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Outcomes of Carotid Artery Stenting in Elderly Patients: A Single Center Retrospective Study: The Effect of Post-dilatation on Outcomes

Yaşlı Hastalarda Karotid Arter Stent Sonuçları: Tek Merkezi Retrospektif Bir Çalışma: Post-dilatasyonun Sonuçlara Etkisi

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ABSTRACT Objective: Carotid artery stenting (CAS) is a current treatment approach that has been applied in symptomatic and asymptomatic carotid artery stenosis. In addition to being a minimally invasive method, it has fewer complications and mortality rates, and short hospital stays when compared to carotid endarterectomy. Some studies showed that the risk of stroke or death twice as high after CAS than after carotid endarterectomy among those ≥70 years old. In this study, we aimed to investigate the short- and long-term complications, efficacy, and durability of CAS in elderly patients (≥70 years old) with carotid artery stenosis with a median follow-up of 5.08 years (interquartile range 3.2-8.1), respectively. **Material and Methods:** A total of 140 patients who underwent CAS due to atherosclerotic carotid artery stenosis were included in the study. Stroke rates (total n=15[10.7%], n=3[5%] vs n=12[15%], p=0.049) were higher in patients who were ≥70 years of age during the follow-up. The two groups (the group with age <70 and the group with age ≥70) were compared according to demographic, biochemical data, and clinical outcomes such as stroke and stroke/death. **Results:** According to multivariate logistic regression analysis, those who were ≥70 years, those with a history of earlier stroke, and the patients requiring post-dilatation were at risk of recurrent stroke. Deaths occurred in 5 of 140 patients in the follow-up. The patients who were ≥70 years (OR 4.577 [95% CI=1.023-5.544], p=0.043), who have a history of earlier stroke (OR=6.965 [95% CI=1.067-13.115], p=0.038), and those requiring post-dilatation (OR=2.312 [95%CI=1.156-5.775], p=0.022) were at risk of recurrent stroke. Only age ≥70 years (OR=4.577 [95% CI=1.210-17.191], p=0.024) was an important risk factor for death/stroke. **Conclusion:** Although the immediate results of the CAS procedure in patients with age ≥70, were successful, they, especially in those with a history of earlier stroke and those requiring post-dilation, had a higher risk of stroke and the combined endpoint of death/stroke in the follow-up.

Keywords: Carotid arteries; stents; stroke; death

ÖZET Amaç: Karotid arter stentlemesi (KAS), semptomatik ve asemptomatik karotid arter stenozunda uygulanan güncel bir tedavi yaklaşımıdır. Minimal invaziv bir yöntem olmasının yanı sıra, karotis endarterektomi ile karşılaştırıldığında daha az komplikasyon ve mortalite oranına sahiptir ve hastalar hastanede daha kısa kalmaktadır. Bazı çalışmalar, 70 yaş ve üzeri kişilerde inme veya ölüm riskinin karotis endarterektomiye göre KAS sonrası 2 kat daha yüksek olduğunu göstermiştir. Biz ortalama 5,08 yıl (çeyrekler arası aralık 3,2-8,1) takip edilen karotis arter darlığı olan yaşlı hastalarda KAS'ın kısa ve uzun dönem komplikasyonlarını, etkinliğini ve dayanıklılığını araştırmayı amaçladık. **Gereç ve Yöntemler:** Aterosklerotik karotis arter darlığı nedeniyle KAS uygulanan 140 hasta çalışmaya dâhil edildi. Takip sırasında ≥70 yaş olan hastalarda inme oranları (toplam n=15 [%10,7], n=3 [%5] vs n=12 [%15], p=0,049) daha yüksekti. İki grup (70 yaşın altında olan grup ve 70 yaş ve üzerinde olan grup) demografik, biyokimyasal veriler ve ölüm ve ölüm/inme gibi klinik sonuçlara göre karşılaştırıldı. **Bulgular:** Çok değişkenli lojistik regresyon analizine göre, ≥70 yaş ve daha erken inme öyküsü olanlar ve post-dilatasyon balon işlemi yapılanlar tekrarlayan inme riski altındaydı. İzlemdeki 140 hastanın 5'inde ölüm meydana geldi. ≥70 yaşında olan hastalar (göreceli olasılık oranı [GOO]=4,577 [%95 güvenlik aralığı (GA)=1,023-5,544], p=0,043), daha önce inme öyküsü olan hastalar (GOO=6,965 [% 95 GA=1,067-13,115], p=0,038) ve post-dilatasyon gerektirenler (GOO=2,312 [%95 GA=1,156-5,775], p=0,022) tekrarlayan inme riski altındaydı. Sadece 70 yaş ve üzeri (GOO=4,577 [%95 GA=1,210-17,191], p=0,024) ölüm/inme için önemli bir risk faktörüydü. **Sonuç:** Her ne kadar 70 yaş ve üstü olan hastalarda, KAS prosedürünün erken sonuçları başarılı olsa da sonraki yaşam takibinde özellikle post-dilatasyon yapılması gerekenler ve önceden inme hikayesi olanlarda, inme riski ve kombine ölüm/inme sonlanım noktaları daha yüksekti.

