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EMERGENCY CAROTID ARTERY STENTING IN ACUTE ISCHEMIC STROKE DUE TO CERVICAL INTERNAL CAROTID ARTERY OCCLUSION OR STENOSIS: A SINGLE-CENTER EXPERIENCE

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Abstract

Objective: This study aims to comprehensively evaluate the effectiveness and safety of emergency carotid artery stenting (CAS) in a selected patient population by consolidating the outcomes of CAS procedures.

Methods: A total of 230 patients who underwent CAS at our interventional radiology unit between January 1, 2020, and July 31, 2024, were retrospectively evaluated. Among these, 35 patients who received emergency CAS due to hemodynamic instability and high National Institutes of Health Stroke Scale (NIHSS) scores (>4) at initial admission; increased frequency of transient ischemic attacks (TIA) during follow-up; clinical deterioration in acute infarction; decline in Glasgow Coma Scale (GCS) scores and consciousness; significantly impaired flow due to dissection; or balloon resistance in tandem occlusion were included in the study. Procedural complications, technical and clinical success, modified Rankin Scale (mRS) scores, and mortality rates were recorded.

Results: Of the 35 patients included, 57.2% (n=20) were male, with a mean age of 67.5±9.4 years. Comorbidities were present in 77.1% (n=27) of the patients, with hypertension being the most common (n=21, 60%). Lesions were located in the right carotid artery in 57.2% (n=20) of cases, and the most frequent degree of stenosis was between 70–90% (n=21, 60%). CAS was performed in 5 patients (14.2%) due to flow-limiting dissection. Predilatation and postdilatation were performed in 20 (57.1%) and 25 (77.1%) patients, respectively, and distal embolic protection filters were used in 20 (57.1%) patients. Procedural vasospasm occurred in 7 patients (20%). Persistent hypotension was observed in 1 patient (2.8%), and hyperperfusion-related hemorrhage occurred in 3 patients (8.6%). Two patients (5.7%) required intensive care unit (ICU) stay longer than 48 hours. At 3 months, 32 patients (91.4%) demonstrated favorable clinical outcomes (mRS ≤ 2). Mortality occurred in one patient (2.8%) due to myocardial infarction.

Conclusion: Emergency CAS offers acceptable early safety and efficacy outcomes in patients with symptomatic high-grade carotid artery stenosis. The findings suggest that emergency CAS may be a viable therapeutic option in selected patients. However, further prospective, randomized controlled, multicenter studies are warranted to validate these results.

Keywords: *Carotid stenosis, carotid artery disease, stents, stroke, endovascular procedures, treatment outcome, postoperative complications.*

Introduction

Carotid artery stenosis, defined as the narrowing of the carotid artery that supplies blood to the brain, is a well-established risk factor for stroke. Particularly, stenoses of 70% or greater significantly increase the risk of ischemic stroke due to inadequate oxygen delivery to brain tissue.[1] For many years, carotid endarterectomy (CEA) has been the standard treatment for such patients. However, in recent years, carotid artery stenting (CAS) has emerged as a significant alternative among endovascular treatment options, especially for patients with high surgical risk or anatomically complex lesions.[2,3] The timing of carotid artery stenting following symptom onset remains a subject of ongoing debate in the literature, particularly in the context of minimizing neurological damage and preventing stroke recurrence. Certain clinical scenarios—such as progressing neurological deficits or hemodynamic instability—may necessitate emergency stenting. In such cases, emergency CAS can serve as a critical intervention that rapidly restores cerebral perfusion and reduces the risk of further ischemic injury. Recent studies suggest that, when performed in carefully selected patients and by experienced interventional teams, emergency carotid stenting may be a safe and effective therapeutic option.[4] Nonetheless, further research is required to better assess its efficacy and safety, anticipate potential complications, observe long-term outcomes, and minimize associated risks. The primary aim of this article is to comprehensively evaluate the effectiveness and safety of emergency CAS in a selected patient population by integrating current evidence from the literature with the outcomes observed in our institution. This evaluation is intended to inform clinical practice and guide future research directions.

