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Clinical efficacy and safety evaluation of intravenous thrombolysis combined with carotid artery stenting in the treatment of acute cerebral infarction

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Abstract

Objective: To evaluate the clinical efficacy and safety of intravenous thrombolysis (IVrtPA) combined with carotid artery stenting (CAS) in the treatment of acute cerebral infarction (ACI). *Methods:* We conducted a single-center retrospective cohort of consecutive adults with anterior-circulation large-vessel occlusion (LVO) and ipsilateral carotid disease between March 2021 and March 2023. Patients receiving intravenous thrombolysis (IVT; alteplase 0.9 mg/kg; 10% bolus then 60-min infusion) plus mechanical thrombectomy (MT) were classified as the control group; those additionally undergoing carotid artery stenting (CAS) for flow-limiting extracranial internal carotid artery (ICA) lesions comprised the intervention group. The primary outcome was good functional outcome (modified Rankin Scale [mRS] 0–2) at 90 days. Safety outcomes were intracranial hemorrhage (ICrH) within 24 h and cumulative ICrH through 7 days. Secondary outcomes included 30-day reinfarction, 90-day all-cause mortality, and 12-month stent patency (duplex/CTA). *Result:* Among 120 patients (intervention n=40; control n=80), the 90-day mRS 0–2 rate was 70% (28/40) vs 50% (40/80) (P=0.037). Day-7 NIHSS improvement was larger with IVT+MT+CAS (8.03 ± 1.15 vs 5.39 ± 2.07; P<0.001). ICrH at 24 h (10.0% vs 7.5%) and cumulative ICrH through 7 days (10.0% vs 7.5%) did not differ significantly. Thirty-day reinfarction and 90-day mortality showed no statistically significant differences. Twelve month stent patency was 90% (36/40).
Conclusion: In LVO with significant carotid disease, adding CAS to IVT+MT was associated with improved early neurological recovery and high 12-month stent patency without an excess of early ICrH; confirmation in larger, multicenter cohorts is warranted.

Keywords: Intravenous thrombolysis, carotid artery stenting, acute cerebral infarction, clinical efficacy, safety evaluation

INTRODUCTION

Acute cerebral infarction (ACI) is one of the major diseases with high mortality and disability rates worldwide, and has brought serious burdens on patients' quality of life and socioeconomic status.[1] The pathogenesis of ACI is mainly due to the sudden blockage of cerebral blood vessels, which leads to local brain tissue ischemia and necrosis, and then causes neurological dysfunction.[2] With the acceleration of population aging, the incidence of ACI has been increasing annually. Effectively treating ACI has thus become a prominent research focus and a significant challenge in the field of neurology.

Intravenous thrombolytic therapy is currently recognized as the standard treatment for ACI. Especially if it is implemented within 4.5 hours after onset, it can significantly improve patient prognosis. Intravenous thrombolysis (IVrtPA) injects thrombolytic drugs to dissolve the blood clots that cause cerebral infarction and replenish the brain's blood supply.[3] However, the efficacy of IVrtPA is limited by various factors such as the onset time window, lesion location, and thrombus size, and there is a risk of intracranial hemorrhage (ICrH), which limits its widespread

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application.[4] Carotid artery stenting (CAS), as a minimally invasive interventional treatment, has gradually occupied an important position in the treatment of ACI. CAS restores vascular patency by implanting a stent into the narrowed or occluded segments of carotid artery, thereby increasing blood flow to the ischemic region. This intervention is particularly suitable for individuals with carotid artery stenosis and effectively reduces the risk of recurrent stroke.[5,6] Although CAS has shown certain advantages in the handling of ACI, its safety and effectiveness in early applications still need to be further verified. Currently, the combined treatment strategy of IVrtPA and CAS is believed to offer potential advantages, such as extending the treatment time window, minimizing brain tissue damage, and improving clinical prognosis. However, the safety concerns associated with this combined approach, including the risk of IH, reperfusion injury, and stent-related complications, require further investigation. Additionally, there is no definitive conclusion regarding the adaptability and efficacy of this combined treatment regimen across different patient subgroups, such as elderly individuals and those with chronic conditions like diabetes and hypertension. Therefore, this study aims to evaluate the efficacy and safety of IVrtPA combined with CAS in individuals with ACI through a systematic clinical investigation. The study will compare the clinical outcomes of IVrtPA alone versus combined therapy, including neurological recovery, all-cause mortality, reinfarction rate, and the incidence of hemorrhagic complications. The objective is to identify the optimal treatment strategy and provide a robust evidence-based foundation for clinical practice.