Anahtar Kelimeler: Karotis arterleri; stentler; inme; ölüm

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Stroke which can present as hemorrhagic or thromboembolic is a serious cause of morbidity and mortality. It constitutes 30% of all-cause mortality and is associated with a high economic burden.[1,2] Atrial fibrillation, patent foramen ovale, or carotid artery stenosis are the major causative pathologies, of which carotid artery stenosis is responsible for 10-15% of stroke cases.[3]

Treatment may be in the form of medical treatment, carotid endarterectomy, or stent deployment. Guidelines recommend symptomatic patients with the range of 50-99% of carotid artery stenosis, or asymptomatic patients with the range of 60-99% of carotid artery stenosis can be treated with carotid artery endarterectomy or carotid artery stenting (CAS).[3,4] In experienced hands, both procedures are generally quite safe and are recommended with less than 6% risk of stroke and death for symptomatic patients and less than 3% risk of death and stroke for asymptomatic patients together with at least a 5-year life expectancy [3,5]

In 1977, Klaus Mathais performed the first carotid artery angioplasty. The first balloon-expandable stent was developed in 1989 and the distal protection method in 1990, respectively.[6,7] The radial expansion of the first stents was poor, and dissections and thrombi were common. After the development of nitinol stents, a better radial expansion against external compression was achieved. The rates of dissection and thrombus formation also decreased. Due to these improvements, the results of the CAS technique have become comparable to those of endarterectomy.[8]

Predilatation is performed to prepare a stenotic vessel, and post-dilatation is used to minimize residual stenosis after CAS deployment by expanding the stent towards the vessel wall, which might be a risk factor for peri-procedural complications.[9,10] Advanced age has been claimed to be another risk factor for CAS, and a meta-analysis involving 3,433 patients found that elderly patients (aged ≥70 years) had an estimated 120-day risk of stroke or death twice as high after CAS than after carotid endarterectomy.[11] Therefore, we planned to evaluate the results of our patients who underwent CAS considering older age and the result of performing the post-dilatation as the major risk factors for stroke and death.

The primary purpose of this study was to determine the results of CAS both in short and long-term follow up in terms of efficacy and durability. Our secondary goal was to identify the risk factors that may be associated with stroke and death in the follow-up among elderly patients (aged ≥70 years).

MATERIAL AND METHODS

PATIENTS AND STUDY DESIGN

The study population consisted of patients who were referred to our center with the diagnosis of severe carotid artery stenosis, and those who underwent carotid angiography during coronary angiography in our hospital. This retrospective study was conducted after obtaining approval from the local ethics committee (no: 2020.139.06.01; date: 18.06.2020). The study was carried out following the Helsinki Declaration principles.

According to our hospital protocol, after the decision of CAS or carotid endarterectomy was made by a council consisting of cardiology, cardiovascular surgery, and neurology specialists, for all patients before the CAS procedure, the routine carotid Doppler ultrasound and computerized cerebral tomography were performed, and the medication with acetylsalicylic acid and clopidogrel was used. During the CAS procedure, heparin was administered as an initial 7500-U IV bolus and adjusted to maintain the activated clotting time above 270 seconds. The stents of all patients were evaluated by using Doppler 6 months later. The patients were followed up regularly in the neurology outpatient clinic.

