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Early Diffusion-Weighted Imaging Lesions and Clinical Outcomes after Carotid Artery Stenting in Symptomatic Patients: A Single-Center Retrospective Study

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Purpose: Carotid artery stenting (CAS) is an established alternative to carotid endarterectomy for selected patients with symptomatic carotid stenosis. Although predictors of periprocedural ischemic lesions detected on diffusion-weighted imaging (DWI) have been described, the relationship between these lesions and long-term functional outcomes remains incompletely understood. This study aimed to identify factors associated with early ischemic lesions after CAS and to evaluate whether these lesions are associated with 1-year clinical outcomes.

Materials and Methods: We retrospectively analyzed 190 patients who underwent CAS for symptomatic carotid artery stenosis at a single tertiary center. The primary outcome was the occurrence of new ischemic lesions on DWI within 24 hours after CAS. Secondary outcomes included periprocedural ischemic or hemorrhagic complications, recurrent ischemic cerebrovascular events within 1-year, restenosis at 1-year, and functional outcome at 1-year assessed by the modified Rankin Scale (mRS). Univariable and multivariable logistic regression analyses were performed to identify predictors of early embolic lesions and good functional outcome (mRS 0–2).

Results: New ischemic lesions on DWI were identified in 52 patients (27.4%). In multivariable analysis, atrial fibrillation was independently associated with early ischemic lesions (odds ratio, 4.747; 95% confidence interval, 1.133–19.888; P=0.033), whereas lesion severity and procedural factors were not. Periprocedural ischemic stroke with neurological deterioration occurred in 2.1% of patients, and symptomatic intracranial hemorrhage occurred in 1.1%. Good functional outcome (mRS 0–2) at 1-year was achieved in 82.1% of patients. New ischemic lesions were not independently associated with 1-year functional outcome, whereas baseline neurological severity was the primary determinant.

Conclusion: New ischemic lesions on DWI were frequently observed after CAS but were not associated with long-term functional outcome. CAS was associated with low periprocedural complication rates and favorable 1-year outcomes in symptomatic patients treated at an experienced center.

Key Words: Carotid artery stenting; Symptomatic carotid stenosis; Diffusion-weighted imaging; Functional outcome

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INTRODUCTION

Randomized trials have shown that carotid artery stenting (CAS) provides long-term protection against ipsilateral stroke comparable to carotid endarterectomy (CEA), despite a higher periprocedural risk of ischemic stroke.[1] With advances in stent technology, embolic protection devices, and operator experience, recent real-world data suggest that CAS can be performed with acceptable safety in symptomatic patients

at experienced centers.[2] Although CEA remains the gold standard for the treatment of symptomatic carotid stenosis,[3] there are clinical scenarios in which CAS may serve as a practical alternative. In particular, revascularization in the acute or early post-stroke period poses challenges for surgical intervention due to concerns regarding hemorrhagic transformation, hyperperfusion syndrome, and perioperative risk.[4] In such settings, CAS is sometimes considered, especially in patients treated with intravenous thrombolysis or in those who experience early neurological deterioration despite initial medical management.[5]

Despite the increasing use of CAS in selected clinical settings, concerns remain regarding periprocedural embolic complications. New ischemic lesions detected on diffusion-weighted imaging (DWI) after CAS are commonly interpreted as markers of procedure-related microembolization.[6,7] However, their association with long-term functional outcomes has not been adequately established. Studies evaluating embolic infarction as reflected by DWI findings after CAS have demonstrated substantial heterogeneity in imaging timing and outcome definitions.[8] Consequently, the relationship between periprocedural embolic risk and long-term clinical benefit after CAS in symptomatic patients remains incompletely defined.