METHODS

Figure 1 shows the flow chart of this research.

Study subjects

The sum of 120 ACI individuals admitted to our hospital from March 2021 to March 2023 were retrospectively selected as observation subjects and separated into intervention group (IVT+MT+CAS), control group (IVT+MT) according to the treatment plan. There was no statistically significant difference between the two patient groups' general information (Table 1). The current study was approved by the Ethics Committee of the General Hospital of Western Theater Command (WGH202501032); informed consent waived for retrospective de-identified data.

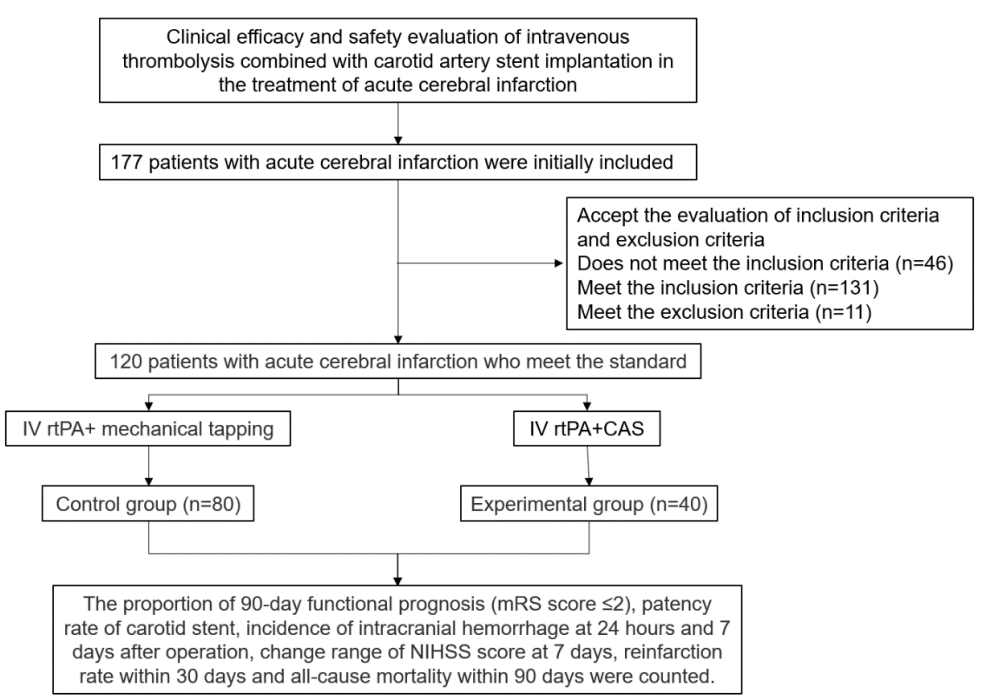

Figure 1. Research flow chart.

Table 1: Baseline characteristics and workflow metrics of patients

Variable	Intervention group (n=40)	Control group (n=80)	P value
Age, years, mean ± SD	67.2 ± 9.5	66.4 ± 10.1	0.62
Male sex, n (%)	26 (65.0)	49 (61.3)	0.70
Hypertension, n (%)	25 (62.5)	52 (65.0)	0.79
Diabetes mellitus, n (%)	14 (35.0)	26 (32.5)	0.81
Atrial fibrillation, n (%)	9 (22.5)	21 (26.3)	0.65
Hyperlipidemia, n (%)	11 (27.5)	24 (30.0)	0.79
Smoking, n (%)	18 (45.0)	34 (42.5)	0.82
Baseline NIHSS score, median (IQR)	15 (12–18)	15 (12–17)	0.87
ASPECTS, median (IQR)	8 (7–9)	8 (7–9)	0.94
Large vessel occlusion site, n (%):			
– ICA terminus	12 (30.0)	22 (27.5)	0.78
– MCA M1	20 (50.0)	42 (52.5)	0.82
– MCA M2	8 (20.0)	16 (20.0)	1.00
*Tandem occlusion, n (%) **	**18 (45.0)**	**22 (27.5)**	**0.066**
Ipsilateral carotid stenosis (NASCET), n (%):			
– 50–69%	11 (27.5)	23 (28.8)	0.88
– 70–89%	19 (47.5)	38 (47.5)	1.00
– 90–99%/occlusion	10 (25.0)	19 (23.7)	0.89
Baseline systolic BP, mmHg, mean ± SD	152 ± 18	149 ± 17	0.36
Baseline diastolic BP, mmHg, mean ± SD	88 ± 12	87 ± 11	0.57
Workflow times, median (IQR), min:			
– Onset-to-CT	42 (35–50)	43 (36–52)	0.71
– Onset-to-IVT	98 (85–110)	95 (83–108)	0.62
– Door-to-needle (DNT)	47 (40–55)	46 (39–54)	0.80
– Onset-to-puncture	175 (160–190)	172 (158–188)	0.69
– Door-to-puncture (DTP)	125 (112–138)	123 (110–136)	0.66
– Door-to-reperfusion (DTR)	158 (140–175)	155 (138–172)	0.62
Acute antithrombotic strategy, n (%):			
– SAPT (aspirin or clopidogrel)	6 (15.0)	14 (17.5)	0.72
– DAPT (aspirin + clopidogrel)	22 (55.0)	44 (55.0)	1.00
– Tirofiban bridging†	12 (30.0)	22 (27.5)	0.78