Methods

This retrospective study was conducted at the Interventional Radiology Unit of Harran University Faculty of Medicine Research and Training Hospital, where 230 patients who underwent CAS between January 1, 2020, and July 31, 2024, were retrospectively reviewed. Inclusion criteria were as follows: patients who underwent emergency CAS due to hemodynamic instability and high National Institutes of Health Stroke Scale (NIHSS) score (>4) at initial presentation; increasing frequency of transient ischemic attacks (TIAs) during follow-up; clinical deterioration in acute infarction; decline in Glasgow Coma Scale (GCS) and consciousness; significant flow restriction due to dissection; or balloon-resistant tandem occlusion. Based on these criteria, 35 patients were included in the study. Ethical approval was obtained from the local ethics committee (number: HRÜ/25.08.23 and date:28.04.2025).

Parameters Evaluated

The parameters evaluated in this study were categorized into demographic, clinical, imaging, procedural, early outcome, and long-term outcome variables. Demographic characteristics included the patients' age, sex, and comorbid conditions such as hypertension, diabetes mellitus, and coronary artery disease. Clinical features at the time of diagnosis were documented, including the use of antiplatelet therapy, the side of the stenotic segment (right or left), the initial presenting symptom (ischemic stroke, transient ischemic attack [TIA], or amaurosis fugax), and the timing of symptom onset. The morphological characteristics of the stenotic plaque were noted, specifically whether the plaque was calcified or non-calcified and whether it was ulcerated. The degree of stenosis was measured, and the presence of thrombus at the site of stenosis was assessed. In addition, the presence of ≥50% stenosis in the contralateral extracranial internal carotid artery (ICA) segment was recorded.

Imaging parameters included the evaluation of stenosis greater than or equal to 50% in the ipsilateral and contralateral distal intracranial ICA segments. Regarding the procedural details, the performance of pre- or post-dilation, the length and diameter of the stents used, and the application of distal embolic protection devices were all documented. Furthermore, any intra-procedural events such as bradycardia or asystole were noted.

Early outcomes included both technical and periprocedural complications. Technical complications encompassed issues such as arterial dissection or stent migration, while periprocedural complications included extracranial complications, stroke, death, hyperperfusion hemorrhage, and local vascular access site complications. The need for intensive care unit (ICU) stay exceeding 48 hours, the development of persistent hypotension, and the occurrence of periprocedural myocardial infarction were also evaluated. Additionally, the degree of residual stenosis and the length of hospital stay were recorded.

Long-term outcomes were assessed at the three-month follow-up visit. These included the modified Rankin Scale (mRS) score to evaluate functional neurological status and the rates of restenosis or occlusion at the site of stenting.

Definitions

The degree of stenosis was assessed using the North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria. A symptomatic patient was defined as one who had carotid artery stenosis accompanied by TIA, severe dizziness, amaurosis fugax, or a history of stroke. Emergency stenting was defined as procedures performed within one week of hospital admission. The decision for emergency intervention was made after consultation with neurology specialists for patients with carotid artery stenosis who showed increasing frequency of TIAs, clinical deterioration during an acute infarct (decrease in GCS, worsening mental status, or progressive motor weakness), significant flow restriction due to dissection, or balloon-resistant tandem occlusion. Patient data were obtained retrospectively from medical records, discharge summaries, the PACS system, and, when necessary, direct contact with the patients. The degree of carotid artery stenosis and plaque morphology were determined based on imaging, medical records, and angiographic evaluations.

Procedure Technique

Carotid artery stenting was performed by three interventional radiologists with 12 (E.K.), 10 (V.K.), and 10 (M.T.) years of experience. Patients were monitored for heart rate, blood pressure, and respiratory status throughout the procedure. To enable early detection of neurological changes, no sedation was administered. After placing the patient in the supine position and ensuring sterile conditions, right femoral artery access was obtained using the Seldinger technique under ultrasound guidance. An 8 F, 11 cm femoral introducer sheath was placed over a guidewire. For patients not on antiplatelet therapy, 300 mg of clopidogrel and 300 mg of aspirin were administered as a loading dose before the procedure. At the beginning of the procedure, 5,000–10,000 units of intravenous heparin were administered to achieve an appropriate activated clotting time (ACT). Diagnostic angiography was performed using Simmons 2 or vertebral catheters appropriate for the patient's vascular anatomy. Both

common carotid arteries (CCA) and vertebral arteries were selectively catheterized and imaged with contrast. During angiographic evaluation, the side, degree, and length of stenosis; lesion localization; plaque morphology; presence of ulceration; and distal intracranial ICA stenosis were analyzed. Stenosis severity was determined using NASCET criteria.

