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ORIGINAL ARTICLE

A SINGLE-CENTER COMPARATIVE STUDY OF ENDARTERECTOMY AND STENTING FOR SYMPTOMATIC CAROTID ARTERY DISEASE: DECISION-MAKING PROCESSES AND EARLY TO MID-TERM OUTCOMES

Abstract

Introduction: Ischemic stroke constitutes a significant burden on global health. Carotid artery atherosclerosis is a significant contributor to the occurrence of ischemic strokes. Both carotid endarterectomy and stenting are viable treatment options for symptomatic carotid artery disease, yet the optimal choice between them remains debated, particularly in elderly patients with multiple comorbidities. This study aims to compare decision-making processes and early to mid-term outcomes between carotid endarterectomy and carotid artery stenting in elderly symptomatic carotid artery disease patients.

Materials and Method: A total of 88 symptomatic carotid artery disease patients (carotid endarterectomy: n=35, mean age: 71.72±7.87 years; carotid artery stenting: n=53, mean age: 70.64±7.46 years) were retrospectively analyzed.

Results: No significant differences were observed in demographic characteristics between carotid endarterectomy and stenting groups. Chronic renal disease was more prevalent in the carotid endarterectomy group. Carotid artery stenting patients had a higher prevalence of 50–69% stenosis and less plaque ulceration. Complication rates were comparable between groups, with longer intensive care and hospitalization durations in the carotid endarterectomy group. Mid-term mortality rates and major complications did not significantly differ between groups.

Conclusion: Both carotid endarterectomy and carotid artery stenting are effective treatments for symptomatic carotid artery disease. Despite differences in lesion characteristics, complication rates were similar between carotid endarterectomy and carotid artery stenting. This study emphasized the efficacy of a full cooperation between the cardiovascular surgery and neurology teams through an in-depth evaluation of each of the patients and the creation of individualized treatment strategies that optimized overall outcomes.

Keywords: Aged; Endarterectomy; Carotid; Carotid Stenosis; Stents.

INTRODUCTION

Stroke, the primary cause of permanent disability and mortality worldwide, predominantly arises from ischemic etiologies, which account for approximately 88% of cases, while hemorrhagic stroke constitutes the remaining 12% (1). Large vessel atherosclerosis, particularly in the extracranial internal carotid artery, is responsible for a considerable number of ischemic stroke cases. Indeed, approximately 20% of all ischemic strokes are caused by carotid artery disease (CAD) and the thromboembolism associated with atherosclerosis (2). The risk of stroke increases as the severity of the stenosis in the carotid arteries increases. Recent studies have found that in asymptomatic patients with 50% carotid artery stenosis, the occurrence of ipsilateral stroke was 4% in five years, while if the stenosis was 70%, the risk was doubled in the same period (3). High-risk patients have an advanced level of stenosis and multiple risk factors, which is why the treatment of stenoses above 50% is clinically important. Age (65 years and older), male gender, smoking, coronary artery disease, hypertension, and hyperlipidemia are the most important clinical risk factors for CAD (4, 5).

Medical treatment, balloon angioplasty, stent placement, and carotid endarterectomy (CEA) surgery are the current treatment options for CAD. Since the provision of medical treatment alone to symptomatic patients does not produce the desired result, surgical treatment has been a focus of interest, and given technological developments in recent decades, carotid artery stent (CAS) placement has become the treatment modality of choice. CAS was first used in the 1980s but has become quite common in recent years. The fact that other surgical treatment options have some known limitations, including wound infection, peripheral nerve injury, challenging anatomical localization, and difficult management of patients with additional comorbidities, has contributed to the popularization of CAS treatment.

Symptomatic carotid disease is defined as focal neurological symptoms that may be associated with atherosclerotic CAD and may include one or more transient ischemic attacks characterized by sudden onset focal neurological dysfunction, transient monocular vision loss, or non-specific neurological symptoms (6). The findings of randomized controlled trials indicate CEA to be a safe and effective treatment method for reducing the risk of ischemic stroke in patients with symptomatic CAD (6, 7). Thus, in recent years, as a result of technological advances, CAS has become a favored technique due to being less invasive than CEA and having fewer negative consequences in high-risk patients. In fact, a number of randomized controlled trials have compared the results of the CAE and CAS procedures in symptomatic CAD patients (8, 9).