Note: Values are reported as mean ± SD, median (IQR), or n (%). Tandem occlusion was defined as extracranial cervical ICA stenosis/occlusion with concurrent intracranial LVO (ICA terminus or MCA). Carotid stenosis severity was graded by NASCET. Patients with 50–69% stenosis were considered for acute stenting only if the extracranial lesion was angiographically flow-limiting and/or collateral support was inadequate. P values were calculated using χ^2 or Fisher's exact test for categorical variables and t test or Mann–Whitney U test for continuous variables, as appropriate.

Inclusion criteria were: (1) Adults with anterior-circulation LVO confirmed by CTA/MRA/DSA and CT/MRI; (2) Individuals were eligible for intravenous thrombolytic therapy; (3) Key outcome data (90-day mRS) available.

Exclusion criteria were: (1) patients with concurrent cerebral hemorrhage; (2) patients with a history of craniocerebral trauma; (3) patients with concurrent urinary tract bleeding, other hemorrhagic diseases, infectious diseases, and other organ diseases; (4) Absence of key outcome data (e.g., day-90 mRS).

Treatment options

Based on the patient's imaging findings, clinical status, and current acute stroke treatment guidelines, mechanical thrombectomy is preferred over CAS for patients without significant carotid stenosis and for whom mechanical thrombectomy is expected to effectively restore cerebral blood flow.

Surgical strategy

Treatment followed an institutional algorithm. Intracranial reperfusion was prioritized first. Carotid artery stenting (CAS) was performed for ≥70% NASCET stenosis, or for extracranial ICA lesions deemed flow-limiting on angiography (e.g., delayed antegrade flow, poor distal opacification), especially in tandem occlusions, defined as concomitant extracranial cervical ICA stenosis/occlusion with intracranial LVO (ICA terminus or MCA). Tandem occlusions were present in the intervention group (n=18/40) and the control group (n=22/80). Importantly, patients with 50–69% NASCET stenosis were considered for acute stenting only when the lesion was angiographically flow-limiting in a tandem setting and/or collateral support was inadequate, rather than based on percentage stenosis alone. In patients with non-patent anterior communicating artery and extracranial stenosis jeopardizing distal perfusion, stenting of the extracranial lesion was indicated. For patients who had received IVT, when hemorrhagic risk was judged high or when extracranial stenosis was due to dissection, simple balloon angioplasty or deferral of stenting was undertaken. This approach was especially applicable in cases with good collateral circulation. Distal intracranial occlusions were managed with thrombectomy using a stent retriever (e.g., Solitaire AB, EV3, USA).

Postoperative medication

For patients undergoing emergent extracranial CAS, tirofiban was administered as a weight-based regimen: 25 μg/kg intravenous bolus over 3 minutes, followed by continuous infusion at 0.15 μg/kg/min for 12–24 hours. After 24-hour follow-up imaging excluded ICrH, therapy was transitioned to dual antiplatelet therapy (DAPT) with aspirin 100 mg/day plus clopidogrel 75 mg/day. CYP2C19 genotyping was not routinely performed. For patients who did not receive primary stenting during the acute phase, DAPT was initiated 24 hours after IVT.

