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ORIGINAL ARTICLE

Efficacy and safety of intra-arterial tirofiban in acute ischemic stroke without large-vessel occlusion

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Abstract

OBJECTIVES: Intra-arterial tirofiban has emerged as a potential alternative for those patients with acute ischemic stroke (AIS). This study evaluated the effectiveness and safety of intra-arterial tirofiban in AIS patients without large- or medium-vessel occlusions.

MATERIAL AND METHODS: Sixty patients with AIS who were within 24 hours of symptom onset and did not have significant blockages in large or medium blood vessels were assigned to treatment and control groups via a non-randomized, patient-preference allocation protocol: the control group (n = 30) received intravenous tirofiban and dual antiplatelet therapy, and the treatment group (n = 30) received intra-arterial tirofiban via catheterization, followed by the same medication regimen. The neurological function, functional outcomes, and safety evaluations were measured at 90 days.

RESULTS: Both groups experienced a substantial decrease in NIHSS scores post-treatment ($p < 0.05$). The treatment group had significantly lower NIHSS scores at 24 hours, 72 hours, and 14 days compared to the control group ($p < 0.05$). The treatment group had a treatment efficacy rate of 91.1% at 14 days, while the control group had a rate of 80.0% ($p < 0.05$). At 90 days, both groups showed significant improvements in mRS and BI scores ($p < 0.05$), with the treatment group having a lower median mRS score and a higher median BI score compared to the control group ($p < 0.05$). There were no statistically significant differences in the incidence of adverse events between the two groups ($p > 0.05$).

CONCLUSION: Intra-arterial tirofiban administration benefits AIS patients without large- or medium-vessel occlusions, improving neurological function, reducing disability, and enhancing functional independence.

INTRODUCTION

Acute ischemic stroke (AIS) is caused by intracerebral arterial thrombosis or embolic events, resulting in arterial stenosis or occlusion (Wang *et al.* 2025, Singh *et al.* 2023). This leads to ischemic and hypoxic conditions in brain tissue, causing neurological deficits characteristic of AIS. Neurons are energy-deficient and highly vulnerable to such conditions, undergoing irreversible damage and lasting neurological impairment within just five minutes of complete cerebral ischemia (Yenari and Han, 2012). Therefore, timely restoration of blood flow and mitigation of secondary brain injury before irreversible neuronal loss are crucial (Figueiredo *et al.* 2024). This approach optimizes neuronal viability, reduces infarct size, and lowers disability and mortality rates, embodying a widely recognized principle in ischemic stroke management (Widimsky *et al.* 2023).

Current international and national guidelines (Powers *et al.* Mulder *et al.* 2024) endorse intravenous thrombolysis and mechanical thrombectomy as the primary methods for prompt reperfusion in AIS. Intravenous thrombolysis, typically involving recombinant tissue plasminogen activator (rt-PA) within 4.5 hours of symptom onset, is limited by strict eligibility criteria and contraindications, such as recent surgery, bleeding risks, and severe hypertension (Berge *et al.* 2021, Mohamad *et al.* 2024). The recanalization success rate with intravenous thrombolysis remains around 30%, particularly for large thrombi (Seners *et al.* 2016). Although mechanical thrombectomy has dramatically improved outcomes for large-vessel occlusions, it is ineffective for small-vessel emboli (Lee *et al.* 2024, Bacigaluppi *et al.* 2019). Therefore, alternative pharmacological approaches like dual antiplatelet therapy (DAPT) and glycoprotein IIb/IIIa inhibitors have been explored for patients who are not eligible for standard reperfusion treatments.

Tirofiban, a glycoprotein IIb/IIIa inhibitor, has shown promise in improving recanalization rates and functional outcomes when used alongside intravenous thrombolysis and mechanical thrombectomy (Brake *et al.* 2024). Aspirin and clopidogrel, commonly used in DAPT, are recommended for AIS patients at risk of early neurological deterioration to reduce the risk of recurrent stroke (Lee *et al.* 2020, Davis *et al.* 2015). However, combining intra-arterial tirofiban with DAPT is not well-studied, despite its potential benefits in enhancing localized antiplatelet effects while reducing systemic complications.

Our interventional team in clinical practice has noted that certain AIS patients, ineligible for standard intravenous thrombolysis or mechanical thrombectomy, exhibit positive responses to low-dose tirofiban administered intra-arterially. This approach has shown comparable clinical benefits to traditional interventions. Through extensive research spanning several years, our team has evaluated the efficacy and safety of this method. This paper presents the findings from our nearly two-year investigation into this innovative therapeutic approach.

