

Impact of Carotid Artery Angioplasty in Symptomatic vs. Asymptomatic Carotid Artery Disease

Karar Nadhum Obaid Aljabry^{1*} , Mohammed Radhi Radeef Al-Dulaimi² , Samir Taha Abeid³, Ali A. Al-Fahham⁴ 

¹Internal Medicine Department, Najaf Cardiac Centre, Medicine College, University of Kufa, Najaf, Iraq.

²Euphrate Neuroscience Center, College of Medicine, University of Kufa, Najaf, Iraq.

³Najaf Cardiac Centre, Medicine College, University of Kufa, Najaf, Iraq.

⁴Faculty of Nursing, University of Kufa, Najaf, Iraq.

*Correspondence to: Karar Nadhum Obaid Aljabry (E-mail: karar.n.ubaid@gmail.com)

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Abstract

Objective: To compare the procedural success as well as periprocedural complications and short-term clinical outcomes on CAS in symptomatic versus asymptomatic patients who have severe carotid artery stenosis.

Methods: This study is an observational, single center, prospective cohort study of 250 patients with a mean age of 74 ± 7.2 years who underwent CAS from 2018 to 2024 in a tertiary cardiovascular center, classified into two groups: symptomatic ($n = 146$), and asymptomatic ($n = 104$). Technical success, early complications within thirty days, restenosis, late stroke, and six-month event-free survival were analyzed.

Results: There was technical success achieved in about 98.3% of the population under study ($n = 246$), while major stroke of early onset was recorded at about 1.6%. Minor stroke/TIA was recorded at about 4.8% percent with a higher percentage among the symptomatic. There were no myocardial infarctions. More than 50% restenosis at 6 months follow-up was noted in 6.8% with an event-free survival of 90%, better for asymptomatic patients (96% vs. 85.6%).

Conclusion: CAS produces a safe and efficient method of revascularization in the management of symptomatic and asymptomatic carotid artery stenoses with high technical success and low complication rates. Short-term results were better in asymptomatic patients; therefore, patient selection and risk stratification are very important when making decisions clinically.

Keywords: Angioplasty, carotid arteries, stroke, atherosclerosis

Introduction

Stroke is one of the leading causes of disability and death globally, with ischemic strokes accounting for more than 85% of all cases.¹ Carotid artery stenosis causes 10–20% of ischemic strokes, especially in elderly individuals who have atherosclerotic risk factors such as hypertension, diabetes, dyslipidemia, and smoking.^{2,3} Effective treatment of disease of the carotid arteries is essential to reduce stroke mortality and morbidity. In the past, carotid endarterectomy (CEA) has served as the primary treatment for significant carotid stenosis, particularly in symptomatic patients. Landmark randomized controlled trials, such as the North Americans with Symptom Carotid Endarterectomy Trial (NASCET) and the European Carotid Surgical Trial (ECST), reveal that CEA reduces stroke risk by roughly 50% in patients with symptomatic stenosis $\geq 70\%$.^{4,5} In asymptomatic patients, trials like the Asymptomatic Carotid Atherosclerosis Study (ACAS) and the Asymptomatic Carotid Surgery Trial (ACST) have shown that CEA has some advantages over medical therapy alone.^{6,7}

Despite its success, CEA can cause cranial nerve injury, myocardial infarction, and perioperative stroke, particularly in elderly or high-risk patients.⁸ This spurred the creation of carotid artery stenting (CAS), a less invasive procedure. CAS has several benefits, including local anesthesia, shorter hospital stays, and the avoidance of general anesthesia-related problems.^{9,10} However, preliminary findings revealed that CAS elevated periprocedural stroke rates, particularly in symptomatic patients with unstable plaques.^{11,12}

Several large randomized controlled trials have compared CAS to CEA. The CREST study revealed no significant variations in the overall endpoint of stroke, myocardial infarction, or death, while CAS had more small strokes and CEA had more myocardial infarctions.¹³ Similarly, the International Carotid Stenting Study (ICSS) and the Stent-Protected Angioplasty versus Carotid Endarterectomy (SPACE) studies reported similar long-term outcomes but raised concerns about periprocedural risks with CAS in symptomatic patients.^{14,15} Meta-analyses supported similar findings, stressing the importance of patient selection and operator competence.^{16,17}

Developments in embolic protection devices, stent technology, and operator competency have improved CAS safety profiles, with new registry data suggesting that selected patients attained results comparable to CEA.^{18,19} However, the optimum therapy for asymptomatic carotid stenosis remains controversial due to developments in medical care, such as statins, antihypertensives, and antiplatelet medicines, which have lowered the natural stroke risk.^{20,21}

Current guidelines propose CAS as an alternative to CEA in symptomatic patients at high surgical risk, as well as in asymptomatic patients with adequate anatomy and little procedural risk.^{22,23} Nonetheless, comprehensive risk categorization is essential to weigh the benefits and risks of revascularization in both categories.