Observation indicators

(1) The National Institutes of Health Stroke Scale (NIHSS) [7] is a standardized tool for assessing the degree of neurological deficit in individuals with acute stroke. The scale covers multiple neurological functions such as level of visual field, eye movement, consciousness, facial paralysis, limb movement, ataxia, language ability, dysarthria and neglect. From 0 (no neurological impairment) to 42 (the most severe neurological deficiency), the NIHSS scales from 0 to 42. Higher scores correspond to greater stroke severity.

(2) The Alberta Stroke Program Early CT Score (ASPECTS) [8] is a 10-point quantitative tool designed to evaluate early ischemic changes in the cerebral hemisphere using non-contrast CT scans in individuals with acute ischemic stroke, particularly those affecting the middle cerebral artery (MCA) territory. The cerebral hemisphere is divided into 10 specific regions, with each normal (non-affected) region scoring 1 point and each abnormal (ischemic or infarcted) region scoring 0 points.

(3) The modified Rankin Scale (mRS) [9] is a widely adopted tool for assessing the functional prognosis of patients following a stroke. It primarily evaluates the level of dependency or incapacity in day-to-day activities. The mRS score ranges from 0 to 6, described as follows: 0: No signs or symptoms 1. Despite modest symptoms, there is no discernible handicap; all daily tasks may be performed; 2. A little impairment; capable of doing everyday duties without help but unable to carry out all prior activities on their own; 3. Moderately disabled; able to walk on their own but needs some assistance; 4: Moderately severe impairment; needs help with everyday tasks and is unable to walk on their own; 5. Severe impairment, bedridden, and in need of all-encompassing care; **6:** Death.

(4) The 90-day good functional prognosis rate (mRS score ≤ 2), the change in NIHSS score at 7 days, the incidence of IH 24 hours and 7 days after surgery, the reinfarction rate within 30 days, and the all-cause mortality rate within 90 days were calculated for the two groups of patients.

Statistical analysis

The statistical program SPSS 21.0 was used. Continuous variables were assessed for normality and are reported as mean ± SD or

median (IQR), as appropriate. Between-group comparisons were performed using the Student's t test or Mann–Whitney U test for continuous variables and the χ^2 test or Fisher's exact test for categorical variables, as appropriate. Two-sided P<0.05 was considered statistically significant.

In addition, to account for potential confounding, multivariable regression analyses were performed. A multivariable logistic regression model was used to estimate the association between treatment strategy (IVT+MT+CAS vs IVT+MT) and good functional outcome at 90 days (mRS 0–2), adjusting for age, sex, baseline NIHSS, ASPECTS, occlusion site, NASCET stenosis category, atrial fibrillation, and workflow time metrics (onset-to-IVT and door-to-reperfusion time). For early neurological outcomes, multivariable linear regression models (ANCOVA framework) were fitted for (i) day-7 NIHSS and (ii) NIHSS improvement from baseline, with baseline NIHSS and the same covariates included as adjusters.

RESULTS

Baseline data

Baseline demographic, clinical, imaging, and workflow characteristics were comparable between the two groups (Table 1), with no statistically significant differences across prespecified variables, including age, sex, vascular risk factors, baseline NIHSS and ASPECTS, occlusion site, NASCET-graded ipsilateral carotid stenosis, tandem occlusion, and treatment time metrics (all P>0.05).

Comparison of good functional prognosis rate (mRS score ≤ 2) at 90 days and improvement of NIHSS score at 7 days between the two groups

This study evaluated and compared neurological recovery and long-term outcomes in the intervention group (IVT+MT+CAS) and the control group (IVT+MT) at 7 and 90 days post-treatment. Day-90 mRS scores were ascertained via outpatient clinic visits or structured telephone interviews; analyses were conducted using available cases without imputation.

At 90 days, patients in the intervention group demonstrated a significantly higher proportion of good functional outcome (mRS ≤2) compared with the control group (70% vs. 50%, P=0.037). To enhance transparency, the entire distribution of mRS scores (0–6) is displayed in Figure 2, rather than only dichotomized outcomes.

At the 7-day time point, patients in the intervention group exhibited a greater mean improvement in NIHSS scores compared with controls (mean change from baseline: 8.03 ± 1.15 vs 5.39 ± 2.07 points, P<0.001). Consistently, the mean NIHSS at day 7 (lower scores indicate better neurological status) was 6.53 in the intervention group versus 8.57 in the control group, aligning with baseline severity and the observed magnitude of improvement.