Procedure Steps

After completing the diagnostic imaging, the procedure began with the advancement of a 6 French (F) long sheath (80–90 cm in length) into the target common carotid artery (CCA) over a 0.035" Amplatz® Super Stiff exchange guidewire. This was achieved with the assistance of either a Simmons 2 or a vertebral catheter. In patients with angiographically observed vasospasm, intra-arterial nimodipine was administered to relieve vascular constriction. When anatomically feasible, a distal embolic protection device (Spider™, Ev3 Inc., Plymouth, MN, USA) was deployed in the petrous segment of the internal carotid artery (ICA) to reduce the risk of distal embolization during the intervention. In cases where advancing the stent was predicted to be technically difficult due to vessel morphology or plaque burden, pre-dilation was performed using monorail balloons measuring 2–4 mm in diameter. Under roadmap fluoroscopic guidance, a self-expandable stent was deployed to cover both the plaque and the adjacent normal arterial segments, ensuring optimal coverage and anchoring. If there was evidence of residual stenosis or inadequate apposition of the stent to the vessel wall, post-dilation was carried out using 5–6 mm diameter balloons to achieve full expansion and adequate lumen gain. To prevent procedure-related bradycardia or asystole, patients with baseline heart rates below 80 beats per minute were prophylactically administered 0.5–1 mg of intravenous atropine. Additional doses were given if the heart rate decreased by more than 20 beats per minute or if asystole developed during balloon inflation or stent deployment. After the stent was successfully implanted and hemodynamic stability was confirmed, the embolic protection device was carefully retrieved. Final control angiographic images were then obtained to evaluate the position and patency of the stent as well as cerebral perfusion status.

Post-procedure Follow-up

Patients were monitored in the ICU for 1 day and in the general ward for 2 more days. Neurological assessments and vital signs were regularly monitored by interventional radiologists and neurologists. Systolic BP <100 mmHg was managed with IV fluids or positive inotropes. Periprocedural complications were defined as events occurring during or after the procedure until hospital discharge. Diffusion-weighted MRI and CT were used in patients with post-procedural neurologic deterioration to evaluate ischemia or hyperperfusion hemorrhage. At discharge, all patients were prescribed dual antiplatelet therapy (75 mg/day clopidogrel and 100 mg/day aspirin) for 6 months, followed by aspirin monotherapy (100 mg/day). All patients were re-evaluated during the first-week follow-up, including clinical status and carotid Doppler ultrasonography to assess stent status and residual stenosis.

Statistical Analysis

All statistical analyses were conducted using SPSS version 22.0 (IBM Corp., Armonk, NY). Variables were categorized as either categorical or continuous. Categorical variables were expressed as counts and percentages. Continuous variables were presented as means and ranges.

Results

Of the 35 patients, 20 (57.2%) were male and 15 (42.8%) were female, with a mean age of 67.5±9.4 years. Comorbidities were present in 27 patients (77.1%), most commonly hypertension (21, 60%) and diabetes mellitus (15, 42.8%) (Table 1).

Table 1. Demographic and Clinical Characteristics of Patients Undergoing Emergency Carotid Artery Stenting

Variables	n (%)
Gender	
Female	20 (57.2)
Male	15 (42.8)
Age (mean ± SD)	67.5±9.4
Comorbidities	27 (77.1)
Hypertension	21 (60.0)
Smoking History	12 (34.3)
Diabetes Mellitus	15 (42.8)
Coronary Artery Disease	14 (40.0)
Antiplatelet Use	25 (71.4)

Vascular imaging characteristics are summarized in Table 2. Lesions were located in the right carotid artery in 20 patients (57.2%). The most frequent stenosis severity was 70–90%, observed in 21 patients (60%). In 5 patients (14.2%), the procedure was performed for dissection causing flow restriction. Ulcerated plaques were present in 15 patients (42.8%), and thrombus was detected in 7 (20%). Concomitant intracranial stenosis was identified in 8 patients (22.8%), with >90% stenosis in 4, all of whom underwent simultaneous treatment.