Given the widespread prevalence of atherosclerosis in elderly people and the growing population of older adults worldwide, there will clearly be an increasing need for approaches to address carotid artery stenosis among this age group in the coming years. The presence of additional comorbidities, anatomical complexities, higher risk of perioperative complications, and greater frailty among elderly patient populations pose challenges when deciding on the suitability of endarterectomy, while technical difficulties, including lesions that are unsuitable for stenting and vascular access site issues, make it difficult to decide on stent placement. Currently, there is no clear strategy for choosing the best treatment option for elderly patients with symptomatic carotid artery stenosis and multiple comorbidities. However, ischemic stroke is a serious cause of both disability and mortality, especially in older populations, which means that the diagnosis and treatment of carotid stenosis are important for stroke prophylaxis. In this single-center study, we sought to present both our decision-making processes and the short- to medium-term outcomes in elderly patients with symptomatic carotid artery stenosis who underwent CEA and CAS through an approach that emphasizes interdisciplinary collaboration and patient-centric assessment.

MATERIALS AND METHOD

In this study, a total of 88 patients who underwent CAS (n=53) and CEA (n=35) for the treatment of CAD were retrospectively analyzed. All the patients enrolled in this study were symptomatic and were initially assessed using Doppler ultrasonography as the primary diagnostic modality. Afterwards, all the patients underwent evaluation by means of computed tomography (CT) angiography and/or conventional digital subtraction angiography (DSA) to ascertain the degree of stenosis and the anatomical extent of the lesion. The stenosis grade was determined according to the North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria (10). Symptomatic patients with 50–99% stenosis at the internal carotid artery according to the NASCET criteria were included in this study. Patients with totally occluded carotid artery lesions were excluded from this study. The patients' demographic characteristics, including age, gender, comorbid conditions, side and severity of the carotid artery lesion(s), symptom details, diameter and length of the stents, patch types used in endarterectomy, post-procedural complications, and durations of intensive care and hospital stay were obtained from hospital records. The patients' symptoms were classified as amaurosis fugax, dizziness, dysarthria, minor cerebrovascular disease (CVD), and/or major CVD.

The study protocol was approved by the Local Ethics Committee of Selçuk University's Faculty of Medicine (approval date: 30.12.2020; decision number: 2020/570). Prior to the procedure, every patient completed a written informed consent form. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki.

Decision-making process

Our decision-making process regarding CEA and CAS, which emphasized interdisciplinary collaboration and patient-centric assessment, proceeded as follows. After each patient's DSA procedure, the invasive neurologist extended an invitation to the surgeon to join them in the angiography unit. In the meeting held in the angiography unit, the

Table 1. Potential challenges from both the surgeon's and interventionalist's perspectives when considering the optimal treatment strategy for the patient during the council.

Surgeon's perspective		Interventionalist's perspective	
Anatomical challenges: exposure problems	Lesion extending very distally High carotid bifurcation Spinal immobility of the neck Short neck	**Aortic arch problems**	Arch anomalies (including bovine arch) Tortuosity Aortic arch atheroma Angulated takeoffs from the arcus
Perioperative anesthesia issues	Poor general condition Recent major stroke Hemodynamic instability Severe pulmonary disease Cardiac problems	**Factors with carotid artery**	Tortuosity, elongation Angulation Severe calcification Long segment lesion Plaque with thrombus
Multiple comorbidities		Renal insufficiency	
Surgical difficulties	Prior neck surgery Neck radiotherapy Tracheostomy	**Femoral access issues**	Peripheral artery disease Leriche syndrome Iliac tortuosity
Hyperperfusion syndrome			
Distal embolism and procedure-related stroke			

patient's age, symptoms, comorbid conditions, carotid lesion characteristics (degree of stenosis, angulation, calcification, ulceration), arcus aorta anatomy, and contralateral carotid lesion were considered to make the best decision for the patient. The decision-making factors concerning surgery or stent implantation are summarized in Table 1. The table outlines the probable challenges that the surgeon and the interventional neurologist may encounter throughout the decision-making process, as considered from both their perspectives. A consensus-based decision was reached after the surgical and interventional teams had presented their arguments during the meeting. If stenting was decided upon, the procedure was performed during the same session, whereas if surgery was chosen, the procedure was completed within 3–5 days.

