

Carotid Artery Stenting: Experiences of a Neurology Department

Karotid Arterin Stentlenmesi; Bir Nöroloji Kliniğinin Deneyimleri

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ABSTRACT

Introduction: Carotid artery stenting (CAS) is a recommended technique for extracranial carotid artery stenosis. CAS is preferred more than carotid endarterectomy because of more non-invasive technique, decreased recovery period, decreased patient discomfort. In this study, we evaluated the data of patients treated with CAS in Kocaeli Derince Training and Research Hospital.

Methods: We retrospectively evaluated the data of patients who were treated with CAS in Kocaeli Training and Research hospital Neurology Department between 2018 and 2020 were included to our study. Demographic data, angiographic findings, periprocedural processes and complications, ischemic stroke, acute myocardial infarction (MI) and death rates in 1 year follow-up were evaluated.

Results: Aseventy-one patients were treated with CAS. Fifty-nine (83.1%) patients were male. Mean age was found as 67,4±8,7 years. CAS was applied to only right carotid artery in 32(45.1%) patients, only left carotid artery in 36(50.7%) patients and bilateral carotid arteries in 3(4.2%) patients. Open-cell stents were placed to 39 (54.9%) patients. Hemodynamic depression occurred in 21(29.5%) patients. Hemodynamic depression was associated with open-cell stents (p=0.005) and coronary artery disease in medical history (p=0.030). Only 2(2.8%) patients had acute ischemic stroke in 1 year follow-up. Acute MI and death didn't occur in our patients.

Discussion and Conclusion: CAS is a safe and effective method in treatment of extracranial carotid artery stenosis. Open-cell stents may increase the risk of hemodynamic depression, but mechanism is unclear.

Keywords: carotid artery stenosis, carotid artery stenting, carotid revascularization

ÖZ

Giriş ve Amaç: Karotid arter stentlenmesi (KAS), ekstrakraniyal karotid darlıklarında önerilen bir tedavi yöntemidir. KAS, daha az invaziv olması ve iyileşme süresinin daha kısa olması nedeni ile endarterektomiye göre günümüzde daha fazla tercih edilmektedir. Bu çalışmada Kocaeli Derince Eğitim ve Araştırma Hastanesi Nöroloji Kliniği'nde KAS yapılmış hastaları inceledik.

Yöntem ve gereçler: Kocaeli Derince Eğitim ve Araştırma Hastanesi Nöroloji Kliniği'nde 2018-2020 arasında KAS yapılmış hastaların dosyaları retrospektif olarak tarandı. Demografik bilgiler, anjiyograf bulguları, periprocedürel işlemler ve komplikasyonlar, 1 yıllık süre içerisinde iskemik inme, akut miyokard infarktı ve ölüm olup olmadığı araştırıldı.

Bulgular: Yetmişbir hasta KAS ile tedavi edildi. Ellidokuz (%83,1) hasta erkekti. Ortalama yaş 67,4±8,7 yıl olarak bulundu. Hastaların 32'sinin (%45,1) sadece sağ karotid arteri, 36'sının (%50,7) sadece sol karotid arteri, 3'ünün (%4,2) ise her iki karotid arteri stentlendi. Otuzdokuz (%54,9) hastaya açık hücreli stent yerleştirildi. Hemodinamik depresyon 21 (%29,5) hastada gözlemlendi. Hemodinamik depresyonun açık hücreli stent yerleştirilmesi (p=0,005) ve koroner arter hastalığı öyküsü olması (p=0,030) ile ilişkili olduğu saptandı. Bir yıllık takip süresinde sadece 2 (2,8) hastada iskemik inme gelişti. Hastalarda akut MI ya da ölüm izlenmedi.

Tartışma ve Sonuç: KAS, karotid arter darlıklarının tedavisinde etkili ve güvenli bir yöntemdir. Açık hücreli stentlerin hemodinamik depresyonu artırdığı izlenmiştir. Ancak bunun mekanizması bilinmemektedir.

Anahtar Kelimeler: karotid arter stentleme, karotid arter stenozu, karotid arter revaskülarizasyonu

Kabul Tarihi: 13.08.2021

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Kocaeli Medical Journal published by Cetus Publishing. 



