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Efficacy and Safety of Acute Carotid Stenting for Tandem Lesions in Acute Ischemic Stroke: A Multicenter, Real-World Registry Cohort Study

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Abstract

Background

Whether to routinely stent extracranial carotid lesions during endovascular thrombectomy (EVT) for anterior circulation tandem lesions remains debated. Because current evidence relies heavily on Western cohorts with different stroke etiologies, we investigated the efficacy and safety of acute extracranial stenting in a real-world Chinese cohort predominantly characterized by atherosclerosis.

Methods

We retrospectively analyzed patients with anterior circulation tandem lesions treated with EVT within 24 hours of onset across seven comprehensive stroke centers in China (July 2021–December 2023). Patients were stratified into acute stenting and non-stenting groups. Multivariable logistic regression was performed to evaluate 90-day functional independence (modified Rankin Scale [mRS] 0–2), 90-day vascular patency (> 50% residual stenosis), and safety outcomes.

Results

Of 142 patients (95.8% atherosclerotic etiology), 113 (79.6%) underwent acute stenting and 29 (20.4%) received non-stenting management, with a higher baseline rate of complete extracranial occlusion in the stent group (69.0% vs. 37.9%, p = 0.002). The stent group achieved a higher rate of 90-day functional independence (61.9% vs. 44.8%). After multivariable adjustment, acute stenting was independently associated with improved 90-day functional independence (adjusted odds ratio [aOR] 3.27, 95% CI 1.24–8.66, p = 0.017), markedly reduced > 50% residual stenosis at 90 days (4.6% vs. 32.1%; aOR 0.04, 95% CI 0.01–0.24, p < 0.001), and lower odds of overall in-hospital complications (31.2% vs. 52.0%; aOR 0.34, 95% CI 0.12–1.00, p = 0.049). Complete reperfusion, 48-hour intracranial hemorrhage, and 90-day mortality did not differ significantly between groups.

Conclusion

In this real-world Chinese cohort, acute extracranial stenting during EVT for tandem lesions improved 90-day functional outcomes and vascular patency while reducing in-hospital complications without increasing bleeding or mortality risks, awaiting confirmation from randomized trials.

Introduction

Tandem lesions, characterized by a proximal intracranial occlusion combined with ipsilateral extracranial carotid stenosis (≥ 70%) or complete occlusion, account for 10%–20% of all anterior circulation ischemic strokes[1,2]. Representing a severe hemodynamic challenge, this stroke subtype is typically marked by a

high thrombus burden and compromised antegrade blood flow[3,4]. Consequently, patients with tandem lesions exhibit poorer prognoses and more limited responses to intravenous thrombolysis compared to those with isolated intracranial occlusions[3,5]. Although endovascular thrombectomy (EVT) has become the established standard of care for intracranial large-vessel occlusions, the optimal acute management of the concomitant extracranial lesion remains highly controversial[6]. Specifically, the necessity and safety of performing acute extracranial carotid stenting concomitantly with EVT have yet to be definitively resolved.

This therapeutic dilemma is underscored by existing observational studies and pooled analyses, which have yielded conflicting results regarding the efficacy of acute stenting. On one hand, acute stenting may enhance recanalization durability and promote favorable functional outcomes[7–9]. Conversely, these potential benefits may be offset by an increased risk of intracranial hemorrhage, primarily driven by periprocedural antithrombotic therapy[9–11]. Such inconsistencies in the literature largely stem from methodological limitations, including modest sample sizes, heterogeneous interventional protocols, and an overrepresentation of Western cohorts. Furthermore, cerebrovascular etiology exhibits marked ethnic disparities; notably, large-artery atherosclerosis is significantly more prevalent in Asian populations than in Western populations, where cervical artery dissection is relatively common[12]. As a result, treatment algorithms derived from Western cohorts may not be directly generalizable to Chinese patients[13], highlighting an urgent need for region-specific real-world evidence.

To bridge this critical knowledge gap, we conducted a multicenter, registry-based cohort study in China to evaluate the efficacy and safety of acute extracranial carotid stenting during EVT for anterior circulation tandem lesions. Through this real-world analysis, we aimed to clarify the risk-benefit profile of concomitant stenting and provide clinical evidence to optimize periprocedural decision-making in atherosclerosis-dominant populations.