This research assesses the efficacy and safety of CAS in a real-world population of symptomatic and asymptomatic patients, with a focus on mechanical success, early and late complications, restenosis, and short-term clinical results.

These findings add to the ongoing discussion over carotid revascularization treatment in the current day and age.

Methods and Materials

Study Design and Population

This was a prospective, observational, single center, cohort study carried out in a tertiary cardiovascular facility between (2018–2024). 250 patients with severe carotid artery stenosis ($\geq 70\%$ by NASCET criteria for symptomatic and $\geq 80\%$ for asymptomatic) underwent carotid artery stenting (CAS). Patients were divided into two groups depending on their clinical presentation: symptomatic ($n = 146$) and asymptomatic ($n = 104$). Symptomatic status was defined as having had a transient ischemic attack (TIA), amaurosis fugax, or ischemic stroke within the previous 6 months in the region fed by the afflicted carotid artery. Asymptomatic patients did not have such a history.

Inclusion Criteria

- Age ≥ 60 years.
- Carotid artery stenosis of $\geq 70\%$ in symptomatic individuals and $\geq 80\%$ in asymptomatic patients.
- Proper vascular architecture for CAS.
- Life expectancy exceeds one year.
- Ability to provide informed consent.

Exclusion Criteria

- Complete blockage of the target carotid artery.
- Had intracranial hemorrhage in the last 6 months.
- Severe allergy to contrast media.
- Contraindications for dual antiplatelet treatment.
- Current intracranial pathology (e.g., arteriovenous malformation or tumor).

Pre-procedural Evaluation

All patients had a clinical neurological examination, carotid Doppler ultrasonography, CT angiography (CTA) or MR angiography (MRA), and echocardiogram. Prior to the operation, patients were given dual antiplatelet treatment.

Procedural Technique

Local anesthetic was used for the procedures; systemic heparin anticoagulation and the regular use of embolic protection devices were utilized. Self-expanding carotid stents

were implanted according to established interventional methods.

Post-procedure Care and Follow-up

Patients had clinical assessment and carotid Doppler examination after the surgery to determine complications and restenosis at 1, 3, and 6 months.

End Points of the Study

The primary outcomes were technical success and periprocedural complications. Secondary outcomes included restenosis, late stroke, and event-free survival.

Statistical Analysis

The data were analyzed with SPSS version [IBM SPSS Statistics version 25]. Continuous data were reported as mean $\pm$ SD, and categorical variables as percentages. Chi-square and *t*-tests were used for comparative analysis. The significance level was chosen at $P < 0.05$.

Ethical Approval

Ethical approval was granted by local health directorate/Al-Najaf cardiac center with reference number MEC – 202. The study was explained to patient and informed consents were obtained. The study does not affect the standard of care in CAS.

Results

Tables 1 and 2 presents demographic and clinical risk factors in 250 patients, of which 146 were categorized under the symptomatic group and another 104 as the asymptomatic group. Mean age was found to be slightly higher among the symptomatic group (75 ± 6.8 years) compared to their counterparts in the asymptomatic group (73 ± 7.6 years). Males were preponderant in both groups with a higher percentage in symptomatic patients, i.e., about 85.7% compared to the percentage of males in that of asymptomatic, i.e., 76%. The most common comorbidity overall was hypertension which accounted for about 70%, more frequent among the symptomatic than the asymptomatic—74% vs. 64%. Similarly, diabetes mellitus (48.6% vs. 44%), dyslipidemia (57% vs. 52%), and coronary artery disease (34% vs. 24%) were slightly more prevalent among those who are symptomatic than those who are not. A much interesting finding would be an apparently large difference in smoking history between these two groups standing at about 43% and only approximately 28%, respectively.