Kocaeli Medical Journal 2021 <https://kocaelimj.org>

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INTRODUCTION

Ischemic stroke is an important cause of mortality and morbidity in adults. Extracranial carotid artery stenosis causes 15-20% of all acute ischemic strokes (1). Revascularization of carotid artery stenosis is recommended for patients with >50% symptomatic or >70% asymptomatic stenosis (2). Previously, carotid endarterectomy (CEA) was used as the only revascularization treatment of carotid artery stenosis. CREST study showed that carotid artery stenting (CAS) had a similar stroke, death, and acute myocardial infarction (MI) rates compared with CEA (3). Being more non-invasive, decreased recovery period, decreased patient discomfort are advantages of CAS (2). Because of these reasons, CAS has been preferred more than CEA. Different medical branches such as cardiologists, radiologists, and neurologists can apply CAS. In this study, we evaluated the patients treated with CAS in a neurology department.

METHODS

The local ethics committee approved our study. All patients treated with CAS in the neurology department between 2018 and 2020 were included in our study. Demographic data, medical history, drug usage, laboratory findings, angiographic findings, interventions during CAS were collected from patient files. Acute MI, ischemic stroke, and death were questioned to patients or their relatives by phone at the end of the first year.

An interventional neurologist in our center applied CAS. Patients were treated with dual-antiaggregant treatment (acetylsalicylic acid 100 mg/day and clopidogrel 75 mg/day) at least two weeks before CAS. Clopidogrel 75mg/day treatment was added to the treatment of patients using oral anticoagulants. Carotid artery stenosis in angiographic images was evaluated according to North American Symptomatic Carotid Endarterectomy Trial (NAS-CET) criteria (4). CAS was performed on patients with >50 % symptomatic or >70% asymptomatic carotid artery stenosis. Symptomatic carotid stenosis was defined as having an ischemic stroke or

transient ischemic attack (TIA) on the ipsilateral cerebral hemisphere within the last six months. During CAS, 6 French (F) sheath was placed to the femoral artery with local anesthesia. 75 U/kg heparin was given to keep activated coagulation time (ACT) between 250-300 seconds after sheath placement. Destination 6F (Terumo, USA) guiding catheter was placed to the common carotid artery (CCA). Stenosis was passed with 0,014 inches width microwire. If needed, balloon angioplasty was performed before stenting (pre-dilatation). Then carotid stent (Xact, Abbott Vascular, USA- Protege, Medtronic, USA- Wallstent, Boston Scientific, USA) was placed to the stenotic segment from internal carotid (ICA) to CCA. Balloon angioplasty (post-dilatation) was performed to residual stenosis over 20%. Atropin with 0,5-1 mg dosage was given if bradycardia occurred during balloon angioplasty or after stenting. The process ended after anterior-posterior and lateral cerebral angiography images. Acute complications including acute carotid stent thrombosis (ACST), hemodynamic depression, cerebral hyperperfusion syndrome (CHS), renal failure, stent occlusion, and ischemic stroke or TIA were noted. Hemodynamic depression was defined as hypotension and/or bradycardia after CAS in the 24 hours. Patients were followed for one year after stenting. Ischemic stroke, MI, and death were questioned to patients or their relatives after a one-year follow-up.

Statistical analyzes were done by SPSS 15.0. Categorical variables were expressed as frequencies and percentages. Continuous variables were expressed as mean (SD) or median (interquartile range [IQR]) for non-normal distribution. Kolmogorov-Smirnov test was used for assessing the normality of distribution. We used Mann-Whitney U, paired T, and independent T-tests for continuous data and χ^2 for binary and categorical data. Binary logistic regression analysis was performed to evaluate independent predictors. All p values <0,05 were considered significant.

RESULTS

We spotted 71 patients with carotid artery stenting between 2018-2020. Fifty-nine (83.1%) of patients were male. Mean age was found as 67.4 ± 8.7 (min 47, max 88) years. There wasn't a difference between the mean age of male and female patients (males: 66.7 ± 9 , females: 70.8 ± 5.7 , $p=0.064$).

Smoking was found high in males ($p=0.003$).