The medical records of patients who underwent CAS between April 2012 and April 2018 were retrospectively evaluated. The degree of carotid artery stenosis was determined by at least 3 cardiologists according to the North American Symptomatic Carotid Endarterectomy Trial.[12] In the event of any mismatch, the majority's opinion was accepted. The inter-and intra-observer correlation coefficients of 3 cardiologists' carotid artery stenosis evaluation were ≥0.95.

CAS performed due to non-atherosclerotic conditions such as arteritis or dissection were excluded from the study. We did not perform CAS procedures on patients with chronic renal failure. Patients with a history of ischemic stroke or transient ischemic attack in the past 6 months, fainting, and dizziness were considered symptomatic. Demographic data and cardiovascular risk factors such as age, gender, hypertension, diabetes mellitus, hyperlipidemia, obesity, coronary artery disease (CAD), previous stroke, and smoking, medications used were obtained from the medical records. Laboratory data such as C-reactive protein, creatinine were derived from the hospital database. Since the purpose of our study was to determine the efficacy and safety of the CAS procedure in elderly patients, all patients were divided into two groups as under 70 and above ≥70. The two groups were compared according to demographic, biochemical data, and clinical outcomes.

CLINICAL ENDPOINTS

The primary clinical outcomes in this study were defined as death and stroke. Stroke was considered as focal or diffuse loss of motor or sensory function; or loss of vision in a way of sudden onset that lasted longer than 24 hours.

PROCEDURE

The routine protocol of the CAS procedure was following the published guidelines.[3] After the puncture of the femoral artery by Seldinger method 7or 8 F Judkins right guiding catheters were used to image carotid arteries from lateral and anteroposterior views. In the case of superposition, additional poses were taken from cranial angles. Lesion length, stability, presence of unstable plaque, and degree of stenosis were noted. After taking the baseline reference images of the carotid artery stenosis to be treated, the distal protection device was placed distal to the target lesion (Acculink-Emboshield, Abbott, or Spider FX, Medtronic). Then open-cell and self-expandable stents of suitable size were used for the stenotic lesion of each patient (Acculink-Accunet, Abbott, or Protégé RX, Medtronic). In necessary cases, pre-dilatation (2.0X15 mm balloon) or post-dilation were carried out (5.0x15 mm balloon). The procedure times and the amount of contrast used were noted for each patient.

STATISTICAL ANALYSIS

All variables were analyzed with SPSS statistical program 22.0. Data with normal distributions were presented as mean±standard deviation, and those without normal distribution were given as median (minimum-maximum). Categorical variables were represented as numbers and percentages (%). The degree of carotid artery stenosis was represented as a percentage (%). In the two-group comparisons, the normally distributed and the non-normally distributed variables were compared with the Student t-test and Mann-Whitney U test, respectively. Chi-square test and Fisher test, if necessary, were used for categorical variables. Variables such as age, gender, hypertension, diabetes mellitus, CAD, smoking, stenosis severity, plaque sensitivity, which may be potential risks for death and stroke were included in the univariate and multivariate logistic regression analysis. Results are shown in the odds ratio and 95% confidence interval (CI). The values of less than 0.05 were considered statistically significant.

RESULTS

Of 140 patients included in the study, 77.9% were male, with a mean age of 71±8.7 years. The rates of hypertension, diabetes mellitus, hyperlipidemia, smoking, and CAD were found as 84.3%, 45.7%, 73.6%, 47.1%, and 55% respectively. Of the patients 78.6% were symptomatic before the CAS. The demographic, clinical, and laboratory data of the patients are presented in Table 1. Data related to CAS are shown in Table 2. No complications occurred in patients within the procedure. There was a bilateral carotid artery lesion in 17.6% of cases (n=25).