Methods

Patients and selection criteria

This multicenter, retrospective observational cohort study analyzed data from the Endovascular Treatment of Acute Ischemic Stroke Tandem Lesions Registry across seven comprehensive stroke centers in China (July 2021–December 2023). Consecutive adult patients (≥18 years) with acute anterior circulation tandem lesions—defined as ipsilateral extracranial internal carotid artery (ICA) high-grade stenosis (≥70%) or complete occlusion accompanied by concomitant intracranial ICA terminus or middle cerebral artery (MCA) M1/M2 occlusion—who underwent EVT within 24 hours of symptom onset were included. Key exclusion criteria were isolated extracranial or intracranial lesions, active bleeding, or severe comorbidities (see Supplementary Methods for full criteria). The study protocol was approved by the local ethics committees of all participating centers with informed consent obtained, and the study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cohort studies.

Interventional treatment

All intracranial occlusions were treated using contemporary mechanical thrombectomy devices, including stent retrievers alone, contact aspiration alone, or a combined approach. The choice between acute extracranial stenting and non-stenting (balloon angioplasty alone or thrombectomy without extracranial angioplasty) was at the treating neurointerventionalist's discretion, based on lesion anatomy, elastic recoil, intracranial clot burden, and patient clinical stability. Detailed procedural protocols and definitions of the treatment sequence (antegrade, half-antegrade, or retrograde) are provided in the Supplementary Materials. Periprocedural antithrombotic and antihypertensive medications were tailored according to baseline medication history, prior intravenous thrombolysis, and bleeding risk (Table 1). In the stent group, patients without significant hemorrhagic transformation were transitioned to a standardized 3-month course of dual antiplatelet therapy (DAPT; aspirin plus clopidogrel) to prevent stent thrombosis, whereas patients in the non-stent group received single antiplatelet therapy or anticoagulation per physician discretion without mandatory DAPT.

Variables and outcomes

Baseline demographics, medical history, laboratory indicators, clinical and imaging characteristics, procedural details, and perioperative medications were systematically collected. Anatomically, tandem lesions were classified into four subtypes (Table 1): extracranial ICA high-grade stenosis/occlusion with concomitant (1) MCA M1 segment occlusion, (2) MCA M2 segment occlusion, (3) ICA terminus (carotid T) occlusion, or (4) multi-segment intracranial occlusion, defined as two or more occlusive lesions within the same vascular territory.

The primary efficacy endpoint was 90-day functional independence, defined as a modified Rankin Scale (mRS) score of 0–2. Secondary efficacy endpoints included 90-day excellent outcome (mRS 0–1), complete post-procedural reperfusion (modified Treatment in Cerebral Ischemia [mTICI] score of 3), functional independence (mRS 0–2) at discharge and at 30 days, and 90-day extracranial residual stenosis >50% assessed by carotid duplex ultrasound. Safety endpoints included any intracranial hemorrhage (ICH) within 48 hours (including parenchymal hematoma, subarachnoid hemorrhage, or intraventricular hemorrhage), overall in-hospital complications (including pneumonia, brain herniation, and gastrointestinal bleeding during hospitalization), and 90-day all-cause mortality. Angiographic characteristics, TO subtypes, and ICH findings were adjudicated by experienced neurointerventionalists and senior neurologists.

Statistical analysis

Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range [Q1, Q3]) and compared using the Student's t-test or Mann–Whitney U test (Wilcoxon test), as appropriate. Categorical variables were reported as frequencies and percentages and compared using the Chi-square test or Fisher's exact test when expected cell frequencies were <5.

Multivariable binary logistic regression was performed to evaluate the associations between treatment modality (stent vs. non-stent) and clinical outcomes. Model 1 was unadjusted; Model 2 adjusted for baseline characteristics showing a trend toward difference ($p \leq 0.10$) between groups in bivariate comparisons (creatinine, current or previous drinking, order of surgical approach, baseline degree of ICA stenosis, perioperative antihypertensive drugs, and anticoagulant drugs); and Model 3 adjusted for predefined clinical and radiological variables known to influence stroke outcomes, including creatinine, antiplatelet treatment, baseline NIHSS score, baseline ASPECTS, type of tandem lesions, intravenous thrombolysis (IVT), symptom onset-to-groin puncture time, and procedure time. A stacked bar graph was used to display the distribution of 90-day mRS scores. Exploratory subgroup analyses for the primary endpoint (90-day mRS 0–2) were conducted across prespecified strata—including antihypertensive use (no vs. yes), surgical order (antegrade, half-antegrade, retrograde), baseline ICA stenosis degree (100%, 90%–99%, 80%–89%), and local anesthesia (no vs. yes)—with interaction terms tested to assess treatment effect homogeneity.