Other risk factors were found similar in male and

female patients. In laboratory findings, we found increased serum creatine, total cholesterol, and hemoglobin A1c levels in males. Diabetes mellitus rates were found similar between male and female patients. Sixty-five (91.5%) patients used dual-antiaggregant treatment, and 6(9.5%) patients used anticoagulant (5 patients warfarin, 1 patient apixaban) and clopidogrel 75mg/day treatment before stenting. Demographic data were shown in Table 1.

	Total(%)	Males(%)	Females(%)	p
n	71(100)	59(83.1)	12(16.9)	
Age (year)	67.3 ± 8.7	66.7 ± 9	70.8 ± 5.7	0.064
Hypertension	54(76.1)	43(72.9)	11(91.7)	0.270
Diabetes Mellitus	26(36.6)	21(35.6)	5(41.7)	0.748
Smoking	34(47.9)	33(35.6)	1(8.3)	0.003
Hyperlipedemia	35(49.3)	28(47.5)	7(58.3)	0.541
Atrial Fibrillation	6(8.5)	5(8.4)	1(8.3)	1.000
Hearth Failure	6(8.5)	5(8.4)	1(8.3)	1.000
Ischemic Stroke	43(60.6)	37(62.7)	6(50)	0.521
Coronary Artery Disease	26(36.6)	22(37.3)	4(33.3)	1.000
WBC (/mm³)	7832 ± 3331	7920 ± 3423	7400 ± 2932	0.382
Neutrophil %	61.8 ± 10.4	61.7 ± 10.5	62.2 ± 10.7	0.829
Hemoglobin (g/dl)	13.3 ± 1.8	13.7 ± 1.6	11.5 ± 1.5	0.525
MCV (fl)	90.5 ± 5.7	90.8 ± 5.4	89 ± 7.4	0.193
Platelet (/mm³)	220070 ± 65748	220644 ± 58411	217250 ± 49925	0.543
MPV (fl)	9.1 ± 0.9	8.9 ± 0.8	9.8 ± 1	0.926
Urea (mg/dl)	41.9 ± 16.3	42.4 ± 16.7	39.8 ± 14.4	0.484
Creatine (mg/dl)	1.04 ± 0.31	1.07 ± 0.3	0.9 ± 0.3	0.032
Triglyceride (mg/dl)	165.5 ± 100	165.5 ± 95.3	165.7 ± 124.9	0.584
Total Cholesterol (mg/dl)	191 ± 51	193.1 ± 46.8	181.2 ± 69.3	0.042
HDL (mg/dl)	40.7 ± 16.8	41.1 ± 17.7	39.2 ± 12.9	0.962
LDL (mg/dl)	116.9 ± 41.3	119.4 ± 39.1	105.4 ± 50.5	0.562
Hemoglobin A1c (%)	7.2 ± 1.6	7.7 ± 1.7	6 ± 0.3	0.044
C-reactive Peptide	13.4 ± 14.4	14.4 ± 16.4	11.6 ± 11.5	0.587
INR	1.03 ± 0.21	1.02 ± 0.22	1.08 ± 0.14	0.148

MCV: Mean corpuscular volume, MPV: Mean platelet volume, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, INR: International normalize ra

In angiography findings, 33(46.5%) patients had <50% stenosis, 10 (14.1%) patients had 50-69% stenosis, 27 (38%) patients had 70-99% stenosis and 1 (1.4%) patient had total occlusion on right carotid artery. Twenty-five (35.2%) patients had <50% stenosis, 7 (9.9%) patients had 50-69%

stenosis, 36 (50.7%) patients had 70-99% stenosis, 1 (1.4%) patient had near-occlusion and 2 (2.8%) patients had total occlusion on left carotid artery. Distribution of levels of stenosis were shown in Figure 1 and 2.