In 10 patients, a contralateral carotid stent was placed in a separate session. Sixty patients were under the age of 70, and 80 patients were 70 years or older. While smoking was higher in patients under the age of 70, there was no difference in terms of other variables between the two groups. There was no death related to the procedure. Stroke occurred in 3 cases in the group ≥70 age, but there was no statistically significant difference between the two groups. Distal protection uses rates, duration of the procedure, and amount of contrast media used, and

TABLE 1: Demographic, clinical, and biochemical properties of the study groups.

Variables	Total (n=140)	Age <70 (n=60)	Age ≥70 (n=80)	p value
Age, years	71±8.7	63±5.5	77±5	<0.001*
Male gender, n (%)	109 (77.9)	49 (81.7)	60 (75)	0.347†
Hypertension, n (%)	118 (84.3)	50 (83.3)	68 (67.4)	0.789†
Hyperlipidemia, n (%)	103 (73.6)	41 (68.3)	62 (58.7)	0.246†
Smoking, n (%)	66 (47.1)	34 (56.7)	32 (40)	0.049†
Diabetes mellitus, n (%)	64 (45.7)	27 (45)	37 (46.3)	0.883†
Ischemic heart disease, n (%)	77 (55)	37 (61.7)	40 (50)	0.170†
Obesity, n (%)	32 (22.9)	15 (25)	17 (21.3)	0.610†
Earlier stroke, n (%)	43 (30.7)	21 (35)	22 (24.6)	0.341†
Symptomatic, n (%)	110 (78.6)	51 (85)	59 (73.8)	0.108†
C-reactive protein, mg/dL	31 (1-744)	26.5 (1-621)	31 (1-744)	0.681‡
LDL-cholesterol, mg/dL	107 (36-401)	105 (45-340)	108 (36-401)	0.835‡
Hemoglobin, mg/dL	12.8±2.0	12.9±2.2	12.6±0.18	0.304*
Creatinine, mg/dL	0.98±0.5	0.9±0.3	1.0±0.7	0.864*
Pre-operative ACEI-ARB, n (%)	113 (80.7)	48 (80)	65 (81.3)	0.853†
Pre-operative beta-blocker, n (%)	73 (52.1)	29 (48.3)	44 (55)	0.435†
Pre-operative CCB, n (%)	51 (36.4)	18 (30)	33 (41.3)	0.171†
Lesion characteristics				
Contralateral stenosis > 50%, n (%)	25 (17.9)	9 (15)	16 (20)	0.445†
Lesion length, mm	21.3 (14.1-25.8)	21.7 (14.7-23.3)	20.8 (14.1-25.8)	0.879‡
Stenosis degree, (%)	81 (71.2-99.5)	78 (71.2-92.4)	82 (75-99.5)	0.432‡
Plaque unstable, n (%)	68 (48.6)	28 (46.7)	40 (50)	0.696†

†Chi-square test; ‡Mann-Whitney U test; *Student t-test; ACEI-ARB: Angiotensin-converting-enzyme inhibitor/Angiotensin-receptor blocker; LDL: Low-density lipoprotein; CCB: Calcium channel blocker.

the complications of the procedure were similar in the two groups. The rates of pre-dilation and post-dilation were higher in those with the age of ≥70 years compared to those with the age of <70 age (Table 2).

On the ROC analysis, patients were categorized according to the age of ≥70 because the mortality and stroke rates were more significant at the age of ≥70 with a sensitivity of 0.79 and specificity of 0.58 (AUC: 0.679 (CI=0.553-0.805 and p=0.012) (Figure 1).

Our peri-procedural stroke rates (n=3/140) were 2.1%. The peri-procedural success rate was 97.9% in-hospital. Since post-procedural stroke occurred in 2 patients during 0-30 days, the success rate of the procedure was 96.4% in the first month. Death did not occur. Post-procedural stroke rates (total n=15[10.7%], n=3[%5] vs n=12[15%], p=0.049) were higher in patients who were ≥70 years during a median follow-up of 5.08 years (interquartile range 3.2-8.1). Death rates were similar (Table 2). Due to