Statistical analyses were performed using SPSS version 26.0, with statistical significance set at a two-tailed $p < 0.05$.

Results

Patient population

Of 285 screened patients, 142 were included in the final analysis, comprising 113 (79.6%) in the stent group and 29 (20.4%) in the non-stent group (Figure 1). Across the entire cohort, atherosclerosis accounted for 95.8% of extracranial ICA lesions, and baseline clinical severity—including age, NIHSS score, ASPECTS, and intravenous thrombolysis rate—was well balanced between groups (Table 1). However, compared with the non-stent group, the stent group had a significantly higher prevalence of complete (100%) extracranial ICA occlusion (69.0% vs. 37.9%, p=0.002), less frequent use of an antegrade approach (25.7% vs. 58.6%, p=0.003), and higher rates of perioperative antihypertensive (25.7% vs. 6.9%, p=0.041) and anticoagulant medication use (18.6% vs. 0.0%, p=0.008) (Table 1).

Efficacy Outcomes

Functional independence at 90 days (mRS 0–2) was achieved in 61.9% of the stent group versus 44.8% of the non-stent group (Figure 2; unadjusted OR 2.00, 95% CI 0.88–4.57, p=0.10). After multivariable adjustment for confounders, acute stenting was independently associated with significantly improved 90-day functional independence in both Model 2 (aOR 3.00, 95% CI 1.07–8.48, p=0.037) and Model 3 (aOR 3.27, 95% CI 1.24–8.66, p=0.017) (Table 2). Moreover, stenting markedly reduced the risk of >50% extracranial residual stenosis at 90 days compared with non-stenting management (4.6% vs. 32.1%; Model 3: aOR 0.04, 95% CI 0.01–0.24, p<0.001). No significant between-group differences were observed in complete reperfusion (mTICI 3: 49.6% vs. 48.3%, p=0.90), 90-day mRS 0–1, or early functional outcomes at discharge and 30 days (Table 2).

Safety outcomes and subgroup analyses

Overall in-hospital complications were less frequent in the stent group than in the non-stent group (31.2% vs. 52.0%), reaching statistical significance after multivariable adjustment (Model 3: aOR 0.34, 95% CI 0.12–1.00, p=0.049). In contrast, rates of 48-hour intracranial hemorrhage (21.2% vs. 27.6%; Model 3: p=0.26) and 90-day all-cause mortality (7.1% vs. 10.3%; Model 3: p=0.50) were comparable between the two groups (Table 2). Subgroup analyses demonstrated a consistent treatment effect favoring stenting across all prespecified strata (p for interaction > 0.05), with more pronounced benefits observed in patients with complete extracranial ICA occlusion (OR 9.26, 95% CI 1.52–56.54, p=0.016) and those without hypertension (OR 8.19, 95% CI 1.36–49.22, p=0.022) (Figure 3).

Discussion

In this multicenter, real-world Chinese registry study of patients with anterior circulation tandem lesions, acute extracranial carotid stenting during EVT was independently associated with a significantly higher rate of 90-day functional independence (mRS 0–2) and a markedly reduced risk of > 50% extracranial residual stenosis at 90 days. Moreover, concomitant stenting demonstrated a favorable safety profile: it was associated with lower adjusted odds of overall in-hospital complications without increasing the risks of 48-hour ICH or 90-day mortality. Together, these findings support the efficacy, anatomical durability, and safety of acute extracranial stenting in an atherosclerosis-dominant Chinese population.