Carotid artery stenting procedure

CAS placement was performed in all patients for whom it was considered appropriate via the right common femoral artery. First, angiography of the arcus was performed and the aortic anatomy was determined. Bilateral selective carotid angiography and selective cerebral angiography were performed. Embolic protection devices (EPDs) were not routinely used. The positioning of the stent was adjusted immediately after passing the carotid artery lesion with the appropriate guide wire. Next, the stent was placed, and if required, balloon dilation was performed. Finally, control angiography images were obtained for both the carotid stent and the distal vascular area. Antiplatelet drugs, which were started prior to the procedure, were continued after the CAS placement for 1–3 months. Following this period, monotherapy was continued.

Surgical technique

CEA was performed under general or local anesthesia. Following the neck incision, the common carotid, external carotid, and internal carotid arteries were explored. The patient was then heparinized and vascular clamps were applied. Then, longitudinal arteriotomy was performed below the carotid bifurcation level, and the incision was extended both proximally and distally. The plaque inside the carotid artery was carefully separated and removed. Fixing sutures were placed at both the proximal and distal ends of the endarterectomy level to stabilize the incision line of the plaque and prevent any possible dissections that may have occurred after the flow was restored. Following the CEA procedure, the arteriotomy was repaired by means of patch angioplasty. The preferred choice of patch material was an autologous saphenous vein, but if that was not available, an expanded polytetrafluoroethylene (ePTFE) was used instead. Due to the slightly aneurysmatic character of the carotid artery, a patch was not applied in one patient included in this study. Finally, the vascular clamps were removed in the appropriate order and the blood flow was restored.

Statistical analysis

All the analyses in this study were performed using SPSS 22.0 (SPSS, Chicago, IL). The normal distribution of the variables was examined using the Kolmogorov-Smirnov test. Continuous variables with a normal distribution were presented as the mean ± standard deviation. Continuous variables that did not conform to a normal distribution were presented as the median (minimum–maximum). Categorical variables were expressed as the number and percentage. Independent groups with normally distributed continuous variables were compared using Student's t-test, while non-normally distributed variables were compared using the Mann-Whitney U test. Categorical variables were compared using the chi-square or Fisher's exact test. A p-value less than 0.05 was considered statistically significant.

RESULTS

The demographic characteristics of the 88 patients (mean age: 71.72±7.87 years) included in this study are presented in Table 2. The patients were divided into two groups: the CEA group (n=35, mean age: 71.72±7.87 years) and the CAS group (n=53, mean age: 70.64±7.46 years). There were no statistically significant differences between the CEA and CAS groups in terms of the patients' age, gender, concomitant hypertension, hyperlipidemia, diabetes

Table 2. Demographic data regarding the study population, endarterectomy, and stent groups and comparisons are given

		All patients (n=88)	Endarterectomy group (n=35)	Stent group (n=53)	p value
Age (year)		71.72±7.87	73.34±8.29	70.64±7.46	0.11
Gender	Male	61 (69.3%)	25 (71.4%)	36 (67.9%)	0.91
	Female	27 (30.7%)	10 (28.6%)	17 (32.1%)	
Hypertension		78 (88.6%)	33 (94.3%)	45 (84.9%)	0.30
Hyperlipidemia		41 (46.6%)	17 (48.6%)	24 (45.3%)	0.93
Diabetes mellitus		33 (37.5%)	13 (37.1%)	20 (37.7%)	1.00
Coronary artery disease		44 (50%)	18 (51.4%)	26 (49.1%)	1.00
COPD		27 (30.7%)	12 (34.3%)	15 (28.3%)	0.72
Chronic renal disease		9 (10.2%)	7 (20%)	2 (3.8%)	**0.026**
Active smoking		37 (42%)	18 (51.4%)	19 (35.8%)	0.22
Symptoms	Amaurosis fugax	7 (8%)	4 (11.4%)	3 (5.7%)	0.45
	Dizziness	22 (25%)	9 (25.7%)	13 (24.5%)	
	Dysarthria	4 (4.5%)	3 (8.6%)	1 (1.9%)	
	Minor CVD	37 (42%)	12 (34.3%)	25 (47.2%)	
	Major CVD	18 (20.5%)	7 (20%)	11 (20.8%)	
Imaging methods	CT Angiography	73 (83%)	26 (74.3%)	47 (88.7%)	0.14
	DSA	86 (97.7%)	33 (94.3%)	53 (100%)	0.15
Aortic arch type	I	34 (38.6%)	11 (31.4%)	23 (43.4%)	**0.03**
	II	38 (43.2%)	13 (37.1%)	25 (47.2%)	
	III	16 (18.2%)	11 (31.4%)	5 (9.4%)	
Bovine arch		11 (12.5%)	5 (14.3%)	6 (11.3%)	0.75
Lesion side	Right	37 (42%)	12 (34.3%)	25 (47.2%)	0.35
	Left	32 (36.4%)	13 (37.1%)	19 (35.8%)	
	Bilateral	19 (21.6%)	10 (28.6%)	9 (17%)	
Degree of stenosis, %*		79.99±15.18	82.74±13.35	78.17±16.14	0.15
Lesion grade	50-69%	21 (23.9%)	3 (8.6%)	18 (34%)	**0.008**
	70-89%	28 (31.8%)	16 (45.7%)	12 (22.6%)	
	≥90%	39 (44.3%)	16 (45.7%)	23 (43.4%)	
Plaque ulceration		33 (37.5%)	20 (57.1%)	13 (24.5%)	**0.004**
Contralateral carotid	>%50 stenosis	11 (12.5%)	8 (22.9%)	3 (5.7%)	0.06
	Total occlusion	8 (9.1%)	2 (5.7%)	6 (11.3%)	

