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Original Article

Perioperative and 90-day Clinical and Radiological Results of Endovascular Treatment of Symptomatic Basilar Artery Stenosis

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ABSTRACT

Objective: The aim of our study is to evaluate the safety and effectiveness of basilar artery stenosis cases in which we applied endovascular treatment due to recurrent stroke under optimal medical management.

Methods: Patients with severe basilar artery stenosis (70-99%) due to atherosclerosis, who had transient ischemic attack or ischemic stroke despite optimal medical management, and who underwent endovascular treatment were retrospectively examined. The primary outcomes were ischemic or hemorrhagic stroke within 90 days after stent deployment and death related to the endovascular procedure during hospitalization. Secondary outcomes were successful revascularization (residual stenosis <30%) and procedure-related complications.

Results: The median age of the 19 patients included in the study was 65 years (IQR, 53-68.5), and 74% were male. The most common area of stenosis was the proximal third of the basilar artery (63%), followed by the middle third (37%). According to the Mori classification, the most common lesion type was MORI A (53%), followed by MORI B (42%). While the stenosis rate before endovascular treatment was 85% (IQR, 80-90%), the median residual stenosis rate after successful stenting was 16% (IQR, 11-20). Treatment was successful in 18 of 19 patients (95%), and only 1 patient died due to basilar artery perforation during the procedure. The mortality rate was 5% (1/19). Asymptomatic stent restenosis was observed in one patient who underwent balloon angioplasty. During this period, no recurrent ischemic stroke was observed in any patient. The 3rd month mRS score was 1 (IQR, 0-1.5).

Conclusion: The endovascular treatment of basilar artery stenosis appears to be safe and effective in experienced centers, despite the potential risk of perioperative complications. Randomized controlled trials are necessary to validate the efficacy and safety outcomes of balloon angioplasty and stenting.

INTRODUCTION

Posterior circulation ischemia (PCI) constitutes around 20% of all cases of ischemic strokes and is often due to large vessel atherosclerosis.[1] Furthermore, the risk of recurrence of stroke or transient ischemic attack (TIA) within 90 days due to basilar artery or intracranial vertebral stenosis is significantly higher than in patients without stenosis.[2,3] Due to the high risk of early recurrence, this situation, where medical treatment is inadequate, has prompted the consideration of endovascular treatments. Comprehensive international studies have demonstrated the benefit of endarterectomy in symptomatic carotid stenosis and stent deployment in selected patients.[4,5] However, knowledge about the optimal management of basilar artery stenosis is insufficient.

The current treatment of basilar artery stenosis (BAS) consists of best medical therapy (BMT), which includes dual antiplatelet therapy and close control of risk factors, and endovascular percutaneous transluminal angioplasty and/or stenting (PTAS).[6]

SAMMPRIS (Stenting and Aggressive Medical Management for Preventing Recurrent Stroke, n=451), VISSIT (Vitesse Intracranial Stent Study for Ischemic Stroke Therapy; n=112), and a single-center randomized controlled trial (RCT) in China (n=70) compared PTAS and BMT in patients with high (>70%) intracranial stenosis who had a stroke or TIA. In the 3 RCTs, 30-day stroke and death

rates were revealed to be higher in the PTAS group.[7-9] These studies mostly included patients with intracranial stenosis in the anterior system.

Nevertheless, the presence of severe symptomatic BAS and acute basilar artery occlusion (BAO) is associated with increased death rates, despite the implementation of BMT.[10]

MATERIALS AND METHODS

This study, collected prospectively and analyzed retrospectively, was conducted by Kartal Dr. Lütfi Kırdar City Hospital and approved by the Institutional Ethics Committee. Prior to the interventional procedure, written informed consent was obtained from all patients and/or their relatives.