Previous studies have suggested that both lesion-related and procedural factors may influence the risk of new ischemic lesions detected on DWI following CAS. Reported risk factors have included high-grade stenosis, plaque morphology, lesion length, and procedural characteristics such as pre- or post-balloon angioplasty.[9-11] In addition, metabolic and laboratory parameters, including low-density lipoprotein cholesterol levels, have been reported to be associated with periprocedural DWI-detected distal embolic lesions in selected cohorts.[12] These findings indicate that periprocedural ischemic lesions after CAS are influenced by a combination of anatomical, procedural, and biological factors. In this context, further evaluation of early DWI lesions and their clinical implications in symptomatic patients undergoing CAS remains relevant. This study aimed to evaluate whether early DWI-detected ischemic lesions following CAS are associated with subsequent clinical outcomes, including long-term functional status and cerebrovascular events, and to explore clinical and procedural factors related to their occurrence.

MATERIALS AND METHODS

Patient Population and Procedural Details

This was a retrospective, single-center observational study of patients who underwent CAS for symptomatic carotid artery stenosis at a tertiary referral center between September 2005 and November 2023. A total of 190 consecutive patients were included in the final analysis. Symptomatic carotid stenosis was defined as ipsilateral ischemic stroke, transient ischemic attack (TIA), or amaurosis fugax attributable to the target carotid artery within 6 months prior to the procedure. Patients with both early post-stroke and delayed presentations were included. Early post-stroke presentation referred to patients who underwent CAS shortly after symptom onset, including those who received intravenous thrombolysis or underwent CAS without sufficient antiplatelet premedication.

Patients were excluded if clinical variables were unavailable, follow-up imaging for restenosis assessment was not performed, or if CAS was performed for non–proximal internal carotid artery lesions, including common carotid artery stenosis or intracranial internal carotid artery stenosis (e.g., cavernous segment). Patients who underwent concomitant mechanical thrombectomy for tandem occlusion and those with a preprocedural modified Rankin Scale (mRS) score >2 were also excluded. Clinical variables collected included age, sex, hypertension, diabetes mellitus, other vascular disease (coronary artery disease and peripheral arterial disease), atrial fibrillation, smoking status, and serum cholesterol levels. Degree of carotid stenosis was assessed using the North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria.[13] Baseline neurological status was evaluated using the National Institutes of Health Stroke Scale (NIHSS) score.

All CAS procedures were performed by experienced neurointerventionists using open-cell, non-tapered carotid stents, predominantly SMART® and PRECISE® stents (Cordis), under distal embolic protection. Procedures were conducted under local anesthesia without sedation, with patients maintained in an awake and alert state to allow continuous neurological monitoring. Distal embolic protection devices were used in all cases, most commonly Angioguard XP (Cordis) or Emboshield NAV (Abbott). Proximal balloon occlusion devices were not used. Pre-balloon angioplasty was performed when the degree of stenosis was too severe to allow safe passage of the stent. Post-balloon angioplasty was selectively performed when sufficient luminal expansion was not achieved after stent deployment. Procedural characteristics,

including the use of pre- and post-balloon angioplasty, were recorded and evaluated as procedural variables. Most patients received dual antiplatelet therapy for at least 1 week prior to the procedure, typically consisting of aspirin and clopidogrel. Alternative antiplatelet regimens were used in selected cases based on individual clinical considerations. In patients who experienced neurological deterioration within 1 week after ischemic stroke, clopidogrel loading was administered prior to the procedure when appropriate. In patients treated with intravenous thrombolysis, CAS was performed without antiplatelet premedication. Accordingly, inadequate antiplatelet therapy was defined as CAS performed without sufficient preprocedural dual antiplatelet loading.