COPD: Chronic obstructive pulmonary disease, CT: Computed tomographic, CVD: Cerebrovascular disease, DSA: Digital subtraction angiography *Based on North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria

mellitus, coronary artery disease, chronic obstructive pulmonary disease, active smoking, symptom characteristics, preoperative imaging modality, side and degree of the carotid artery lesion, and contralateral carotid lesion (p=0.11, p=0.91, p=0.30, p=0.93, p=1.00, p=1.00, p=0.72, p=0.22, p=0.45, p=0.14, p=0.15, p=0.35, p=0.15, and p=0.06, respectively). However, chronic renal disease was found to be significantly elevated in the patients who underwent CAE (n=7, 20%) when compared with the patients who underwent CAS (n=2, 3.8%) (p=0.026). The prevalence of a type III aortic arch was also higher in the CEA group when compared with the CAS group (p=0.03). The lesion grade distribution significantly varied between the two groups (p=0.008), with the CAS group having a higher prevalence of stenosis in the 50–69% range. Moreover, the plaque ulceration exhibited a statistically significant increase in the CEA group (p=0.004).

The characteristics of the CEA and CAS procedures are provided in Table 3. The mean proximal diameter of the stents used in the CAS

Table 3. Procedural and post-procedural data are provided for CEA and CAS groups

		Endarterectomy group (n=35)	Stent group (n=53)	p value
Stent size	Proximal diameter (mm)	-	8.96±0.92	-
	Distal diameter (mm)	-	6.79±0.88	
	Length (mm)	-	36.6±4.78	
Type of anesthesia	General	31 (88.6%)	-	-
	Local	4 (11.4%)	-	
Localization of endarterectomy	Isolated ICA	7 (20%)	-	-
	ICA+CCA	28 (80%)	-	
Side of procedure	Right	18 (51.4%)	26 (49.1%)	1.00
	Left	17 (48.6%)	27 (50.9%)	
Type of patch	Saphenous vein	30 (85.7%)	-	-
	ePTFE	4 (11.4%)	-	
	No patch	1 (2.9%)	-	
Shunt usage		4 (11.4%)	-	-
X-clamp time (min.)		20.69±6.53	-	-
Complications	Death	-	3 (5.7%)	0.36
	Myocardial infarction	1 (2.9%)	1 (1.9%)	
	Minor CVD	1 (2.9%)	3 (5.7%)	
	Intracranial hemorrhage	-	2 (3.8%)	
	Hyperperfusion syndrome	2 (5.9%)	7 (13.2%)	
	Postoperative bleeding	2 (5.9%)	-	
	Hypoglossal nerve injury	2 (5.9%)	-	
Intensive care unit duration (day)		1 (1-57)	1 (0-9)	**<0.001**
Hospitalization duration (day)		4 (2-90)	3 (2-27)	**<0.001**

CCA: Common carotid artery, ECA: External carotid artery, ePTFE: Expanded polytetrafluoroethylene, ICA: Internal carotid artery, CVD: Cerebrovascular disease

procedure was 8.96±0.92 mm, while the mean distal diameter was 6.79±0.88 mm and the mean length was 36.6±4.78 mm. The mean X-clamp time for the CEA procedure was 20.69±6.53 minutes. There was no statistically significant difference between the CEA and CAS groups in terms of the complications seen after the procedures (p=0.36). Two patients (5.9%) in the CEA group required surgical revision on the first postoperative day due to local hematoma. The durations of the intensive care and hospitalization periods were found to be statistically significantly longer in the CEA group when compared with the CAS group (p<0.001). There was no procedural mortality or myocardial infarction in either group. However, in the CAS group, three deaths (5.7%) and one myocardial infarction (1.9%) occurred during the intensive care unit follow-up after the procedure, whereas one myocardial infarction (1.9%) was observed in the CEA group following the operation.