Patients over 18 years of age who had a stroke or TIA that did not cause serious disability in the basilar artery vascular area within 90 days under BMT between February 2020 and January 2024 were retrospectively screened. According to the North American Symptomatic Carotid Endarterectomy Study (NASCET) standard, patients with severe stenosis of the basilar artery (stenosis ≥70%) on CTA or MRA whose stenosis was confirmed by DSA were included in the study.[11] Other inclusion criteria were pre-procedure modified Rankin Score (mRS) <3 and at least one atherosclerotic risk factor (hypertension, diabetes mellitus, hyperlipidemia, and smoking). Exclusion criteria included 1-Non-atherosclerotic stenosis, presence of thromboembolic or non-hemodynamic stroke symptoms (including perforator strokes), intracranial hemorrhage in the stenotic artery region within 3-6 weeks, 4-Simultaneous presence of an intracranial tumor, aneurysm, and cerebral arteriovenous malformation, 5-Concurrent ≥50% vertebral artery or extracranial carotid stenosis, 6-Documented contraindication to heparin, aspirin, clopidogrel, anesthetic, and contrast media, 7- Platelet count <100,000; international normalized ratio (INR) >1.5 (irreversible) and life expectancy <1 year due to uncorrectable bleeding diathesis and other medical conditions.

BMT was designed in accordance with the SAMPRISS study.[7] Pre-procedure, acetylsalicylic acid and clopidogrel resistance were requested for all patients.

The basilar artery was anatomically partitioned into three distinct segments: distal segment, middle segment, and proximal segment, utilizing the anterior inferior cerebellar artery and superior cerebellar artery.[12] In addition, based on the Mori classification, Mori A refers to a lesion that is small and concentric with a length of less than 5 mm. Mori B is a tubular or very eccentric lesion with a length ranging from 5 to 10 mm. The lesion Mori C, characterized by diffuseness and a length exceeding 10 mm, was classified.[13]

Successful stent deployment involves ensuring that the target lesion is fully covered, achieving less than 30% residual stenosis or reducing stenosis by more than 50%. However, since complete dilatation of the basilar artery to 100% is not recommended, a small residual stenosis is aimed for. Restenosis was described as ≥50% BAS detected at the latest available follow-up in individuals who underwent successful intervention.[10,14]

The endovascular therapy choices were balloon-mounted stenting, angioplasty alone, and angioplasty with a self-expanding stent inserted thereafter. The clinical and endovascular treatment processes were both carried out by two interventional neurologists. Clinical complications such as stroke, TIA, and mortality were documented after endovascular procedures. Following the treatment, a regimen of dual antiplatelet therapy was maintained for a minimum duration of 3 months. The National Institutes of Health Stroke Scale (NIHSS) and mRS were used for clinical assessment. Stenosis was identified by measuring distal normal vessel diameter as defined by the North American Symptomatic Carotid Endarterectomy Trial (NASCET). Self-expandable stenting Neuroform stent (Stryker, Kalamazoo, Michigan, USA) was utilized.

Primary outcomes were ischemic or hemorrhagic stroke after stent deployment within 30 days, TIA, and death from the endovascular procedure during hospitalization.[15] Secondary outcomes were successful revascularization (residual stenosis <30%) and peri-procedural complications such as vessel dissection and acute stent thrombosis after stenting.

Statistical Analysis

Continuous variables were presented as the median and interquartile range (IQR). Categorical variables were offered as frequency (n) and percentage (%). The statistical analyses were conducted using IBM SPSS Statistics Software 21 (SPSS Inc., Chicago, IL, USA).

RESULTS

Nineteen patients were included in the study. The median age of the participants was 65 years (IQR, 53–68.5), and 74% were male. The most typical comorbidities were arterial hypertension (74%), dyslipidemia (16%), diabetes mellitus (65%), and coronary artery disease (11%). The most common area of stenosis was the proximal third of the BA (63%), followed by the middle third (37%).

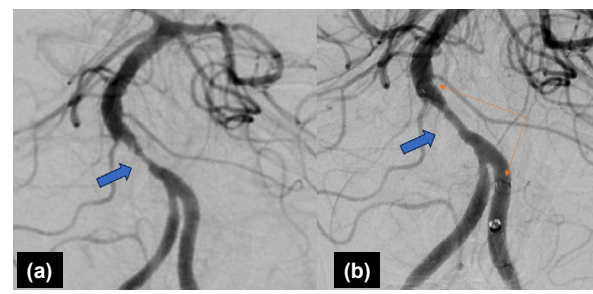

Figure 1. Angiographic imaging findings of a patient with basilar artery proximal stenosis before and after treatment. **(a)** Basilar artery angiography in frontal view before the procedure, high grade ostial stenosis in the proximal segment of basilar artery (blue arrow). **(b)** After primary stenting with a balloon-mounted stent, control angiography imaging confirms adequate restoration of the vessel lumen.