Outcome Measures

DWI was reviewed by a single experienced reader who was not involved in the procedures and was blinded to clinical data, procedural details, and follow-up outcomes. The primary imaging outcome was the occurrence of new ischemic lesions on DWI within 24 hours after CAS, compared with available baseline imaging. Secondary outcomes included early clinical safety events within 30 days after CAS, defined as periprocedural ischemic stroke or intracranial hemorrhage associated with neurological deterioration. Long-term outcomes, evaluated to assess the clinical relevance of early imaging findings, included new ischemic cerebrovascular events within 1-year, functional outcome at 1-year, assessed using the mRS, with good functional outcome defined as an mRS score of 0–2, and restenosis at 1-year, assessed on follow-up imaging as an exploratory outcome. Restenosis was assessed using follow-up imaging performed at 1-year after CAS (±1 month), including computed tomography angiography, magnetic resonance angiography, or duplex ultrasound, and was defined as significant luminal narrowing. On duplex ultrasound, restenosis was determined based on an increase in flow velocity across the stented segment compared with post-procedural baseline carotid ultrasound findings. Clinically significant restenosis was defined as ≥50% luminal narrowing on follow-up imaging.

Statistical Analysis

Continuous variables are presented as mean±standard deviation or median with interquartile range, as appropriate, and categorical variables as counts and percentages. Univariable logistic regression analyses were performed to identify factors associated with the occurrence of new ischemic lesions on DWI and functional outcomes at 1 year. Variables considered clinically relevant and those showing associations in univariable analyses were subsequently entered into multivariable logistic regression models to identify independent predictors, adjusting for potential confounders including age, vascular risk factors, degree of stenosis, and baseline neurological severity assessed by the NIHSS. To avoid multicollinearity, pre-procedural and post-procedural systolic blood pressure (SBP) were not included simultaneously in the multivariable models; instead, the change in SBP (ΔSBP) was used. ΔSBP was defined as pre-procedural minus post-procedural SBP and analyzed per 10-mmHg increment. Due to the limited number of events, analyses of early safety outcomes, new ischemic cerebrovascular events and restenosis were considered exploratory, and multivariable analysis for restenosis was not performed. A 2-sided P-value<0.05 was considered statistically significant. All statistical analyses were performed using R version 4.2.3 (R Foundation for Statistical Computing).

RESULTS

A total of 190 patients with symptomatic carotid artery stenosis were included in this study. The mean age was 71.8±7.7 years, and 86.3% of the patients were male. The qualifying symptom was ischemic stroke in 128 patients (67.4%), TIA in 58 (30.5%), and amaurosis fugax in 4 (2.1%). The median baseline NIHSS score was 3.0 [interquartile range, 1.0–7.2]. Among the study population, 27 patients (14.2%) underwent CAS with inadequate antiplatelet therapy. This included patients who underwent CAS within 1 week after ischemic stroke due to neurological deterioration, as well as those treated after intravenous thrombolysis (n=16). Atrial fibrillation was present in 10 patients (5.3%). Baseline clinical characteristics, comorbidities, and lesion-related variables are summarized in Table 1.

New ischemic lesions on DWI within 24 hours after CAS were identified in 52 patients (27.4%) (Table 2). In univariable analyses, atrial fibrillation was significantly associated with the occurrence of new ischemic lesions, whereas lesion severity and procedural factors showed no significant associations (Supplementary Table 1). In multivariable logistic regression analysis adjusting for relevant clinical covariates, atrial fibrillation remained independently associated with early ischemic lesions on DWI (odds ratio [OR], 4.747; 95%

Table 1. Baseline clinical and procedural characteristics of the study population (n=190)

Variable	Value
Male	164 (86.3)
Age (y)	71.8±7.7
Hypertension	139 (73.2)
Diabetes mellitus	80 (42.1)
Vascular disease	55 (28.9)
Atrial fibrillation	10 (5.3)
Smoking	76 (40.0)
Symptom	
Ischemic stroke	128 (67.4)
Baseline NIHSS score	3.0 [1.0–7.2]
TIA	58 (30.5)
Inadequate antiplatelet therapy	27 (14.2)
IV tPA	16 (8.4)
Laboratory findings (mg/dL)	
Total cholesterol	142.5 [119.0–174.3]
HDL-C	38.0 [33.0–44.3]
LDL-C	88.5 [62.3–113.8]
Pre-SBP (mmHg)	146.1±22.4
Post-SBP (mmHg)	122.0±27.8
ΔSBP (pre-post)*	24.3±27.9
Lesion side (right)	96 (50.5)
Lesion diameter	1.1 [0.7–1.5]
Degree of stenosis (%)	76.2 [67.8–81.8]
Pre-balloon angioplasty	154 (81.1)
Post-balloon angioplasty	141 (74.2)