Current evidence regarding acute stenting for tandem lesions remains divided. While several meta-analyses and pilot trials have linked emergent stenting to improved functional outcomes14-17, post-hoc analyses from Western registries and trials—including TITAN and ESCAPE-NA1—have reported neutral functional results18,19. These discrepancies likely reflect underlying ethnic and etiological differences. Unlike Western cohorts where cervical artery dissection accounts for 20%–30% of tandem lesions and often remodels favorably without stenting, large-artery atherosclerosis accounted for 95.8% of extracranial ICA lesions in our Chinese cohort (with dissection representing only 4.2%). This etiological profile directly explains the approximately 4:1 sample size distribution between the stent and non-stent groups (79.6% vs. 20.4%) in our real-world registry. Notably, baseline complete (100%) extracranial ICA occlusion was nearly twice as prevalent in the stent group as in the non-stent group (69.0% vs. 37.9%). Because severe atherosclerotic occlusion is highly prone to acute elastic recoil and re-occlusion after balloon angioplasty alone, neurointerventionalists were frequently compelled to deploy stents to maintain luminal patency, whereas non-stenting management was mostly confined to lesions with residual patency (80%–99% stenosis). Furthermore, this baseline anatomical imbalance acted as a negative confounder: the greater baseline occlusion severity in the stent group partially masked the treatment benefit in unadjusted analysis (p = 0.10), whereas adjusting for baseline confounders revealed a robust independent association with 90-day functional independence (aOR 3.27, p = 0.017). Although immediate complete reperfusion (mTICI 3) and early functional outcomes did not differ significantly between groups—consistent with several prior retrospective studies20-23 despite contrasting with others24,25—90-day duplex ultrasound confirmed that stenting drastically reduced > 50% residual

stenosis compared with non-stenting management (4.6% vs. 32.1%)21,28,29. Thus, the functional benefit of acute stenting appears to be driven primarily by durable long-term extracranial patency and prevention of subacute re-occlusion rather than immediate angiographic differences.

Regarding safety, earlier observational studies raised concerns that emergent stenting and obligatory antithrombotic therapy might increase hemorrhagic transformation20,24,25. In our cohort, however, 48-hour ICH rates were comparable between the stent and non-stent groups (21.2% vs. 27.6%). This reassuring safety profile was not confounded by prior intravenous thrombolysis (IVT), which was well balanced between groups (35.4% vs. 41.4%). Instead, hemorrhagic risk in tandem lesions appears largely driven by ischemic core vulnerability, blood-brain barrier disruption26, and endothelial injury during mechanical manipulation or angioplasty27, which occurred in both groups. Beyond intracranial bleeding, acute stenting was independently associated with significantly lower odds of overall in-hospital complications (31.2% vs. 52.0%; aOR 0.34) and a numerically lower 90-day mortality rate (7.1% vs. 10.3%), aligning with previous observational studies21. By stabilizing antegrade cerebral perfusion and preventing recurrent cervical carotid re-occlusion, acute stenting may mitigate secondary neurological deterioration, brain herniation, and stroke-associated medical complications during hospitalization.

In exploratory subgroup analyses, no significant treatment-by-subgroup interactions were detected (p for interaction > 0.05 across all strata), indicating a generally consistent benefit of acute stenting across diverse clinical profiles. The more pronounced effect estimates observed in patients with complete extracranial ICA occlusion and those without hypertension further underscore the value of mechanical scaffolding in total occlusive lesions; nevertheless, given the modest stratum sizes and wide confidence intervals, these subgroup signals should be considered strictly hypothesis-generating.

Several limitations warrant consideration. First, because of the retrospective, non-randomized registry design, treatment allocation was at the discretion of the treating neurointerventionalists, resulting in an unbalanced sample size between the stent and non-stent groups (113 vs. 29), and 143 of 285 screened patients were excluded primarily due to incomplete imaging or follow-up data. Although this 4:1 ratio reflects real-world clinical decision-making in a population dominated by atherosclerotic complete occlusions, the small sample size of the non-stent group ($n = 29$) limited statistical power for secondary endpoints and contributed to relatively wide confidence intervals in multivariable and subgroup models. Second, angiographic outcomes and 90-day carotid ultrasound assessments were adjudicated by local investigators rather than an independent core laboratory. Finally, a small proportion of baseline laboratory and procedural variables had missing values, and residual confounding from unmeasured factors—such as detailed collateral circulation grades, plaque morphology, or individualized antiplatelet adjustments—cannot be completely excluded.