Table 1. Patients' clinical data and imaging features

No	Gender	Age	Location Class.	MORI (%)	Pre-stenosis methods	Interventional (%)	Post-stenosis	Complication	Re-stenozis
1	M	74	prx	2	80	PTA+Stenting	10	no	no
2	M	65	mid	2	90	PTA+Stenting	10	no	no
3	M	67	Prx	2	90	PTA+Stenting	10	no	no
4	M	76	prx	1	85	PTA+Stenting	15	no	no
5	F	68	mid	1	90	PTA+Stenting	20	no	no
6	M	54	Prx	2	90	PTA+Stenting	10	no	no
7	M	68	Prx	2	80	PTA+Stenting	20	no	no
8	M	69	Prx	1	80	PTA+Stenting	20	no	no
9	M	56	Prx	2	90	PTA+Stenting	20	no	no
10	M	36	Prx	1	80	PTA+Stenting	20	no	no
11	F	65	Prx	2	80	PTA	25	no	yes
12	M	52	mid	2	80	PTA+Stenting	15	dissection	no
13	M	46	mid	1	90	PTA+Stenting	20	no	no
14	M	63	mid	2	85	PTA+Stenting	10	no	no
15	F	50	Prx	1	75	PTA+Stenting	20	no	no
16	F	71	prx	1	85	PTA+Stenting	20	dissection	no
17	F	72	mid	2	90	X	n	perforation	X
18	M	46	prx	1	90	PTA+Stenting	10	no	no
19	F	64	mid	2	75	PTA+Stenting	20	no	no

M: Male; F: Female; Class: Classification; PTA: Percutaneous transluminal angioplasty; mid: Middle; Prx: Proximal; Dist: Distal.

Table 2. Three months post procedure clinical and imaging outcome

	Total n:19
mRS (n,%)	1 (IQR, 0-1.5)
0-2 16	
3-4 2	
5 locked-in syndrome	0
6 (death)	1
Imaging study at 3 months (n, %)	
Stent restenosis (>30%)	1
Stent occlusion	0

mRS: Modified Rankin Scale; IQR: Interquartile range.

Eighteen (95%) patients underwent balloon angioplasty, and 17 (89%) patients received stenting. According to the Mori classification, the most common lesion type was MORI A, with 53%, followed by MORI B, with a frequency of 42%. Patients' data, as well as clinical and technical results, are summarized in Table 1.

Before stenting, the rate of stenosis was 85% (IQR, 80–90%), while after successful stent deployment, residual stenosis of 16% (IQR, 11–20%) was observed. Out of the 19 patients who had the procedure, successful stent placement was performed on 18 of them (95%) (Figure 1a-1b). Dissection developed in two patients during the PTA procedure (Case 12, 16). In one of these patients (Case 12), an ischemic stroke attributed to perforator injury occurred within 24 hours after endovascular treatment. Another patient remained asymptomatic (Case 16). During the PTA procedure, the patient experienced vascular perforation due to microwire, resulting in diffuse ischemia and subsequent death during hospitalization (Case 17). The mortality rate was 5% (1/19).

The duration of observation for the surviving patients was measured as the median follow-up period of 12 months (IQR, 7–24). Stent restenosis was observed in one patient who only underwent the PTA procedure due to severe elongation of the vessel (Case 11). However, no intervention was carried out due to its asymptomatic status. The 3rd-month mRS score was 1 (IQR, 0–1.5) (Table 2).