Table 2. Distribution of Patients According to Vascular Pathological Characteristics

Variables	n (%)
Lesion Side	
Right	20 (57.2)
Left	15 (42.8)
Degree of Stenosis	
50–70%	5 (14.2)
70–90%	21 (60.0)
≥90%	4 (11.4)
Dissection	5 (14.2)
Plaque Characteristics	
Ulcerated	15 (42.8)
Thrombus	7 (20.0)
Accompanying Stenoses	
Contralateral ICA ≥50% Stenosis	25 (71.4)
Intracranial ≥50% Stenosis	8 (22.8)
Ipsilateral	5 (14.2)
Contralateral	3 (8.5)

Procedural techniques are shown in Table 3. Predilatation was performed in 20 patients (57.1%), postdilatation in 25 (77.1%), and distal embolic protection filters were used in 20 (57.1%).

Periprocedural complications and outcomes are summarized in Table 4. Vasospasm occurred in 7 patients (20%), persistent hypotension in 1 (2.8%), and hyperperfusion hemorrhage in 3 (8.6%). Two patients (5.7%) required intensive care unit admission >48 hours. At the 3-month follow-up, clinical success (mRS ≤2) was achieved in 32 patients (91.4%). One patient (2.8%) died from myocardial infarction. Figures 1 and 2 show cases in which emergency stenting was performed.

Table 3. Distribution of Patients According to Procedural Techniques

Variables	n (%)
Procedural Techniques	
Predilatation Balloon Angioplasty	20 (57.1)
Postdilatation Balloon Angioplasty	25 (77.1)
Intra-procedural Asystole/Bradycardia	22 (62.8)
Use of Distal Embolic Protection Device	20 (57.1)
Use of Two Stents	
Due to Thrombus	7 (20.0)
Due to Stent Malapposition	1 (2.8)

Table 4. Periprocedural Complications and Follow-up Outcomes

Variables	n (%)
Vasospasm During the Procedure	7 (20.0)
Access Site Hematoma	3 (8.6)
Acute Stent Thrombosis	0 (0.0)
Persistent Hypotension	1 (2.8)
Hyperperfusion Hemorrhage	3 (8.6)
ICU Stay >48 Hours	2 (5.7)
Technical Success	35 (100)
Modified Rankin Scale (mRS) ≤ 2 at 3 Months	32 (91.4)
Modified Rankin Scale (mRS) > 2 at 3 Months	3 (8.6)
Mortality	1 (2.8)
Restenosis During Follow-up	2 (5.7)