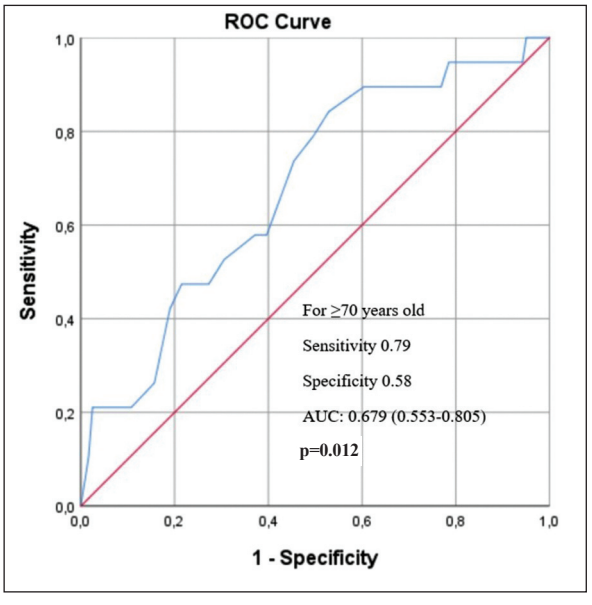

FIGURE 1: Shows the receiver operating characteristic analysis.

significant restenosis, one patient was treated with carotid balloon angioplasty.

TABLE 2: Procedural characteristics according to age category.

Procedural characteristics	Total (n=140)	Age <70 (n=60)	Age ≥70 (n=80)	p value
Stent				
Acculink-Accunet, Abbott, n (%)	59 (42.1)	27 (45)	32 (40)	0.553
Protégé RX, Medtronic, n (%)	81 (57.9)	33 (55)	48 (60)	0.553
Embolic protection device				
Acculink-Emboshield, Abbott, n (%)	87 (62.1)	37 (61.7)	50 (62.5)	0.920
Spider FX, Medtronic, n (%)	53 (37.9)	23 (38.3)	30 (37.5)	0.920
Pre-dilatation, n (%)	30 (21.4)	6 (10)	24 (30)	0.004
Post-dilatation, n (%)	81 (57.9)	29 (48.3)	52 (65)	0.048
Procedure time, minutes, n (%)	23.5±7	23±6	24±8	0.486
Amount of contrast media, mL	148±37	139±39	155±34	0.123
Peri-procedural complications				
Bradycardia/ Hypotension, n (%)	28 (20)	13 (21.7)	15 (18.8)	0.669
Stroke, n (%)	3 (2.1)	0 (0)	3 (3.8)	0.260
Post-procedural complications (0-30 days)				
Prolonged bradycardia/Hypotension, n (%)	4 (2.9)	3 (5)	1 (1.3)	0.210
Hyperperfusion syndrome, n (%)	2 (1.4)	1 (1.7)	1 (1.1)	0.675
Stroke/ Cerebral hemorrhage, n (%)	2 (1.4)	1 (1.7)	1 (1.3)	0.675
Myocardial infarction, n (%)	0	0	0	
Death, n (%)	0	0	0	
Late complications >30 days				
Stroke/ Cerebral hemorrhage, n (%)	15 (10.7)	3 (5)	12 (15)	0.049§
Ipsilateral cerebral lesion, n (%)	8 (5.7)	1 (1.7)	7 (8.8)	0.138§
Myocardial infarction, n (%)	3 (2.1)	2 (3.3)	1 (1.3)	0.576§
Total death, n (%)	5 (3.6)	1 (1.7)	4 (5)	0.285§
Vascular death, n (%)	2	1 (1.7)	1 (1.7)	0.675§

§ Fisher test.

To determine the predictors of death and death/stroke, age ≥70 years, male gender, hypertension, hyperlipidemia, diabetes mellitus, CAD, obesity, previous stroke, presence of ≥70% carotid artery stenosis, and presence of unstable plaque were analyzed in univariate and multivariate logistic regression analysis. According to multivariate logistic regression analysis, those who were ≥70 years (OR=4.577 [95%CI=1.023-5.544], p=0.043), those with a history of earlier stroke (OR=6.965 [95%CI=1.067-13.115], p=0.038), and those requiring post-dilatation (OR=2.312 [95%CI= 1.156-5.775], p=0.022) were at risk of recurrent stroke. Only age ≥70 years (OR=4.577 [95% CI=1.210-17.191], p=0.024) was an important risk factor for death/stroke (Table 3). Deaths occurred in 5 of 140 patients in the long-term follow-up. Two of these patients who suffered prior stroke died due to respiratory aspiration. Two patients died due to acute myocardial infarction. One patient died of prostate cancer. None of the deaths were due to cerebral causes.