Conclusion

In this multicenter, real-world Chinese cohort, acute extracranial carotid stenting during EVT for anterior circulation tandem lesions was independently associated with improved 90-day functional

independence, fewer in-hospital complications, and durable 90-day vascular patency, without increasing the risk of intracranial hemorrhage or mortality. These findings support concomitant extracranial stenting as a safe and effective strategy in atherosclerosis-dominant populations, awaiting definitive confirmation from ongoing randomized controlled trials.

Declarations

Conflict of interest

The authors have declared that they have no conflicts of interest to disclose in relation to this manuscript.

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Author Contribution

Hao Chen, Jingping Sun and Changjuan Zheng contributed to the concept and design, acquisition of data, analysis, and interpretation of data; drafted the article; revised the article critically; and approved the version to be published. Xueli Cai and Hongxing Han contributed to the data supervision and quality control; and approved the version to be published. Ke Wang and Yuzheng Wang contributed to collect data. Tingyu Yi, Wenqiang Cai, Jingwei Li, En Wang, and Wei Hu, serving as the director of the local stroke center, contributed to the original data registration; revised the article critically; approved the version to be published.

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Data Availability

The datasets generated during and/or analyzed during the current study are not publicly available due to patient privacy and ethical restrictions, but are available from the corresponding author on reasonable request.

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Tables

Table 1 and 2 are available in the Supplementary Files section.