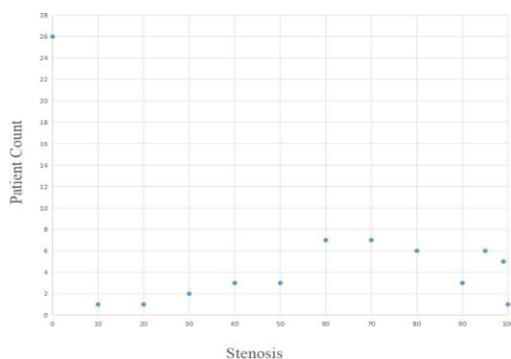


Figure 1. Distribution of levels of stenosis in right ICA

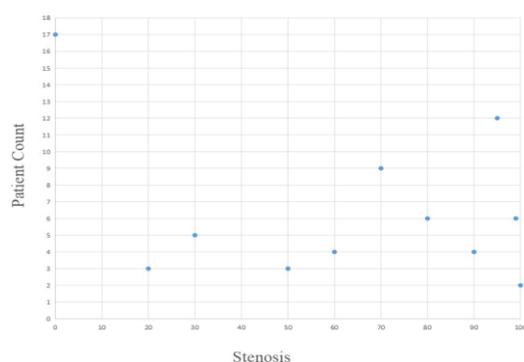


Figure 2. Distribution of levels of stenosis in left ICA

CAS was performed to only right carotid artery in 32 (45.1%) patients, only left carotid artery in 36 (50.7%) patients and bilateral carotid arteries in 3(4.2%) patients. Among the 35 patients who underwent right CAS, 27 (77.1%) patients had 70-99% stenosis, and 8 (22.9%) patients had 50-69% stenosis. Among the 39 patients who underwent left CAS, 35 (89.7%) patients had 70-99% stenosis, and 4 (10.3%) patients had 50-69% stenosis. Balloon angioplasty was applied to 20 (57.1%) patients (16 predilatation, 4 postdilatation) on right carotid artery and to 27 (69.2%) patients (21 predilatation, 3 postdilatation, 3 predilatation and postdilatation). Thirty-nine (54.9%) patients were stented with open-cell stents.

Twenty-one (29.5%) patients had hemodynamic depression during the procedure or within 24 hours after the procedure. Nine (12.7%) patients had bradycardia, 5 (7%) patients had hypotension, and 7 (9.9%) patients had both bradycardia and

hypotension after the procedure. Hemodynamic depression rate was found high in patients stented with open-cell stents and patients with coronary artery disease (CAD) in medical history. We found hemodynamic depression in 17 (43.6%) patients stented with open-cell stents and in 4 (12.5%) patients stented with closed-cell stents. Hemodynamic depression occurred in 12(46.2%) patients with CAD in medical history and 9 (20%) patients without CAD in medical history. Bradycardia recovered after 0.25-1 mg atropine treatment. In multivariable regression analysis, placement of open-cell stents (OR:5.409, 95% CI: 1.591-18.395, p=0.007) and CAD in medical history(OR: 3.429, 95% CI: 1.185-9.917, p=0.023) were found predictors of hemodynamic depression. Hypotension was treated with only intravenous hydration, and any patient didn't need inotrope infusion. Stent thrombosis was seen in 2 (2.8%) patients, and it disappeared after tirofiban infusion. Hyperperfusion syndrome occurred in 2 (2.8%) patients. Two (2.8%) patients had a mild increase in creatine level after the procedure. But these patients didn't need hemodialysis. Two (2.8%) patients had a mild acute ischemic stroke two days after stenting. One(1.4%) of these patients had acute stent occlusion. Any of our patients died in 1 year period after stenting. Complications were shown in Table2.

	Total(%)	Males(%)	Females(%)	p
Bradycardia	16(22.5)	14(23.7)	2(16.7)	0.722
Hypotension	12(16.9)	10(16.9)	2(16.7)	1.000
Stent thrombosis	2(2.8)	2(3.4)	0(0)	
Cerebral Hyperperfusion Syndrome	2(2.8)	1(1.7)	1(8.3)	
Elevated serum creatine level	2(2.8)	2(3.4)	0(0)	
Ischemic stroke	2(2.8)	2(3.4)	0(0)	
Acute stent occlusion	1(1.4)	1(1.7)	0(0)	

DISCUSSION

We evaluated the data of patients treated with CAS. Total ischemic stroke, acute MI, and the mortality rate was 2.8% in 1-year follow-up. In the CAVATAS study, death or ischemic stroke rate was found as 6.4% in patients with CAS (5). In the CREST study, periprocedural ischemic stroke, acute MI, or death rate was found as 5.2% in the CAS group (6). In a meta-analysis evaluating EVA-3S, SPACE, and ICSS studies, Borati et al. found ischemic stroke or death in 8.9% of patients treated with CAS (7). In a meta-analysis of five studies, the periprocedural event rate during CAS was found as 6.2% (8). AHA/ASA guideline suggests that periprocedural death or stroke rates during CAS should be <6% (2). Our periprocedural event rate was found lower than 6%.

