracranial vessels, the long period results are not clear. The late and very late thrombosis remains as a problem. In the light of these data and considering the costs, as of today, DESs are preferred to be used in the ostial VA stenosis for stent-in-stent placement for ISR of BMS and/or broken stents.

Treatment protocols of VAOS still maintain their dynamism. Recently, the use of distal protection devices and the self-expandable stents for the treatment of ostial VA stenosis have been investigated (28, 29). To define the best therapy option, prospective studies with long-term results are required.

We assessed the technical success, efficiency, clinical and angiographic results of PES in vertebral ostial stenosis. Despite the shortcomings of a retrospective study, we showed that VAOS can be treated effectively and safely with high technical success and low ISR-rates with paclitaxel DESs. With low restenosis rates, the antiproliferative DESs are still an alternative for reducing the VA ISR.

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