Figures

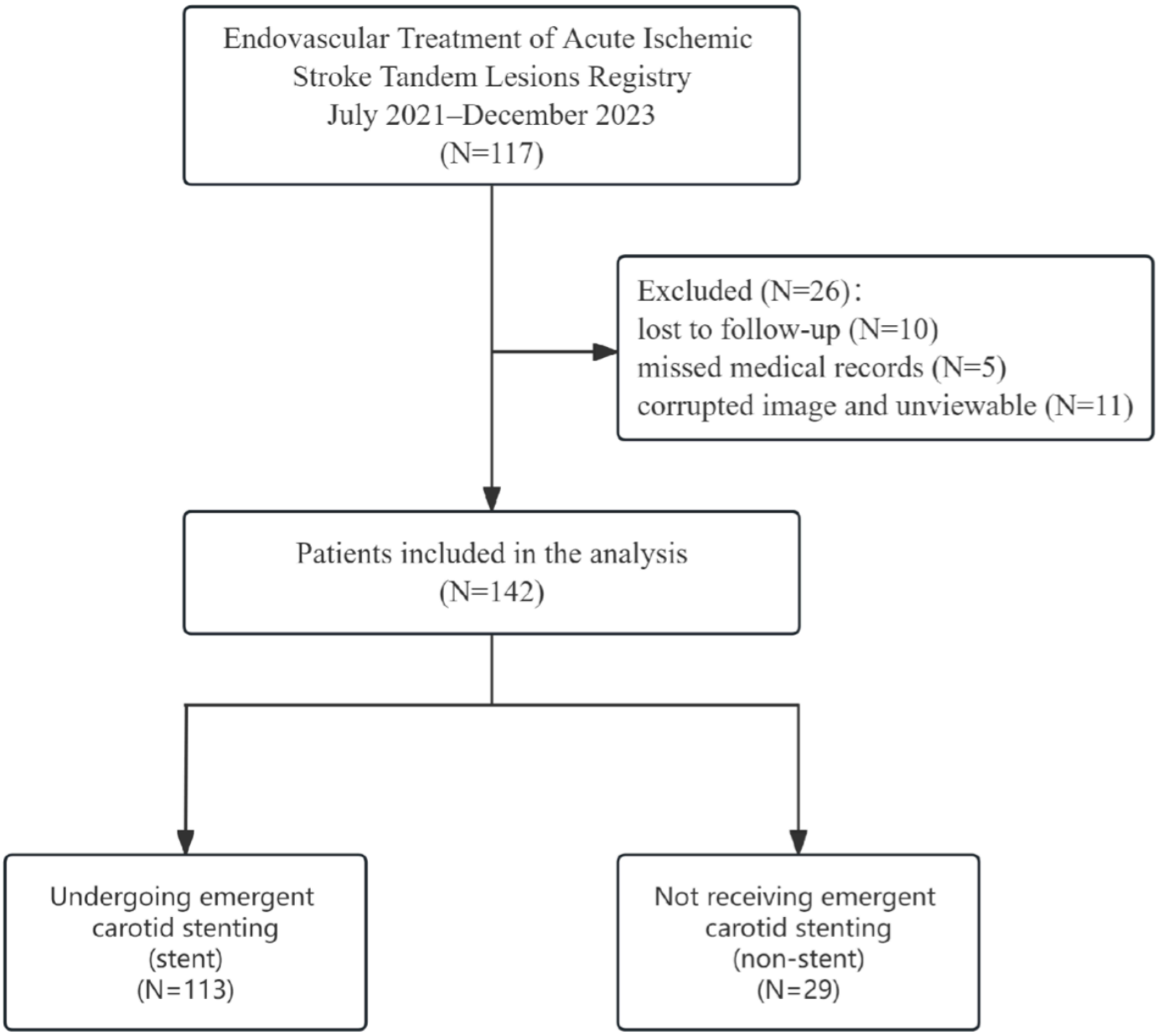


Figure 1

Flow chart of the participant selection.

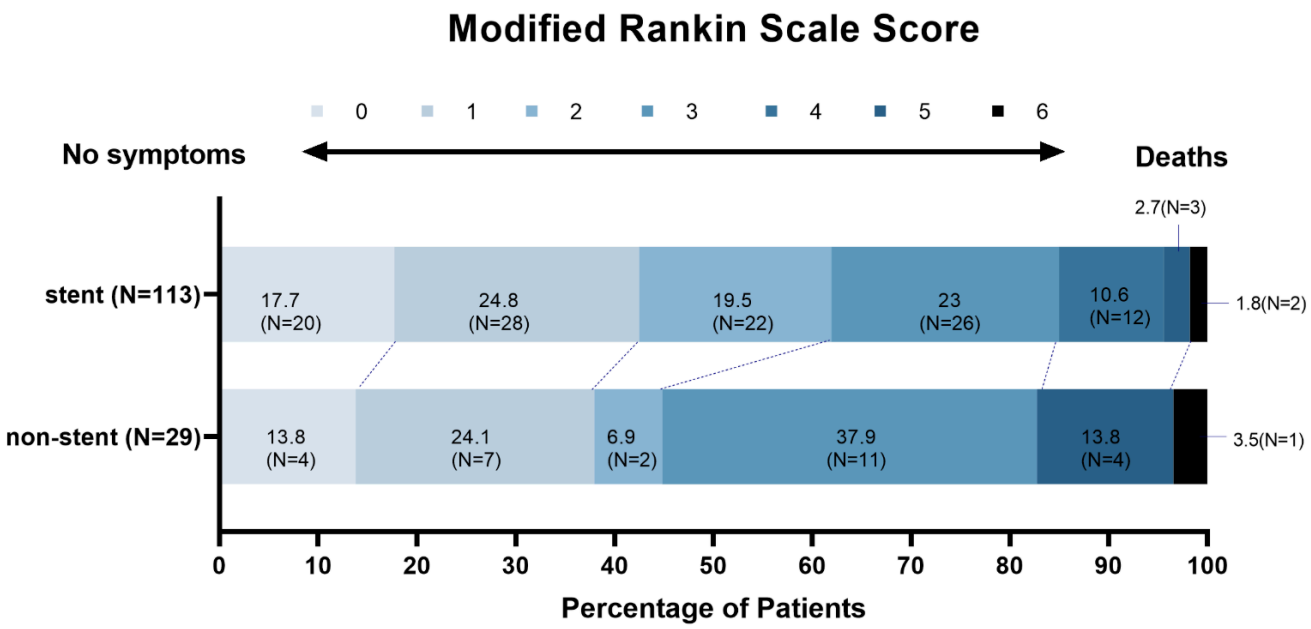


Figure 2

Distribution of modified rankin scale (mRS) score at 90 days post-treatment. Scores range from 0 to 6, with (0) indicating no symptoms; (1) no significant disability; (2) mild disability (patient can manage self-care independently but cannot perform all previous activities); (3) moderate disability (patient requires some assistance but can walk unassisted); (4) moderately severe disability (patient cannot attend to physical needs or walk without assistance); (5) severe disability (patient requires constant care and attention); and (6) death.