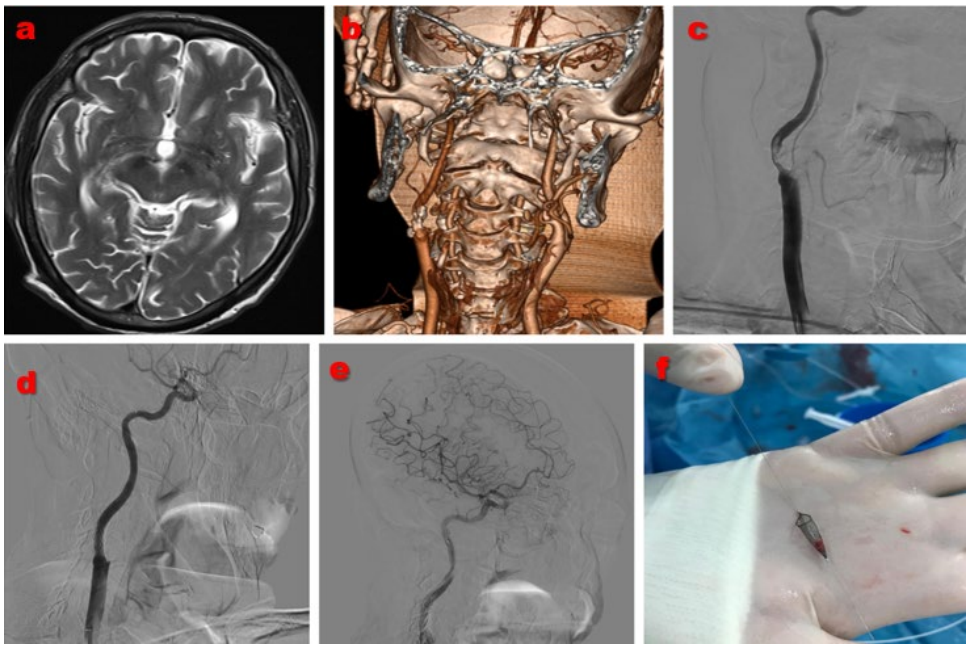

Figure 1. Imaging findings of a 75-year-old male patient presenting with transient ischemic attack (TIA). a) Cranial T2-weighted magnetic resonance imaging (MRI) showing no evidence of infarction. b) Three-dimensional computed tomography (CT) angiography revealing significant stenosis in the right internal carotid artery. c) Conventional digital subtraction angiography (DSA) image showing the stenosis and intraluminal thrombus. d) Post-stenting image demonstrating successful revascularization. e) No loss of intracranial arterial branches is observed. f) Image showing the thrombus captured in the distal embolic protection device.

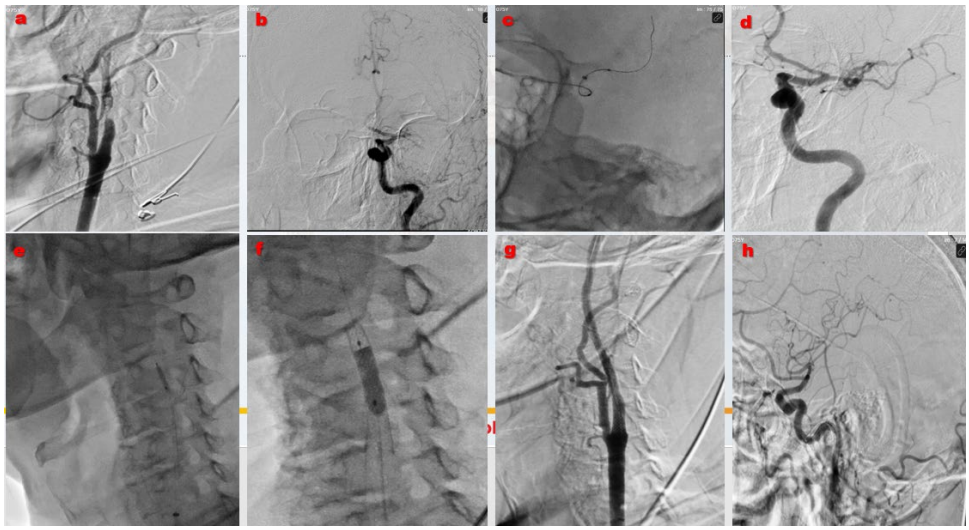

Figure 2. Angiographic images of a 75-year-old patient presenting with acute ischemic stroke (NIHSS score: 22), with left middle cerebral artery (MCA) occlusion and severe left internal carotid artery (ICA) stenosis. a) Conventional digital subtraction angiography (DSA) image showing severe proximal stenosis of the left ICA. b) Occlusion of the left MCA. c) Mechanical thrombectomy performed in the left MCA. d) Complete recanalization of the left MCA after thrombectomy. e) Predilatation balloon angioplasty applied to the ICA. f) Carotid artery stenting followed by postdilatation. g) Post-procedural image showing successful revascularization of the ICA. h) Revascularization of the left MCA demonstrated after the intervention.

Discussion

In this study, early outcomes of emergency CAS in patients with symptomatic severe carotid artery stenosis were evaluated. Our findings, when compared to previous literature, suggest that emergency CAS has an acceptable safety and efficacy profile in selected patient populations. In our study, all emergency CAS procedures were performed with a high technical success rate (100%), which aligns with previous studies. For instance, researchers such as Son et al.[5] and Bruno et al.[6] have reported successful stent deployment in the majority of patients undergoing emergency CAS. This supports the notion that emergency CAS is technically feasible when appropriate patient selection is made and procedures are performed by experienced operators.