DISCUSSION

This study has proved both the long- and short-term efficacy and durability of the CAS in the prevention of stroke. Age ≥70 years, previous stroke, and CAS with post-stenting balloon dilatation were determined as the risk factors associated with recurrent stroke and long-term mortality following CAS procedure. The previous stroke was considered to be a risk factor for recurrent stroke in the long term after CAS. In our series, the perioperative stroke rate was 2.1% which is compatible with the literature recommended being below 3%.[3,5]

The CAS is the preferred method in the severe lesion of the contralateral carotid artery, previous radiation therapy to the neck, bilateral carotid artery stenosis, high bifurcation lesion in or near the head, restenosis after carotid endarterectomy, renal failure, acute coronary syndrome, or comorbid conditions

TABLE 3: Univariate and multivariate logistical regression analysis.

Risk factor	n Total n%		Death +Stroke N	n Non-death and stroke, n	Univariate OR (95% CI) OR (95% Confidence interval)	p value	Multivariate OR (95% CI) OR (95% Confidence interval)	p value
Age ≥70	80	D+S	**19**	61	**4.750 (1.316-17.148)**	0.017	4.577 (1.210-17.191)	**0.024**
		S	15		3.651 (1.029-5.141)	**0.037**	3.475 (1.023-5.544)	**0.043**
Male gender, n (%)	109	D+S	17	92	2.679 (0.584-12.293)	0.205		
		S	13		1.964 (0.419-9.210)	0.392		
Hypertension	118	D+S	17	101	1.683 (0.360-7.865)	0.508		
		S	14		2.827 (0.352-22.679)	0.328		
Hyperlipidemia	103	D+S	15	88	1.329 (0.472-3.740)	0.590		
		S	13	90	2.897 (0.968-8.668)	0.057	2.038 (0.576-7.214)	0.269
Diabetes mellitus	**64**	D+S	**12**	**52**	2.275 (0.837-6.179)	**0.107**	2.751 (0.939-8.062)	0.065
		S		9	1.909 (0.641-5.688)	0.246		
Ischemic heart disease	**77**	D+S	**12**	**55**	**2.353 (0.866-6.393)**	**0.093**	2.456 (0.889-6.768)	0.083
		S	9		1.972 (0.662-5.877)	0.223		
Obesity	**32**	D+S	**1**	**31**	**6.200 (0.794-48.384)**	**0.082**	7.86186 (0.953-64.930)	0.058
		S	1		4.617 (0.583-12.683)	0.147	4.535 (0.554-12.786)	0.159
Earlier stroke	**43**	D+S	**2**	**41**	**4.356 (0.960-19.774)**	**0.057**	4.579 (0.988-21.228)	0.058
		S	2		7.341 (1.034-11.911)	0.034	6.965 (1.067-13.115)	0.038
Stenosis degree >70%	125	D+S	15	110	1.320 (0.355-4.898)	0.679		
		S	12		3.677 (0.462-12.332)	0.219		
Plaque unstable	68	D+S	14	54	1.278 (0.204-6.813)	0.643		
		S	11		1.298 (0.332-5.778)	0.613		
Post-dilatation	81	D+S	5	76	1.876 (0.665-5.765)	0.234		
		S	5	76	**2.112 (1.126-5.304)**	**0.022**	**2.312 (1.156-5.775)**	**0.022**

CI: Confidence interval; D: Death; S: Stroke.

that increase the risk of surgery, such as being over the age of 80, heart failure, and chronic obstructive lung disease.[13,14] As a less invasive procedure compared to carotid endarterectomy, CAS is accepted as a routine and contemporary treatment method.[3,4,14,15] The risk of stroke, myocardial infarction, and cranial nerve paralysis is also less common in the CAS method.[3,4,16] Therefore, it is a safe technique not only in those with symptomatic stenosis but also in older patients with asymptomatic carotid stenosis.[13] Another advantage is that the length of stay in the hospital is less than that of carotid artery endarterectomy.