Continuous variables are presented as mean±standard deviation or median [interquartile range], as appropriate, and categorical variables as number (%).
NIHSS, National Institutes of Health Stroke Scale; TIA, transient ischemic attack; IV tPA, intravenous tissue plasminogen activator; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure.
*ΔSBP was calculated as pre-procedural minus post-procedural SBP.

Table 2. Early and 1-year clinical outcomes after carotid artery stenting (n=190)

New ischemic lesion within 24 hours	52 (27.4)
Periprocedural ischemic stroke with neurological deterioration	4 (2.1)
Symptomatic intracranial hemorrhage	2 (1.1)
New ischemic cerebrovascular event within 1-year	3 (1.6)
Restenosis at 1-year	16 (8.4)
Good functional outcome at 1-year	156 (82.1)

Values are presented as number (%).

confidence interval [CI], 1.133–19.888; P=0.033) (Table 3). No lesion-related or procedural variables were significantly associated with the new ischemic lesions.

Periprocedural ischemic stroke associated with neurological deterioration occurred in 4 patients (2.1%) within 30 days after CAS (Table 2). All ischemic events occurred in patients who underwent CAS outside the hyperacute period and had received adequate antiplatelet premedication prior to the procedure. Periprocedural ischemic strokes were characterized by mild neurological deterioration within 24 hours after the procedure. Three patients showed a 1-point increase, and 1 patient showed a 2-point increase in the NIHSS score, and all cases were attributable to lesions in the vascular territory of the treated artery.

Intracranial hemorrhage associated with neurological deterioration occurred in 2 patients (1.1%), both of whom were treated in the early post-stroke period, including patients who had received intravenous thrombolysis or underwent CAS without sufficient antiplatelet premedication. These hemorrhagic events were associated with hemorrhagic transformation of acute infarction; 1 case was accompanied by intraventricular hemorrhage and the other by subarachnoid hemorrhage. Notably, all early safety events occurred within 72 hours after CAS. Due to the limited number of events, these outcomes were analyzed descriptively.

During the 1-year follow-up period, new ischemic cerebrovascular events occurred in 3 patients (1.6%). All events were ischemic strokes, and no TIAs were observed during follow-up. One patient developed an infarction in the ipsilateral middle cerebral artery territory approximately 11 months after CAS. The remaining 2 patients experienced infarctions in the posterior circulation at 1 month and 3 months after the procedure, respectively.

At 1-year follow-up, 156 patients (82.1%) achieved a good functional outcome. In univariable analyses, older age, higher baseline NIHSS score, and inadequate antiplatelet therapy prior to the procedure were significantly associated with poor functional outcome at 1-year. In multivariable logistic regression analysis, baseline NIHSS score remained independently associated with functional outcome at 1-year after adjustment for other clinically relevant variables (OR, 0.782; 95% CI, 0.684–0.895; P<0.001) (Table 4). The presence of new ischemic lesions detected within 24 hours after CAS was not significantly associated with good functional outcome at

Table 3. Multivariable logistic regression analysis of predictors of new ischemic lesions on diffusion-weighted imaging

Variable	ORs (95% CI)	P-value
Sex	0.371 (0.120–1.147)	0.085
Age	1.004 (0.952–1.059)	0.883
Hypertension	1.345 (0.505–3.586)	0.553
Diabetes mellitus	0.646 (0.280–1.493)	0.306
Vascular disease	1.387 (0.546–3.522)	0.491
Atrial fibrillation	4.747 (1.133–19.888)	0.033
Smoking	1.691 (0.672–4.255)	0.234
Inadequate antiplatelet therapy	0.358 (0.055–2.346)	0.284
IV tPA	0.465 (0.036–5.977)	0.557
HDL-C	0.972 (0.928–1.018)	0.225
LDL-C	1.005 (0.994–1.017)	0.341
Pre-balloon angioplasty	0.474 (0.125–1.795)	0.272
Post-balloon angioplasty	0.521 (0.177–1.539)	0.238
Lesion diameter	0.882 (0.353–2.201)	0.788
ΔSBP	1.104 (0.958–1.273)	0.172