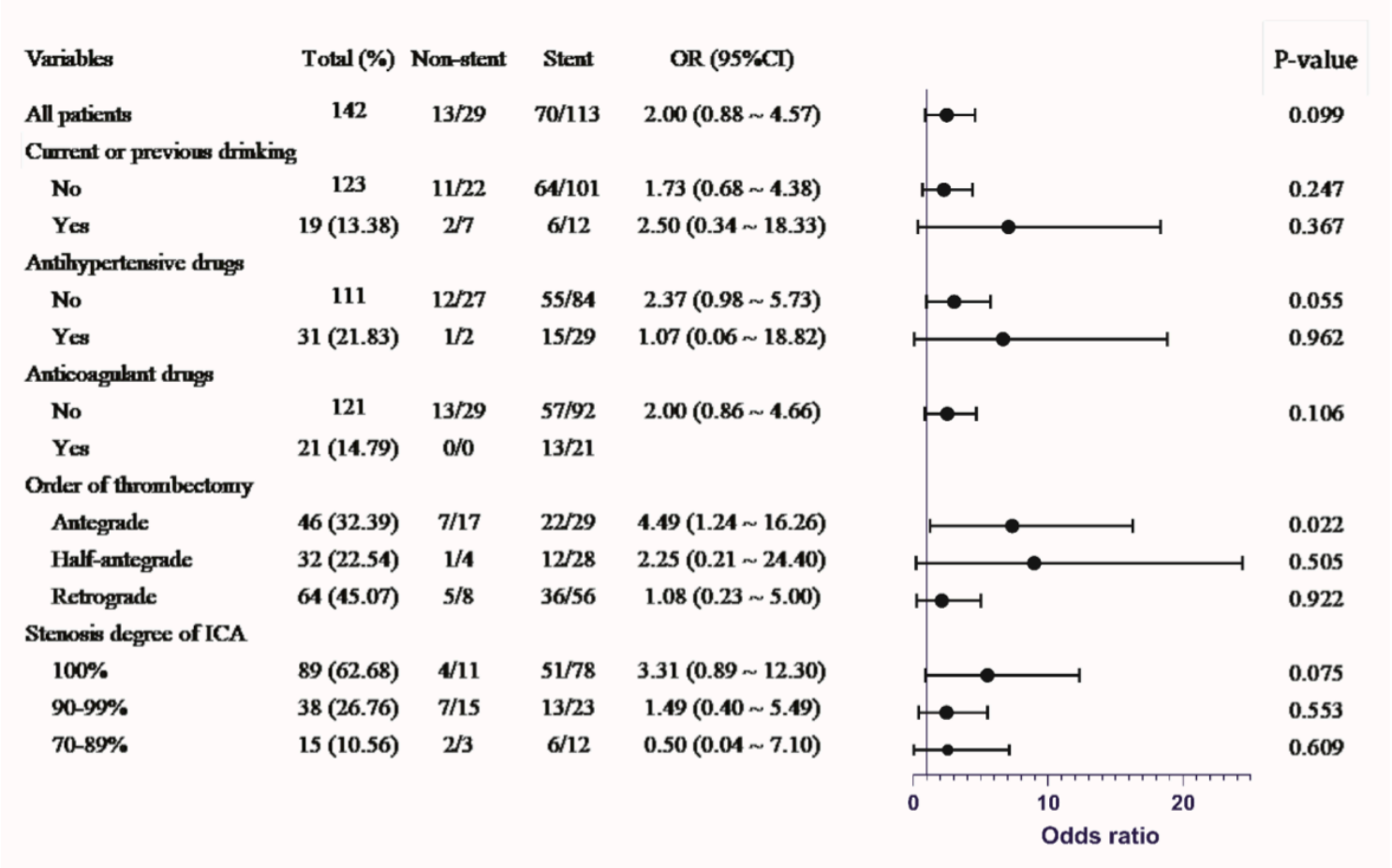


Figure 3

Forest Plot of Subgroup Analyses Comparing Acute Stenting versus Non-Stenting for Favorable Functional Outcomes (90-day mRS 0-2) in Acute Anterior Circulation Tandem Lesions. ICA, internal carotid artery

Supplementary Files

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- Table20250116Vfinal.docx