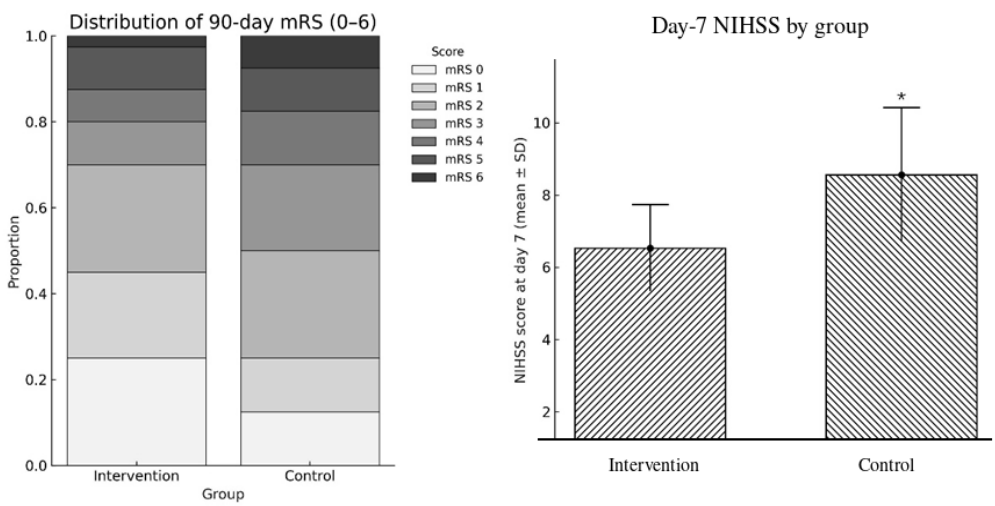

Figure 2. Distribution of 90-day mRS scores (0–6) and day-7 NIHSS (mean ± SD; lower is better) in the intervention (IVT+MT+CAS) and control (IVT+MT) groups. The intervention group had a higher 90-day mRS 0–2 rate (70% vs 50%, P=0.037) and a lower day-7 NIHSS (6.53 vs 8.57), consistent with greater NIHSS improvement from baseline (8.03 ± 1.15 vs 5.39 ± 2.07 points; P<0.001).

Collectively, these findings support a potential benefit of adding CAS to IVT+MT for early neurological recovery, as shown in Figure 2.

Multivariable analyses showed that, after adjustment for age, sex, baseline NIHSS, ASPECTS, occlusion site, NASCET category, atrial fibrillation, and workflow times, the addition of CAS remained associated with higher odds of good functional outcome at 90 days (adjusted OR 6.11, 95% CI 1.51–24.66, P=0.011; Table S1). Similarly, in the adjusted model for early neurological status, the intervention group had a lower day-7 NIHSS (adjusted β −1.87, 95% CI −2.49 to −1.26, P<0.001; Table S1) and greater NIHSS improvement (adjusted β 1.87, 95% CI 1.26–2.49, P<0.001; Table S1). Given the limited number of ICrH events (n=10), adjusted modeling for hemorrhage outcomes was not performed and results are presented descriptively.

Comparison of intracranial hemorrhage at 24 h and cumulative to 7 d

The incidence of intracranial hemorrhage (ICrH) within 24 hours was 4/40 (10.0%) in the intervention group (IVT+MT+CAS) and 6/80 (7.5%) in the control group (IVT+MT), with no statistically significant difference (P=0.640). Because ICrH was analyzed cumulatively through day 7 and no additional events occurred after 24 hours, the 7-day cumulative incidence equaled the 24-hour incidence in both groups (4/40 [10.0%] vs 6/80 [7.5%], P=0.640). See Table 2 and Figure 3.

Comparison of reinfarction rate within 30 days and all-cause mortality within 90 days involving the two groupings

The 30-day reinfarction rate was 5.0% (2/40) in the intervention group versus 6.25% (5/80) in the control group (P=0.78), and the 90-day all-cause mortality was 1.25% (1/40) versus 7.5% (6/80) (P=0.27), without statistically significant differences (Figure 4).