Our findings are fully compatible with the guidelines. There was no death during the procedure that reveals the importance of the procedure performed by experienced specialists.[5]

Distal protection devices have gradually decreased the embolism rates. Since lower embolism rates have already been reported with distal protection devices, the indication of distal protection devices was changed from 2B to 2A in ESC guidelines.[3] Moreover, an increase in the number of experienced centers is seen as the most important reason that determines the success of the CAS. Another important reason is that the manufacturers make the quality of stents and distal protection devices progressively better.[17] The use of high-profile guiding catheters and delivery systems also increases the risk of air bubble embolism, which we paid attention to avoid. We believe that this partly contributed to better immediate results of our CAS procedures.

Complications related to parasympathetic discharge such as bradycardia, heart block, and moderate-to-severe hypotension may be seen with a rate of 20%-60% following a CAS procedure.[18] Especially prolonged bradycardia and hypotension are more common in patients with severely stenotic calcific lesions.[19,20] In our cases, the rate of hypotension and

bradycardia was 20%. Lower rates of hypotension and bradycardia in our series compared to the literature may be associated with our routine use of prophylactic intravenous atropine before post-dilation balloon. Secondly, continuous blood pressure monitoring and routine isotonic infusion due to the possibility of hemodynamic disturbance that may occur during the procedure. In the case of hypotensive events despite the above precautions, we perform rapid isotonic infusion and inotropic treatment.

Post-dilatation associates with peri-procedural cerebral embolic events; therefore, it should be reserved only in cases with severe residual stenosis after CAS. In our study, we found that post-dilation is an important risk factor for stroke.[9,10]

In the SAPPHIRE study, in which 71% of cases were asymptomatic though high-risk patients for surgical treatment, noninferiority of CAS with distal protection was proven against endarterectomy.[14] Moreover, this study showed that the rates of death and stroke were better in CAS with distal protection compared to that without distal protection. Since distal protection was performed in all our cases, our stroke rates were compatible with the literature.[3,15,21]

In our results, our rate of asymptomatic patients was 31.4%. Our less asymptomatic patient rates were related to our being a referral center. Before 2017, asymptomatic patients were treated with the Class 2B indication; however, our asymptomatic patients were those with silent cerebral ischemia detected by magnetic resonance imaging.[3]

Cerebral hyperperfusion syndrome (CHS) was seen in 2 patients. (1.4%). Both had hypertension and diabetes. Some studies show the incidence of CHS after CAS is about 1% to 3%.[22] Surprisingly, some studies did not find any hypoperfusion case in patients who underwent CAS procedure.[23,24] CHS development is independent of the success of the operation and is related to the patient's risk factors such as decreased cerebral vasoreactivity, contralateral stenosis >70%, post-procedural hypertension, and recent ipsilateral stroke. Sometimes it develops insidiously and cannot be diagnosed correctly. For this reason, we thought that our CHS rate was in parallel with the literature. The pathophysiology is not fully understood. Due to the sudden increase in blood supply to the brain, the blood-brain barrier is disrupted, and cerebral autoregulation is impaired, and cerebral edema occurs.[25] This syndrome can be treated without sequelae if diagnosed early in patients with ipsilateral headache, blurred vision, and confusion.[26] Intensive hemodynamic monitoring, blood pressure control, and assessment of cerebral blood flow should be done to prevent CHS.

CONCLUSION

Internal CAS is a very safe and effective treatment method in the prevention of stroke and treating the symptoms in those with carotid artery stenosis and contraindication to surgery. However, our results suggest that patients who have a history of the previous stroke, who are older than ≥70 years, and who needed balloon post-dilatation after CAS are prone to recurrent stroke in the follow-up despite successful immediate results of CAS.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

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