ORs for ΔSBP are presented per 10-mmHg increment.
OR, odds ratio; CI, confidence interval; IV tPA, intravenous tissue plasminogen activator; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure.

Table 4. Multivariable logistic regression analysis of predictors of good functional outcome at 1-year

Variable	ORs (95% CI)	P-value
Sex	0.626 (0.099–3.956)	0.618
Age	0.928 (0.851–1.011)	0.087
Atrial fibrillation	0.600 (0.042–8.582)	0.707
NIHSS	0.782 (0.684–0.895)	<0.001
LDL-C	1.019 (0.999–1.039)	0.063
Inadequate antiplatelet therapy	2.512 (0.450–14.019)	0.294
ΔSBP	1.294 (0.995–1.681)	0.054
New ischemic lesion	1.087 (0.241–4.893)	0.914

Variables included in the multivariable logistic regression models were selected based on clinical relevance and univariate analysis results.
OR, odds ratio; CI, confidence interval; NIHSS, National Institutes of Health Stroke Scale; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure.

1-year (OR, 1.087; 95% CI, 0.241–4.893; P=0.914).

Restenosis at 1-year follow-up was observed in 16 patients (8.4%); however, only 3 patients (1.6%) had clinically significant restenosis defined as ≥50% luminal narrowing, while the remaining cases showed mild increases in peak systolic velocity or intimal hyperplasia. Given the limited number of restenosis events, multivariable analysis was not pursued, and these findings were interpreted descriptively.

DISCUSSION

In this single-center cohort of patients with symptomatic carotid artery stenosis undergoing CAS, several clinically relevant findings were observed. New ischemic lesions on DWI within 24 hours after the procedure were common, occurring in more than 25% of patients. Among the clinical, lesion-related, and procedural variables examined, atrial fibrillation was independently associated with the occurrence of early ischemic lesions, whereas angiographic stenosis se-

verity and procedural factors, including balloon angioplasty, were not. Importantly, despite the frequent occurrence of early DWI lesions, their presence was not associated with worse functional outcomes at 1-year. The 1-year functional outcome was selected to reflect relatively stable neurological status after completion of the acute recovery and rehabilitation phases, allowing assessment of the sustained clinical relevance of early imaging findings rather than transient post-procedural effects. Instead, long-term functional outcome was predominantly determined by baseline neurological severity, as reflected by the NIHSS score. Periprocedural clinical complications were infrequent and occurred mainly in the early post-procedural period, and overall 1-year clinical and angiographic outcomes were favorable. These findings suggest that while early DWI-detected ischemic lesions are frequently observed after CAS, their association with long-term functional recovery appears limited in symptomatic patients treated at an experienced center.

Previous studies have consistently demonstrated that new ischemic lesions on DWI are common after CAS. Systematic reviews and meta-analyses have reported DWI-positive lesion rates of approximately 30–40% following CAS, although substantial heterogeneity exists depending on imaging timing, patient selection, and study design.[8,14] Most prior analyses included DWI performed within several days to 1 week after the procedure, potentially capturing both immediate periprocedural embolization and delayed lesion evolution. In this context, the 27.4% incidence of new ischemic lesions detected within 24 hours in the present study is broadly consistent with previously reported ranges, while reflecting the use of a standardized early imaging point. Prior observational studies have suggested a higher burden of post-procedural ischemic lesions in symptomatic patients, with reported rates approaching 50% in some cohorts.[15] Against this background, the DWI lesion rate observed in our symptomatic population appears comparable to the lower range of published estimates. New ischemic lesions detected on DWI after CAS are generally interpreted as imaging markers of procedure-related microembolization rather than clinically overt stroke.[7,16] Although some studies have linked these lesions to subsequent cerebrovascular events,[15] studies evaluating DWI findings after CAS have shown marked heterogeneity in imaging protocols and outcome definitions, and relatively few have examined their association with long-term functional status. In our cohort, the presence of early DWI lesions was not associated with functional outcome at 1-year, suggesting that many of these lesions may be clinically silent and of limited prognostic relevance for long-term disability in symptomatic patients treated with contemporary CAS techniques.