Serious complications such as cerebral hyperperfusion syndrome, stroke, and death have been reported in association with emergency CAS in the literature.[7] Similarly, our study observed periprocedural stroke and mortality rates of 2.8% each. However, these rates are relatively lower compared to some prior studies, where 30-day stroke and death rates following emergency CAS have been reported to range between 4% and 8%.[8,9] These differences may be attributable to heterogeneity in patient populations, the severity of neurological deficits at presentation, and variations in procedural techniques. In our study, careful patient selection, widespread use of embolic protection devices (85.7%), and the procedures being performed by an experienced team may have contributed to the lower complication rates.

The rate of hyperperfusion hemorrhage in our study (8.5%) was comparable to that reported in some previous studies. Hyperperfusion is a serious complication, particularly in patients with recent stroke, and is characterized by excessive blood flow to damaged brain tissue due to impaired autoregulation.[10] In our cohort, all patients who developed hyperperfusion hemorrhage had a recent history of cerebral infarction. This finding underscores the importance of strict blood pressure control and close neurological monitoring in patients undergoing emergency CAS.

Cardiovascular complications such as bradycardia or asystole were frequently observed (57.1%) during the procedure, which has also been reported in previous studies.[11] Manipulation of the carotid artery can trigger vagal reflexes, resulting in bradycardia and asystole. These events are usually manageable with atropine, but require vigilant monitoring and preparedness. In our study, all such complications were successfully managed with atropine by an experienced team.

The primary goal of emergency CAS is to reduce the risk of stroke associated with carotid artery stenosis. In our study, the post-procedural stroke rate was low (2.8%), suggesting that emergency CAS may be an effective stroke prevention strategy. Similar findings have been reported in the literature, highlighting the potential efficacy of emergency CAS in stroke prevention.[12] However, further long-term follow-up data and comparative studies with CEA are necessary to confirm this.

The importance of appropriate patient selection and optimal timing of the procedure for the success of emergency CAS has been emphasized in the literatüre.[12,13] In our study, patients were carefully selected, and the intervention was performed in the early phase following symptom onset. Early revascularization is known to help salvage the ischemic penumbra and limit neurological damage,[14] which may have contributed to the favorable outcomes observed in our cohort.

Several studies have compared emergency CAS with CEA. Some have suggested that CAS may offer comparable or even superior outcomes, particularly in patients at high surgical risk.[15,16] Nonetheless, more randomized controlled trials are needed to establish definitive conclusions on this topic.

Limitations

This study has several limitations. First, its retrospective design may introduce selection bias and inconsistencies in data recording. Second, as a single-center study, the generalizability of the findings may be limited. Third, the relatively small sample size may not allow for accurate estimation of rare complications. Lastly, the absence of long-term follow-up data prevents assessment of restenosis rates and long-term stroke risk. These limitations highlight the need for cautious interpretation of the results and further research in this area.

In conclusion, this study supports that emergency CAS offers acceptable early safety and efficacy outcomes in patients with symptomatic severe carotid artery stenosis. Our findings are consistent with existing literature and suggest that emergency CAS can be an effective treatment option in selected patients. However, prospective, randomized controlled studies are needed to further evaluate the comparative effectiveness of emergency CAS versus CEA, long-term outcomes, and optimal patient selection criteria. Further research is also warranted on the timing of emergency CAS, the efficacy of embolic protection devices, and optimal antiplatelet therapy regimens.

Conflict of Interest

The authors have no conflicts of interest to disclose.

Ethics and permissions

This study was approved by the Non-Interventional Clinical Research Ethics Committee of Harran University Faculty of Medicine on April 28, 2025, with the decision Number (25.08.23).

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Author Contributions

E.K. and V.K.: Study idea/Hypothesis; E.K., M.T., E.Ç.,L.T.: Design; A.S.O., G.S.: Data Collection; E.K. and M.T. : Analysis; V.K. and E.K.: Literature review; E.K. and E.Ç.: Writing; G.S. and M.T.: Critical review

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