Hypotension was seen in 10-42%, and bradycardia was seen in 27-37% of patients in the literature. In a recent study, hypotension and bradycardia rates after CAS within 12 hours were found respectively 28% and 38% (9). Predictors of hemodynamic depression were found as age, asymptomatic stenosis, antihypertensive drug usage, dilatation rate, and stenosis location (on <10mm of the carotid bulb) (9). In another study, having CAD was found as a predictor of hemodynamic depression (10). We found similar hemodynamic depression rates with the literature. Open-cell stents and CAD in medical history were found as predictors of hemodynamic depression. However, there isn't any information about the effect of stent types on hemodynamic depression. In a recent meta-analysis, Texakalidis et al. reported that patients stented with open or closed-cell stents had similar hemodynamic depression after CAS (11).

Cerebral hyperperfusion syndrome is a rare and dangerous complication of CAS. In a review, Moulakakis et al. reported incidence of CHS as 1.16% after carotid artery recanalization (12). In another meta-analysis, the CHS rate was found as 4.6% (13). In a prospective study, Abou-Chebl et al. found CHS rate as 2.9% after CAS. Intracranial atherosclerotic stenosis >90%, severe contralateral

carotid stenosis, and longstanding hypertension were found as three important factors increasing the risk of CHS after CAS (14). Additionally, post-operative SBP over 150 mmHg increases the risk of CHS (15). The most accepted mechanism of CHS is impaired cerebral autoregulation. Cerebral autoregulation maintains the cerebral perfusion in an acceptable range to blood flow and cerebral perfusion pressure changes. In the chronic ischemic brain, arterioles and capillaries are vulnerable to bleeding after CAS due to increased cerebral perfusion pressure (15). In our study, 2.8% of patients had CHS after CAS. These patients were treated with mannitol and glycerol trinitrate infusions.

Acute carotid stent thrombosis (ACST) is a rare complication of CAS that occurs in the first hours and may cause a stroke. ACST rate was found in range from 0.36% to 33% in the literature (16). Antiplatelet non-compliance or resistance, long stenotic lesions, and emergent CAS were found as predictors of ACST (16). Anticoagulants, glycoprotein IIb/IIIa antagonists, and intravenous thrombolytic treatment can be used as medical treatment of ACST (17-18). CEA and mechanic thrombectomy may be required in a patient with neurological deterioration (19). We found the ACST rate as 2.8%, which is compatible with the literature. ACST disappeared after tirofiban infusion in all patients.

We didn't use embolic protection devices (EPD) in our patients. Zahn et al. reported that patients who used EPDs during CAS had lower rates of ipsilateral stroke in the periprocedural period (20). But in two randomized control trials, authors reported that EPDs had no benefit on prognosis (21-22). The same findings were found in the SPACE trial, too (23). Binning et al. reported acute MI in 2% in the perioperative period, and they reported that CAS without EPDs could be performed safely in experienced hands (24).

Our study has some limitations. First of all, it's a retrospective study. Our study was performed in a single center. CAS was compared with CEA in

many studies. But we didn't have a control group.

CONCLUSION

Carotid artery stenosis is an important cause of acute ischemic stroke. Revascularization treatments are important methods for preventing stroke. CAS is a safe and effective method in the treatment of extracranial carotid artery stenosis. Open-cell stents may increase the risk of hemodynamic depression, but the mechanism is unclear. Additionally, CAS without EPD can be performed safely in experienced centers. Further studies will increase our knowledge about CAS and the prevention of complications.

Ethics Committee Approval: This study was approved by Kocaeli Health Sciences University Dince Training and Research Hospital Ethics Committee

Authors' Contributions: All stages of this study were performed by a single author.

Conflict of Interest: None

Fundings: None

Informed Consent: This is a retrospective study.

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