Table 1. Demographic and risk factors of patients with carotid artery disease

Characteristic	Symptomatic ($n = 146$)	Asymptomatic ($n = 104$)	P-value	95% CI for difference (%)
Male sex	125 (85.7%)	79 (76%)	0.08	−0.01 to 0.20
Female sex	21 (14.3%)	25 (24%)	0.08	−0.20 to 0.01
Hypertension	108 (74%)	67 (64%)	0.10	−0.01 to 0.21
Diabetes mellitus	71 (48.6%)	46 (44%)	0.48	−0.09 to 0.17
Dyslipidemia	83 (57%)	55 (52%)	0.46	−0.10 to 0.20
Smoking history	63 (43%)	29 (28%)	0.03*	0.01 to 0.27
Coronary artery disease	50 (34%)	25 (24%)	0.09	−0.01 to 0.21
Age, mean $\pm$ SD (years)	75 ± 6.8	73 ± 7.6	0.08	−0.4 to 4.4

*: P-value less than 0.05 is significant.

Table 3 presents the lesion and disease characteristics of patients with carotid artery disease comparing those who are symptomatic to those who are asymptomatic. Unilateral disease was more common in the asymptomatic group at 76% compared to 57% of their symptomatic counterparts while bilateral disease was much higher among the symptomatic counterparts at 43% versus 24%. This speaks volumes about the burden of the disease. Average percentage stenosis on the treated side was more among the symptomatic group (82%) when compared with that among their asymptomatic counterparts (74%) hence suggesting greater degree of arterial narrowing. Plaque ulceration detected by carotid doppler was also noted more among the symptomatic group (31%) against a mere 12% from their asymptomatic counterparts which further validates its role in symptomatology. In this intervention, embolic protection devices were used in most cases across both groups—91% in the symptomatic and 92% in their asymptomatic counterparts reflecting consistency as a precaution during interventions—the data seem to indicate that the carotid artery disease has much more extensive and advanced pathology.

Table 4 reveal that the technical success rate was 97.3% among symptomatic patients, 100% among asymptomatic patients, and an overall technical success rate of 98.3%. **Table 4**

shows a summary of procedural and early clinical outcomes in all treated patients with carotid artery disease by group: symptomatic ($n = 146$) and asymptomatic ($n = 104$). In the symptomatic group, major stroke accounted for 2.7%, minor stroke or TIA for 5.5%, deaths for 2.7%, and in the asymptomatic group, only minor stroke or TIA was observed accounting for 3.8% with no major strokes or deaths observed. No case of myocardial infarction was observed in any of the groups. Hospitalization extending more than three days was evidently more common in the symptomatic group at a rate of about 13.7% compared to about half that percentage in the asymptomatic group at a rate of about 7.7%. It further justifies that while interventions are relatively safe and effective, early complications are somewhat more pronounced in the symptomatic group with longer hospitalization.

Asymptomatic patients had a better short-term prognosis with 96.2% survival compared to 85.6% in the symptomatic group at six months follow-up, hence validating the same trend and results reflected through less morbidity of events in **Table 5** at six months follow-up. Greater than 50% restenosis was noted more frequently in the symptomatic group (8.9%) compared to the asymptomatic group (4%). Late stroke as well as reintervention were seen only in the symptomatic group, accounting for 2.8% individually. Dual antiplatelet therapy adherence was recorded at a high percentage in both groups: 91% for the symptomatic group and 92% for the asymptomatic group, reflecting overall good compliance within this cohort. This, therefore, presents fair mid-term outcomes with higher risks that tilt towards events on becoming symptomatic.

Discussion

Carotid artery stenting (CAS) has emerged as a feasible and less invasive approach for carotid revascularization, particularly in patients at high risk for surgery. In this 250-patient research, we obtained a technical success rate of 98.3%, consistent with rates published in previous multicenter registries and studies.^{24,25}

Table 2. Logistic regression analysis for predictors of adverse outcomes

Variable	B (Coefficient)	SE	OR (95% CI)	P-value
Age (years)	0.05	0.04	1.05 (0.97–1.13)	0.23
Diabetes mellitus (Yes)	0.42	0.61	1.52 (0.44–5.27)	0.38
Hypertension (Yes)	0.35	0.57	1.42 (0.45–4.45)	0.54
Smoking (Yes)	0.80	0.69	2.22 (0.57–8.65)	0.24
Baseline stenosis (%)	0.08	0.04	1.08 (1.00–1.16)	0.05*

*: P-value less than 0.05 is significant.