DISCUSSION

The purpose of this study is to review our experiences on the safety and clinical outcomes of endovascular interventions in severe basilar artery stenosis. Our success rate in performing PTA or stenting on our patients was 95% (18/19). The rate of peri-procedural complications was 16% (3/19), with a symptomatic complication rate of 11% (2/19). Of these complications, two were dissections and one was vessel perforation. While one of the patients who developed dissection did not have any symptoms, the other patient developed ischemia as a result of perforator injury. The patient who developed perforation died during hospitalization. During follow-up, asymptomatic restenosis was observed in one patient. No patient had recurrent stroke.

Two large studies on the subject, the SAMMPRIS and VISSIT studies, distinctly showed the superiority of aggres-

sive medical treatment over PTAS in patients with stenosis of intracranial arteries.[7,9] In a subgroup analysis of patients with basilar artery stenosis from the SAMMPRIS trial, the endovascular treatment group had a higher primary endpoint of stroke or death than the aggressive medical treatment group (10%, n=51 vs. 25% in the PTAS group, n=49).[7,14] In the group of 97 patients with vertebrobasilar stenosis who underwent stenting by Liu et al.,[15] ischemic stroke occurred in 3.1% (3/97) and transient ischemic attack occurred in four patients (4.1%, 4/97). In the study by Bai et al.,[16] the perioperative ischemic stroke or death rate was 14.3% (13/92). When examining the primary outcome of our study, we observed dissection-related stroke in 5% (1/19) of patients and death during hospitalization in 5% (1/19) of patients.

Our study had a peri-procedural complication rate of 16% (3/19) and a symptomatic complication rate of 11% (2/19). In the study by Maier et al.,[14] nine (11.4%) peri-procedural events occurred in the endovascular treatment group. Six of these patients (7.5%) were diagnosed with ischemic stroke after the procedure, and the others had no clinically significant events.[14] It is thought that the selection of patients with good collateral circulation, strict implementation of perioperative management, performance of the procedure by experienced operators, and correct material choices contribute to the increase in treatment success.

In our study, while the stenosis rate before the procedure was 85% (IQR, 80–90%), the residual stenosis rate after successful stent placement was 16% (IQR, 11–20%). Looking at the literature, this rate varies depending on the type of stent used and the type of lesion.[13-17] In the meta-analysis conducted by Palmisciano et al.,[17] median BAS at baseline was 81% (range, 53–99%) (data available in 659 cases), while median BAS post-intervention was 13% (0–75%). The cause of this residual stenosis can be explained by the fact that the basilar artery is more tortuous in some patients, the perforators originate near the stenotic segment, and operators are forced to perform submaximal dilatation with small-caliber balloons.

Perforating strokes (PS) are frequent complications of intracranial endovascular management. Particularly, the basilar artery is one of the regions where perforator arteries are most frequently located. It has been discussed in the literature that this may result from migration of atherosclerotic debris or "snowplowing" on the perforator outlets during angioplasty or stent deployment. The SAMMPRIS trial reported a 16% occurrence rate of PS in the basilar artery.[7] In the study by Liu et al.,[15] which included 102 patients with vertebrobasilar artery stenosis, three dissection cases were observed, and all of them were patients with basilar stenosis. In our study, PS was observed in one (5%) of the patients who developed dissection, and it was observed to be low compared to the literature.

In BA pathologies, proximal and mid-segment occlusions are typically associated with atherosclerosis, while occlusion of the distal one-third is often caused by emboli.[10,18] In our patient group, stenosis was observed in the proximal BA (68%) and in the middle segment of the BA (32%), consistent with the literature. At the same time, the middle segment of the basilar artery (BA) is the segment that affects the clinic the most. This is mainly because the perforators are mostly located here.

During follow-up, stent restenosis was observed in one patient (5%), but no intervention was performed due to the patient being asymptomatic. When looking at the literature, Hatano et al.[19] reported a stent restenosis rate of 27% (4/15) and 7% (1/15) cases of stent thrombosis. In the study conducted by Machado et al.,[10] restenosis occurred in one out of 14 patients, while stent thrombosis developed in another patient. The reason why our results are more positive than the literature may be appropriate patient selection and the use of fit caliber balloon and stent.

In our study, no recurrent stroke occurred in the patients during the follow-up period. According to the literature, it has been reported that in patients with vertebrobasilar stenosis under intensive medical treatment, the annual rates of cerebrovascular events are around 10-15%.[10] Therefore, we believe that endovascular treatments will be prominent, especially in posterior system strokes, with the correct patient selection and intervention by experienced operators.