In this study, atrial fibrillation was independently associated with the occurrence of new ischemic lesions on DWI after CAS. This finding should be interpreted cautiously, as patients with atrial fibrillation are often preferentially managed with CEA rather than CAS because of concerns regarding periprocedural anticoagulation and bleeding risk, leading to their underrepresentation in many CAS cohorts.[17] Atrial fibrillation is a well-established cardioembolic condition, and subclinical ischemic brain lesions on DWI have been frequently reported after catheter-based interventions such as atrial fibrillation ablation, even in the absence of overt neurological symptoms.[18,19] These observations provide a plausible explanation for the association observed in the present study, suggesting increased susceptibility to procedure-related microembolization. Given the limited number of affected patients, this finding should be regarded as exploratory.

In this cohort, most patients achieved a favorable functional outcome at 1 year after CAS, with more than 80% attaining an mRS score of 0–2. Baseline neurological severity was the primary determinant of long-term functional outcome, whereas the presence of new ischemic lesions on early post-procedural MRI was not independently associated with functional status at 1-year. This finding is consistent with previous studies demonstrating that baseline neurological deficit is a major predictor of long-term functional outcome in patients with ischemic stroke.[20] In the context of carotid revascularization, prior studies of patients undergoing CEA have similarly demonstrated that higher admission NIHSS scores, particularly NIHSS >4, are associated with subsequent functional dependence, underscoring the dominant influence of initial stroke severity on long-term recovery.[21] Although these lesions are commonly detected after CAS and are considered imaging markers of periprocedural embolization, our findings suggest that most are clinically silent and do not translate into sustained functional disability. This finding is in line with previous reports indicating that DWI-positive lesions after carotid revascularization are often clinically silent, and that their association with long-term functional outcome remains limited or inconsistent, particularly in the absence of overt periprocedural stroke.[8]

During 1-year follow-up, both recurrent ischemic cerebrovascular events and restenosis after CAS were infrequent in the present study and were comparable to rates reported in

previous trials and observational studies of symptomatic carotid stenosis. Prior studies have reported that the 1-year risk of recurrent ischemic stroke after CAS is generally in the single-digit percentage range.[22,23] In contrast, reported rates of restenosis at 1-year vary widely, ranging from approximately 5% to 20%, depending on the restenosis threshold, imaging modality, and follow-up strategy.[24,25] In our cohort, new ischemic events occurred in 1.6% of patients and restenosis was observed in 8.4%, falling well within the range of previously reported outcomes. These findings suggest that, when performed in an experienced single-center setting with standardized techniques and follow-up, CAS can provide durable mid-term clinical and angiographic outcomes in symptomatic patients. In addition, the rates of periprocedural ischemic and hemorrhagic complications in the present study were low (2.1% and 1.1%, respectively), and are comparable to or lower than those reported in prior randomized trials and large observational studies of CAS in symptomatic patients.[23,26]