DISCUSSION

ACI is a condition characterized by the obstruction of cerebral blood vessels, leading to ischemia and hypoxia of brain tissue. If not promptly treated, it can result in brain tissue necrosis and may pose life-threatening risks in severe cases.[10,11] Currently, the primary treatment strategies for ACI in clinical practice include IVrtPA, endovascular intervention, and carotid artery stent implantation. IVrtPA involves the dissolution of blood clots and the restoration of cerebral blood flow through the administration of thrombolytic agents, such as recombinant tissue plasminogen activator (rt-PA). The advantages of IVrtPA are its simplicity of administration and rapid onset of action. This treatment can promptly restore cerebral blood flow, thereby reducing brain tissue damage and improving patient outcomes.[12] Despite its advantages, IVrtPA presents several limitations. Notably, it has a narrow treatment time window, around 4.5 hours after the beginning of symptoms, though advanced imaging may extend the window in selected patients; mechanical thrombectomy can be performed up to 24 hours with appropriate selection. Additionally, IVrtPA is connected to a significant risk of bleeding complications, particularly ICrH, which poses a grave danger to patient safety. These drawbacks limit the widespread adoption of IVrtPA as a standalone treatment for ACI.[13] Arterial endovascular intervention in which a catheter is inserted into the blood vessel to directly reach the thrombus site and remove the thrombus using a mechanical device. The advantage of arterial thrombectomy is that it has a wide range of applications, especially for patients with large blood vessel obstruction, and has a more significant effect in restoring blood flow.[14] However, arterial thrombectomy also has its limitations, such as complex surgical procedures, high technical requirements, and the need for hospitals with appropriate equipment and professionals. In addition, there is also a risk of bleeding during the operation, and the cost is

Table 2: Intracranial hemorrhage (ICrH) within 24 h and cumulative through day 7

Time point	Intervention (IVT+MT+CAS), n/N (%)	Control (IVT+MT), n/N (%)	P value
Within 24 h	4/40 (10.0)	6/80 (7.5)	0.640
Cumulative through day 7	4/40 (10.0)	6/80 (7.5)	0.640

No additional ICrH events occurred after 24 h; therefore, cumulative incidence through day 7 equaled the 24-h incidence.

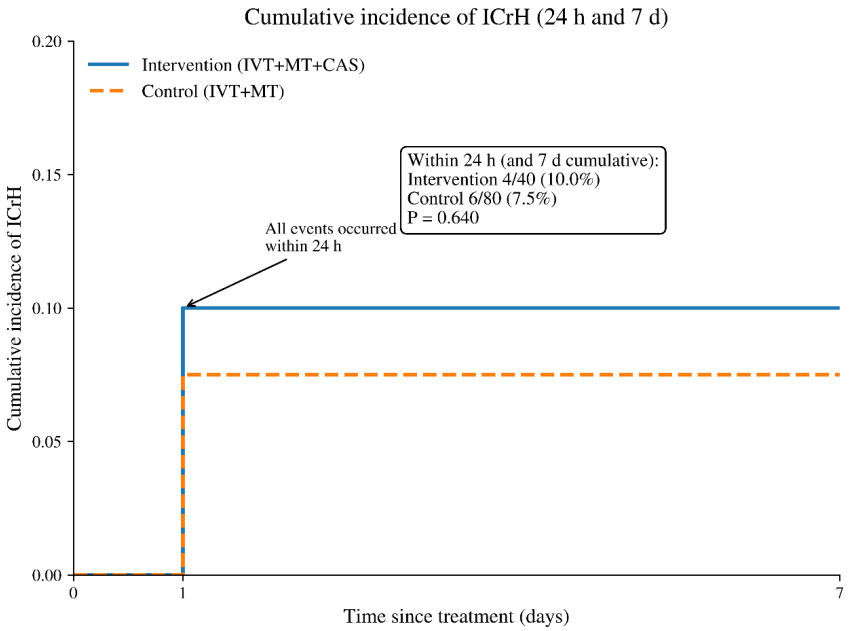

Figure 3. Cumulative incidence of intracranial hemorrhage (ICrH) within 7 days after treatment. ICrH occurred in 4/40 (10.0%) patients in the intervention group and 6/80 (7.5%) in the control group, with all events occurring within the first 24 h and no additional events thereafter; therefore, the curves show a single step increase at 24 h that reflects multiple events.

high. CAS implantation is a method of implanting a stent into a narrowed carotid artery to keep the blood vessel open and prevent thrombosis. CAS offers the significant advantage of effectively preventing the recurrence of cerebral infarction while incurring relatively minimal surgical trauma.[15]

This study investigates the clinical efficacy and safety of combining IVrtPA with CAS (IVrtPA + CAS) in the treatment of ACI. All CAS patients also underwent thrombectomy for large vessel occlusion, and the control group also comprised