One of the limitations of our study is that it is retrospective, which may lead to potential selection bias since the enrolled patients were not randomized. Secondly, our small number of patients and relatively short follow-up period limit its value. The third limitation is the use of a single type of stent and the absence of comparison. Therefore, randomized, prospective, and large-sample studies are needed to provide stronger evidence about efficacy and safety results.

Conclusion

Endovascular treatment has the advantage of lowering the long-term risk of fatal and severely incapacitating stroke in patients with severe basilar artery stenosis, even though its superiority has not yet been proven in the literature. If perioperative complications can be minimized, we believe that basilar artery stenting may be beneficial for patients with severe basilar artery stenosis.

Ethics Committee Approval

The study was approved by the Kartal Dr. Lütfi Kırdar City Hospital Ethics Committee (Date: 26.07.2021, Decision No: 20211010.9916139).

Informed Consent

Retrospective study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: A.Ö.; Design: A.Ö., E.G.; Supervision: E.G.; Fundings: E.G.; Materials: A.Ö.; Data: A.Ö., E.G.; Analysis: A.Ö., E.G.; Literature search: A.Ö.; Writing: A.Ö.; Critical revision: E.G.

Conflict of Interest

None declared.

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Semptomatik Baziler Arter Stenozunun Endovasküler Tedavisinin Perioperatif ve 90 Günlük Klinik ve Radyolojik Sonuçları

Amaç: Çalışmamızın amacı, en iyi medikal tedavi altında tekrarlayan inme nedeni ile endovasküler tedavi uyguladığımız baziler arter stenozu olgularımızın tedavi güvenliği ve etkinliğini değerlendirmektir.

Gereç ve Yöntem: Ateroskleroza bağlı şiddetli baziler arter stenozu (%70-99) olan, en iyi medikal tedavi altında geçici iskemik atak veya iskemik inme geçiren ve endovasküler tedavi uygulanan hastalar geriye dönük incelendi. Birincil sonuçlar, stent yerleştirilmesinden sonra 90 gün içinde iskemik veya hemorajik inme ve hastanede yatış sırasında endovasküler prosedürden kaynaklanan ölümdü. İkincil sonuçlar başarılı revaskülarizasyon (rezidüel stenoz <%30) ve işleme bağlı komplikasyonlar olarak belirlendi.

Bulgular: Hastaların 19'unun yaş ortalaması 65 (IQR, 53-68.5) olup %74'ü erkekti. Stenozun en fazla görüldüğü alan BA'nın proksimal üçte birlik kısmı (%63) olurken, bunu orta üçte birlik kısım (%37) takip etti. Mori sınıflamasına göre lezyon tipi en sık %53 ile Mori A ve 42% Mori B ile idi. Stent öncesi darlık oranı ortalaması %85 (IQR, 80-90%), iken başarılı stent yerleştirme sonrası ortalama %16 (IQR, 11-20) rezidüel stenoz izlendi. Çalışmaya alınan 19 hastanın 18'sinde başarılı stent uygulandı (%95). İşlem sırasında 1 hastada damar perforasyonu ve 1 hastada diseksiyona bağlı iskemi gelişti. Mortalite oranı %5 (1/19) idi. PTA yapılan bir hastada asemptomatik stent restenozu izlendi. Bu süreçte hiçbir hastada tekrarlayan iskemik inme görülmedi. Üçüncü ay mRS skoru 1 (IQR, 0-1.5) idi.

Sonuç: Baziler arter stenozunun endovasküler tedavisi potansiyel perioperatif komplikasyon riskleri barındırmakla birlikte tecrübeli merkezlerde güvenli ve etkin tedaviler gibi görünmektedir. Balon anjiyoplasti ve stentlemenin etkinlik ve güvenlik sonuçlarını doğrulamak için randomize kontrollü çalışmalara ihtiyaç vardır.

Anahtar Sözcükler: Ateroskleroz; baziler arter; iskemik inme; perkutan anjiyoplasti ve stentleme.