Table 3. Lesion and disease characteristics of patients with carotid artery disease

Variable	Total ($n = 250$)	Symptomatic ($n = 146$)	Asymptomatic ($n = 104$)	P-value	95% CI for difference (%)
Unilateral disease	162 (65%)	83 (57%)	79 (76%)	0.002*	0.08 to 0.28
Bilateral disease	88 (35%)	63 (43%)	25 (24%)	0.002*	0.08 to 0.28
Mean stenosis % (treated side)	78%	74%	82%	0.001*	3% to 12%
Plaque ulceration on imaging	58 (23.3%)	45 (31%)	13 (12%)	0.001*	0.11 to 0.29
Use of embolic protection device	229 (91.7%)	133 (91%)	96 (92%)	0.78	−0.07 to 0.05

*: P-value less than 0.05 is significant.

Table 4. Procedural and early outcomes of patients with carotid artery disease

Outcome	Symptomatic ($n = 146$)	Asymptomatic ($n = 104$)	Total ($n = 250$)	P-value	95% CI for difference (%)
Technical success	142 (97.3%)	104 (100%)	246 (98.4%)	0.14	−0.01 to 0.06
Major stroke	4 (2.7%)	0 (0%)	4 (1.6%)	0.12	−0.01 to 0.06
Minor stroke/TIA	8 (5.5%)	4 (3.8%)	12 (4.8%)	0.56	−0.04 to 0.08
Myocardial infarction	0 (0%)	0 (0%)	0	—	—
Death	4 (2.7%)	0 (0%)	4 (1.6%)	0.12	−0.01 to 0.06
Hospital stay >3 days	20 (13.7%)	8 (7.7%)	28 (11.2%)	0.18	−0.02 to 0.15

Table 5. Six-month follow-up

Outcome	Symptomatic (n = 146)	Asymptomatic (n = 104)	Total (n = 250)	P-value	95% CI for difference (%)
Event-free survival	125 (85.6%)	100 (96.2%)	225 (90%)	0.01*	0.03 to 0.19
Restenosis (>50%)	13 (8.9%)	4 (3.8%)	17 (6.8%)	0.10	−0.01 to 0.12
Late stroke	4 (2.7%)	0 (0%)	4 (1.6%)	0.11	−0.01 to 0.06
Reintervention	4 (2.7%)	0 (0%)	4 (1.6%)	0.11	−0.01 to 0.06
Dual antiplatelet adherence	133 (91%)	96 (92%)	229 (91.6%)	0.77	−0.06 to 0.05

Our findings demonstrated that symptomatic patients had greater rates of early complications, such as stroke and mortality, which is consistent with previous research stressing this group's elevated periprocedural risk due to plaque instability and higher embolic potential.^{26,27} The reported major stroke rate of 1.6% and small stroke/TIA rate of 4.8% are consistent with big studies like CREST and ICSS.^{13,14}

There were no myocardial infarctions in the early period, which presumably reflected improvements in perioperative care and patient selection.²⁸ The 6-month restenosis rate of 6.8% was consistent with earlier research, although somewhat higher in symptomatic patients, probably due to more severe atherosclerosis or inadequate plaque stabilization.²⁹

Notably, asymptomatic individuals had a higher event-free survival rate (96%) than symptomatic patients (85.6%), indicating that cautious patient selection improves outcomes in CAS.³⁰ This is consistent with current guidelines, which prescribe CAS in asymptomatic patients with other high-risk traits while simultaneously emphasizing the efficiency of optimal medical treatment.²²

The advancement of embolic protection devices and enhanced procedural facilities have significantly contributed to the improved safety profile of CAS.³¹ Operator expertise and center volume continue to have a significant impact on procedural success and complication rates.³²

Nevertheless, the function of CAS is evolving. Emerging data indicates that advancements in imaging, plaque classification, and patient-specific risk assessment can help identify

patients who will benefit the most from treatments.³³ Continuous randomized trials and long-term registries are required to determine appropriate treatment methods in the precision medicine age.

Conclusion and Limitation

Carotid artery stenting is a safe and effective therapy for symptomatic and asymptomatic carotid artery disease, with high technical success and low complication rates. Asymptomatic patients had superior results, including fewer early problems and longer event-free survival. These findings support the ongoing use of CAS in selected patients, with particular care in symptomatic patients due to the increased procedural risk. However, the study is limited by its relatively short follow-up duration; therefore, larger studies with longer follow-up are required to confirm these findings.

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Conflicts of Interest

None. ■

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