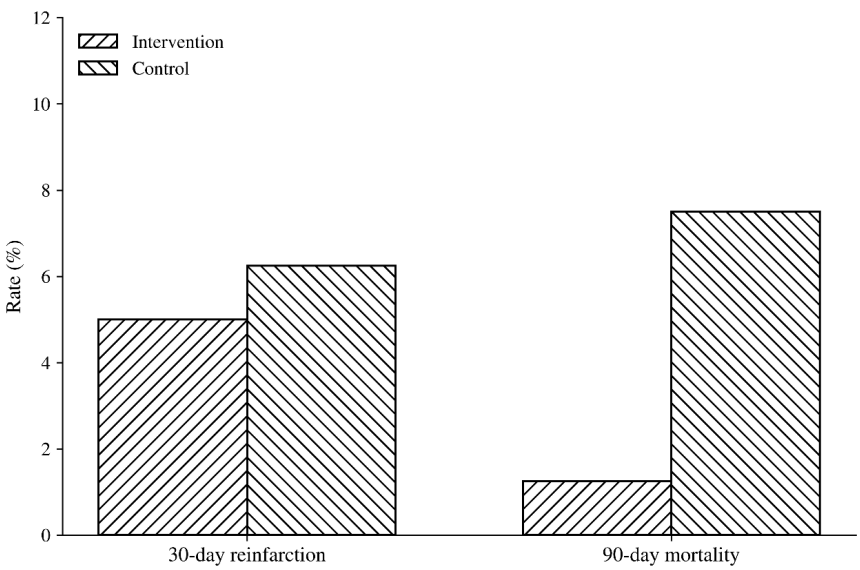

Figure 4. Comparison of reinfarction rate within 30 days and all-cause mortality within 90 days between the two groups.

patients with LVO and ipsilateral carotid stenosis; NASCET strata were reported to demonstrate comparability, though residual confounding cannot be excluded. The results demonstrate that this combined therapy enhances neurological recovery. Day-90 mRS outcomes were confirmed by outpatient or telephone follow-up; analyses used available data without imputation. Figure 2 illustrates the full mRS 0–6 distribution, showing that 70% in the intervention group versus 50% in the control group achieved mRS ≤2 (P=0.037). The NIHSS scores of the RG significantly improved at 7 days post-treatment in contrast to the CG. This suggests that the combined therapy of IVrtPA and CAS plays a crucial part in the neurological recovery of patients with ACI. The observed improvement may be closely related to the synergistic effects of IVrtPA and CAS. IVrtPA rapidly dissolves thrombi, thereby restoring blood flow to ischemic cerebral regions within a short timeframe. However, IVrtPA alone is associated with a risk of reocclusion, especially in arteries with significant stenosis.[16] CAS addresses this limitation by implanting a stent in the carotid artery to mechanically dilate the stenotic segment, ensuring sustained and smooth blood flow while minimizing the risk of reocclusion.[17,18] Therefore, the combined therapy not only promptly reestablishes cerebral perfusion but also enhances long-term vascular patency, contributing to improved neurological outcomes. This dual approach leverages the rapid clot resolution provided by thrombolysis and the structural stabilization offered by stenting, resulting in a more effective and durable restoration of cerebral blood flow.

Secondly, the reinfarction rate within 30 days was considerably reduced in the RG, further substantiating the pivotal role of CAS in mitigating the risk of recurrent cerebral infarction. Carotid artery stenosis is a major risk factor for reinfarction[19], and CAS effectively decreases the likelihood of thrombus reformation by dilating the stenotic segment. Additionally, the antiplatelet medications administered in this study may have contributed to the reduced thrombosis risk, providing a synergistic effect alongside CAS. These findings suggest that the combination of IVrtPA and CAS represents a more optimal treatment strategy for patients with ACI and concurrent carotid artery stenosis.