This study has several limitations that should be acknowledged. First, its retrospective design and single-center nature may limit generalizability, and unmeasured confounding factors cannot be fully excluded despite multivariable adjustment. However, all procedures were performed by experienced neurointerventionists using standardized techniques, which reduces procedural heterogeneity and allows a focused evaluation of outcomes in a real-world setting. Second, detailed plaque characteristics, such as plaque composition or vulnerability assessed by advanced imaging, were not systematically available and therefore could not be incorporated into the analysis. As plaque morphology has been suggested as a potential determinant of embolic risk during CAS,[27] the absence of these data limits mechanistic interpretation of early DWI-detected ischemic lesions. Third, the number of early clinical safety events and restenosis cases was relatively small, limiting statistical power for identifying predictors of these outcomes and precluding robust multivariable analyses. Consequently, analyses of early complications and restenosis should be considered exploratory. Fourth, because preprocedural DWI was not uniformly repeated immediately before CAS in this retrospective cohort, some early DWI-detected ischemic lesions identified after the procedure may have occurred during the interval between the index cerebrovascular event and CAS and therefore could not be definitively distinguished from procedure-related lesions. In addition, assessment of early DWI-detected ischemic lesions was performed by a single reader, precluding formal inter-rater reliability analysis. Finally, while the inclusion of patients treated in the acute or early post-stroke period reflects contemporary clinical practice, the timing of CAS after symptom onset was heterogeneous and not prospectively predefined, which may have influenced periprocedural risk. Despite these limitations, this study provides detailed early imaging and long-term clinical outcome data in a relatively large cohort of symptomatic patients undergoing CAS, offering insight into early DWI-detected ischemic lesions, safety, and functional outcomes in a real-world clinical setting.

CONCLUSION

In this single-center study of patients with symptomatic carotid artery stenosis, CAS was associated with low periprocedural complication rates and favorable 1-year clinical outcomes. New ischemic lesions detected on early DWI were relatively common but were not independently associated with long-term functional outcome. These findings suggest that, when performed in experienced centers, CAS can be a safe and effective revascularization strategy for selected symptomatic patients, including those treated in the acute or early post-stroke period.

SUPPLEMENTARY MATERIAL

Supplementary material related to this article can be found online at https://doi.org/10.5469/neuroint.2026.00192.

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Ethics Statement
This study was approved by the Institutional Review Board of the Gangnam Severance Hospital (3-2023-0463), which waived the requirement for informed consent. We anonymized patient information that could identify an individual.

Conflicts of Interest
SHS and KDS have been the editor-in-chief and editor of the *Neurointervention* since 2022 and 2025. No potential conflict of interest relevant to this article was reported.

Author Contributions

Concept and design: KDS, TK, and SHS. Analysis and interpretation: KDS and SHS. Data collection: TK and MS. Writing the article: KDS. Critical revision of the article: KDS. Final approval of the article: KDS, TK, MS, and SHS. Statistical analysis: KDS. Obtained funding: none. Overall responsibility: SHS.

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Supplementary Table 1. Univariable logistic regression analysis of factors associated with early ischemic lesions on diffusion-weighted imaging

Variable	ORs (95% CI)	P-value
Sex	0.455 (0.193–1.068)	0.071
Age	0.980 (0.940–1.021)	0.332
Hypertension	1.279 (0.607–2.697)	0.517
Diabetes mellitus	0.571 (0.292–1.115)	0.101
Vascular disease	0.983 (0.486–1.988)	0.962
Atrial fibrillation	4.370 (1.180–16.174)	0.027
Smoking	0.818 (0.424–1.580)	0.550
Total cholesterol	1.001 (0.993–1.009)	0.782
HDL-C	1.000 (0.968–1.033)	0.999
LDL-C	1.002 (0.993–1.011)	0.655
Inadequate antiplatelet therapy	0.181 (0.041–0.793)	0.023
IV tPA	0.161 (0.021–1.249)	0.081
Lesion diameter	1.340 (0.779–2.306)	0.290
Degree of stenosis	0.983 (0.954–1.014)	0.277
Pre-balloon angioplasty	0.975 (0.433–2.194)	0.951
Post-balloon angioplasty	0.622 (0.308–1.253)	0.184
ΔSBP	1.060 (0.934–1.203)	0.366

OR, odds ratio; CI, confidence interval; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; IV tPA, intravenous tissue plasminogen activator; SBP, systolic blood pressure.

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