The median follow-up period was 28.83 (range 0–61) months. Within this follow-up period, two patients in the CAS group required reintervention due to restenosis. Additionally, CVD occurred in three patients in the CEA group and five patients in the CAS group during the follow-up period. These events were not attributed to the vessel that previously underwent intervention; rather, they were associated with either the contralateral side or embolism of cardiac origin. At our mid-term follow-up, the mortality rates were found to be comparable between the CAS and CEA groups, with 34 patients (64.2%) in the CAS group and 23 patients (65.7%) in the CEA group experiencing death (p=0.88). The leading causes of death were cardiac and pulmonary issues, while cancer, general debility, infection, diabetes complications, and renal and hepatic failure were among the other contributing factors.

In the subgroup analyses of patients below and above 75 years of age, no significant difference was observed between the CEA and CAS groups regarding the major cumulative complications, including permanent disability and death.

DISCUSSION

CEA and CAS are two effective treatment modalities for the management of symptomatic CAD. Although endovascular treatments have made significant progress in recent years, the easy accessibility of the cervical carotid artery and the low risk of complications associated with the surgery have resulted in the continued preference for surgical approaches as the primary treatment modalities.

When considering the suitability of CEA for a patient, the surgeon must conduct a comprehensive evaluation that encompasses various dimensions. This entails more than merely executing the CEA procedure, as it necessitates a holistic assessment of both the patient and the pathology. Factors such as the presence of multiple comorbidities, anatomical complexities, anesthetic challenges, and other potential surgical intricacies must all be carefully considered. With the aging population and the increasing prominence of geriatric patients worldwide, healthcare professionals are increasingly encountering individuals who present with such complexities. However, there appears to be a paradigm shift favoring stent placement in the management of symptomatic CAD, as CAS is less invasive and is now commonly performed in numerous centers. While guidelines offer extensive information on the topic, it is prudent to approach real-life situations based on the principle that "there is no disease, there is only the patient." This is because each patient presents with a multitude of unique conditions beyond CAD. Therefore, during the patient evaluation, both the surgeon and the neurologist must strive to make the optimal decision by considering the factors outlined in Table 1 and beyond. In this study, no attempt was made to demonstrate the superiority of one procedure over the other; rather, it was recognized that both procedures may be more appropriate, depending

on the individual patient and their specific situation. Instead, this study highlighted the achievement of comprehensive collaboration between the neurology and cardiovascular surgery teams by meticulously evaluating each patient and devising a treatment plan that was tailored to optimize the outcomes in all aspects.

The CEA and CAS groups were similar in terms of the patients' demographic characteristics, comorbidities, and symptoms, although patients with chronic kidney disease were statistically more prevalent in the CEA group. This trend may have arisen due to a preference for surgery, potentially influenced by patients with chronic kidney disease opting to avoid additional contrast agent use during the procedure. While contralateral carotid stenosis or occlusion may influence the decision-making process regarding stenting or surgery due to perceived impacts on procedural outcomes, our patient cohort exhibited comparable occurrences between the two groups (p=0.06). Additionally, the study by Deser et al. similarly suggests that the presence of contralateral severe internal carotid artery stenosis does not elevate the risk of postoperative stroke, mortality rates, or blood pressure fluctuations (11).

Table 1 outlines the factors that present challenges from both the surgeon's and the interventionalist's perspectives when determining the optimal treatment strategy for a patient. Aortic arch issues represent significant limiting factors for CAS because the aortic arch is an important cause of cerebral embolization during both diagnostic and interventional procedures involving supra-aortic vessels (12). The presence of a complex aortic arch anatomy, such as a type III arch or bovine arch, can render CAS more challenging and increase the likelihood of neurological problems when using the femoral access route (12-14). Indeed, in our study, a statistically significant difference was found between the CEA and CAS groups in terms of the aortic arch structure. More specifically, a type III arch was observed more frequently in the CEA group. We suggest that the preference for surgery in patients with a type III arch may stem from concerns about the risk of cerebral embolization attributed to the existing anatomy, as discussed during the decision-making meetings. Still, the lesion severity and plaque morphology also play crucial roles when deciding between stenting and surgery. In our cohort, patients with greater levels of stenosis and ulcerated plaque tended to undergo CEA.