Importantly, reinfarction and mortality differences did not reach statistical significance (P>0.05), and conclusions were worded accordingly. Furthermore, while these findings suggest feasibility and potential safety advantages of IVrtPA+CAS, the analyses were unadjusted and cannot establish causality. We acknowledge this limitation and interpret the results primarily as feasibility and safety signals, requiring validation in larger multicenter cohorts with confounder adjustment.[20]

Despite the promising findings, it is important to recognise the many limitations of this research. Firstly, it is a single-center retrospective analysis with a relatively small sample size, which may introduce selection bias and limit the generalizability of the results. Secondly, the study did not perform a detailed subgroup analysis to assess the efficacy of the combined treatment in specific patient populations, such as elderly individuals or those with comorbidities like diabetes and hypertension. Future research should investigate how these factors influence treatment outcomes. Additionally, the follow-up period in this study was relatively short, preventing the evaluation of the long-term prognosis and sustained efficacy of the combined therapy. Consequently, larger-scale, multicenter randomized controlled trials are necessary to validate these findings, improve treatment plans and patient selection standards. Future studies should also aim to explore the application of IVrtPA combined with CAS across diverse patient groups and assess its long-term safety and effectiveness through extended follow-up periods, thereby providing more comprehensive evidence to support clinical practice.

In conclusion, the combination of IVrtPA and carotid artery stent implantation demonstrates significant clinical efficacy and maintains a high safety profile in the treatment of ACI. For individuals presenting with ACI accompanied by carotid artery stenosis, this combined therapeutic approach may offer a more effective treatment option compared to IVrtPA alone. These findings support the integration of combined therapy into clinical practice as a viable strategy to enhance patient outcomes in this patient population.

DISCLOSURE

Ethics: The current study was approved by the Ethics Committee of the General Hospital of Western Theater Command (approval number WGH202501032). Due to the retrospective design and anonymized data, written informed consent was waived by the Ethics Committee.

Data availability: The datasets used and/or

analyzed during the current study are available from the corresponding author on reasonable request.

Financial support: None

Conflict of interests: None

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Table S1. Multivariable regression analyses

Predictor	Adjusted OR (95% CI) Good outcome	P value	Adjusted β (95% CI) Day-7 NIHSS	P value	Adjusted β (95% CI) NIHSS improvement	P value
ASPECTS, per point	1.09 (0.62–1.92)	0.759	0.14 (-0.14 to 0.42)	0.334	-0.14 (-0.42 to 0.14)	0.334
Occlusion site: MCA M1 (ref: ICA terminus)	0.35 (0.00–105.58)	0.717	1.12 (-0.27 to 2.51)	0.114	-1.12 (-2.51 to 0.27)	0.114
Occlusion site: MCA M2 (ref: ICA terminus)	0.16 (0.00–209.11)	0.618	0.06 (-1.80 to 1.92)	0.952	-0.06 (-1.92 to 1.80)	0.952
NASCET stenosis: 70–89% (ref: 50–69%)	0.06 (0.00–19.38)	0.345	-1.58 (-3.00 to -0.17)	0.028	1.58 (0.17 to 3.00)	0.028
NASCET stenosis: 90–99%/occlusion (ref: 50–69%)	0.00 (0.00–1.38)	0.062	-1.12 (-2.84 to 0.61)	0.204	1.12 (-0.61 to 2.84)	0.204
Door-to-reperfusion time, per min	1.00 (0.98–1.02)	0.757	-0.01 (-0.02 to 0.00)	0.156	0.01 (-0.00 to 0.02)	0.156
Age, per year	0.98 (0.93–1.04)	0.492	-0.00 (-0.03 to 0.02)	0.797	0.00 (-0.02 to 0.03)	0.797
Atrial fibrillation	1.83 (0.45–7.49)	0.401	0.10 (-0.66 to 0.87)	0.790	-0.10 (-0.87 to 0.66)	0.790
Baseline NIHSS, per point	1.12 (0.91–1.39)	0.284	-0.09 (-0.20 to 0.02)	0.129	1.09 (0.98 to 1.20)	<0.001
Onset-to-IVT time, per min	1.02 (0.98–1.06)	0.352	-0.00 (-0.02 to 0.02)	0.916	0.00 (-0.02 to 0.02)	0.916
Male sex	2.04 (0.61–6.89)	0.248	0.08 (-0.58 to 0.75)	0.805	-0.08 (-0.75 to 0.58)	0.805
CAS added (Intervention vs Control)	6.11 (1.51–24.66)	0.011	-1.87 (-2.49 to -1.26)	<0.001	1.87 (1.26 to 2.49)	<0.001

Multivariable models adjusted for age, sex, baseline NIHSS, ASPECTS, occlusion site, NASCET category, atrial fibrillation, and workflow times. Good functional outcome (mRS 0–2 at 90 days) was analyzed using Firth penalized logistic regression. Day-7 NIHSS and NIHSS improvement were analyzed using linear regression with robust standard errors.