Two different methods can be used in CEA—namely, conventional and eversion endarterectomy. When applying the conventional technique, following the longitudinal arteriotomy of the internal carotid artery, endarterectomy is performed and the arteriotomy is repaired or patch angioplasty is performed. The patch angioplasty technique is most commonly applied and has been demonstrated to offer better results in some studies (15, 16). When applying the eversion technique, after the internal carotid artery is obliquely transected from its origin, the artery is turned inside out, plaque excision is performed, and the internal carotid artery is reimplanted into the bulbus. Additionally, various modifications to the eversion method have been described and found to offer satisfactory results (17). Several studies have reported that both the conventional method and the eversion method are associated with similar efficacy and reliability (18-20). All the patients enrolled in our study underwent longitudinal arteriotomy followed by conventional endarterectomy. Patch angioplasty was utilized for the arteriotomy repair in all the patients except one, where the primary repair approach was chosen due to the mildly aneurysmal artery structure.

Another key point that should be emphasized procedurally in terms of CAS is the usage of a distal EPD. The use of EPDs has been limited in the initial studies concerning CAS. In accordance with this situation, an EPD was not used in the CAVATAS trial, where higher rates of stroke and restenosis were

found after eight years of follow-up and only 26% of patients were treated with stent implantation (21). By contrast, as a combined primary endpoint, an EPD was used in every technically feasible case in the CREST study, where no significant difference was found between CAS and CEA with regard to myocardial infarction, stroke, 30-day mortality, and ipsilateral stroke in the first four days (22). In our study, the utilization of EPDs was not favored.

In the vast majority of randomized controlled trials conducted in the last decade to compare CAS and CEA, the results obtained using the two methods have largely been consistent. Among these trials, the CEA results were found to be better when compared with the CAS results in the EVA-3S study, which was one of the first studies in this area where the use of more sophisticated devices was limited (23). Although the CAVATAS study did not have sufficient power for the evaluation of the efficacy and reliability, the SAPPHIRE, CREST, and ICSS studies met the non-inferiority criteria for CAS when compared with CEA, while very similar results were also obtained in the SPACE study (8, 9, 22, 24). When sub-group analyses of these studies were analyzed to facilitate patient selection, it was noteworthy that while the same results were obtained in general terms, myocardial infarction was more common in patients who underwent CEA and stroke was more common in patients who underwent CAS. The greater occurrence of myocardial infarction during CEA has been linked to the emotional stress created by the surgery for the patient, as well as to possible alterations in the antiplatelet treatment regimen, whereas the higher incidence of stroke in CAS has been attributed to the patients' more advanced age. In our study, no difference was detected between the two groups in terms of the complications, including myocardial infarction and stroke, during the hospital stay.

Interestingly, in this study, CAS, which represents a less invasive technique for patients over 70 years of age, was significantly associated with an increased incidence of stroke when compared with CEA. It has previously been stated that this situation might be primarily due to the increased vascular tortuosity that occurs with advancing age. The subgroup analysis in the NASCET study revealed that patients aged 75 years and older, and with 50–99% stenosis, experienced greater benefits following CEA when compared with younger individuals (25). However, our subgroup analyses of patients aged below and over 75 years old did not reveal any significant difference between the CEA and CAS groups when it came to the major cumulative complications. We suggest that the lack of significant findings in our subgroup analyses may be attributed to the limited sample size, which potentially constrained our ability to conduct robust subgroup evaluations.

Despite the limited patient population, there was no significant difference between the two groups in terms of the patients' demographic data, post-procedural complications, and mid-term outcomes, indicating that the two treatment approaches were used successfully in the appropriate patient groups in our study. Advancements in stent technology and the use of sophisticated materials may alter treatment choices in the future, although surgery will retain its indispensable role. Large randomized prospective trials are still required to determine the most appropriate treatment, particularly for asymptomatic individuals, including symptomatic patients.

Conflict of Interest: The authors state that the study was conducted without any commercial or financial relationships that could be seen as a potential conflict of interest.

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