PATIENTS AND METHODS

General information

This study enrolled AIS patients admitted to the Neurology Department of the No. 922 Hospital of the Joint Logistics Support Force of the Chinese People's Liberation Army between August 2022 and August 2025. Patients presented within 24 hours of symptom onset and were confirmed through cranial magnetic resonance angiography (MRA), computed tomography angiography (CTA), or digital subtraction angiography (DSA) to have no significant intracranial or extracranial large or medium vessel stenosis or occlusion. Eligible patients were assigned to treatment and control groups via a non-randomized, patient-preference allocation protocol. The control group received intravenous tirofiban at a maintenance dose of 0.1 μg/kg/min for 48 hours, with dual antiplatelet therapy (aspirin enteric-coated tablets 100 mg/d and clopidogrel hydrogen sulfate tablets 75 mg/d) initiated 4 hours before tirofiban discontinuation. The treatment group received 0.4-0.5 mg of tirofiban via arterial catheterization, followed by the same postoperative management as the control group. A total of 60 patients were enrolled, with 30 in each group. Neurological function was assessed 24 hours, 72 hours, and 14 days post-treatment using the National Institutes of Health Stroke Scale (NIHSS). Functional disability and activities of daily living were evaluated at 90 days post-treatment using the modified Rankin Scale (mRS) and Barthel Index (BI). Adverse events, including hemorrhage, thrombocytopenia, allergic reactions, and mortality within 90 days, were recorded.

This study was approved by the institutional ethical review board (No. 2022-10). All participants provided written informed consent.

Inclusion criteria

Patients meeting the following criteria were included: diagnosis of AIS according to the 2018 Chinese Guidelines, age over 18 years, presentation within 24 hours of symptom onset, confirmed neurological deficits, pre-stroke mRS score <2, cranial CT ruling out hemorrhage, ASPECTS score ≥7, NIHSS score between 4 and 20, and absence of significant vascular stenosis or occlusion confirmed by MRA, CTA, or DSA. Patients meeting the criteria but refusing thrombolysis, presenting beyond the time window, having wake-up stroke, or experiencing post-thrombolysis deterioration within 24 hours at another hospital were included with informed consent.

Exclusion criteria

Patients were excluded if they had any intracranial hemorrhage, history of intracranial hemorrhage, major trauma, recent surgery within three months, active bleeding in other organs, large cerebral aneurysms, arteriovenous malformations, brain tumors, uncontrolled hypertension (blood pressure persistently >180/110 mmHg despite treatment), platelet count $<100\times10^9$/L, long-term anticoagulant use, severe organ dysfunction, significant intracranial or extracranial vascular stenosis or occlusion, concurrent stent implantation, mechanical thrombectomy, or other endovascular treatments. Exclusions also applied to stroke from infection, immune disease, fat embolism, large infarcts (>1/3 of middle cerebral artery territory on imaging), severe blood glucose abnormalities (<2.8 mmol/L or >22.22 mmol/L), or refusal of arterial treatment.

Information collection

Patient data included demographics, medical history (e.g., stroke, transient ischemic attack, aneurysms, arteriovenous malformations, tumors, prior surgeries, hypertension, cerebral hemorrhage, diabetes, coronary artery disease, atrial fibrillation, hyperlipidemia, hyperthyroidism, infections, and autoimmune diseases), lifestyle factors (smoking, alcohol consumption, and allergy history), and clinical assessments such as NIHSS scores pre- and post-treatment at 24 hours, 72 hours, and 14 days. Functional outcomes were assessed using mRS and BI scores before and at 90 days post-treatment. Laboratory analyses included complete blood count, glycated hemoglobin, homocysteine, lipid profile, liver and kidney function, and coagulation parameters. Imaging data from cranial CT, MRA, CTA, or DSA were documented. Adverse events, such as hemorrhage, thrombocytopenia, allergic reactions, and mortality, were recorded alongside patient outcomes.

Treatments

During treatment, patients in the treatment group underwent DSA to identify the responsible artery. A catheter was positioned at the proximal segment of the affected artery for the slow infusion of 0.4-0.5 mg of tirofiban (Wuhan Yuanda Pharmaceutical Group Co., Ltd., 100 mL: 5 mg: 0.9 g, H20041165) at a rate of 0.4-0.5 mL/min (0.02-0.025 mg/min). Subsequently, patients received intravenous tirofiban at 0.1 μg/kg/min for 48 hours. Cranial CT scans were conducted to rule out hemorrhagic complications. If no contraindications were present, dual antiplatelet therapy (aspirin 100 mg/d and clopidogrel 75 mg/d) was initiated 4 hours before tirofiban discontinuation. The control group was administered intravenous tirofiban at 0.08-0.1 μg/kg/min for 48 hours post MRA, CTA, or DSA. Dual antiplatelet therapy was commenced 4 hours before tirofiban cessation.

Both groups underwent standardized stroke management, which included vital signs monitoring, oxygen therapy, lipid-lowering treatment, plaque stabilization, and supportive care. Dual antiplatelet therapy was administered for 21 days, after which monotherapy with either aspirin or clopidogrel was continued for 90 days.

Outcome measurements

Clinical efficacy and prognosis were evaluated by experienced neurologists using NIHSS scores before treatment and at 24 hours, 72 hours, and 14 days post-treatment. Stroke recovery categories included complete recovery (91-100% NIHSS score reduction), significant improvement (46-90% reduction), improvement (18-45% reduction), no change (within ±17%), and deterioration (≥18% increase or death. The total efficacy rate was calculated based on the percentage of patients achieving complete recovery, significant improvement, or improvement. Functional outcomes at 90 days post-treatment were assessed through phone follow-ups, video calls, or outpatient visits using mRS and BI scores. A favorable prognosis was defined as an mRS score ≤2 and a BI score ≥80, while an unfavorable prognosis was indicated by an mRS score ≥3 or a BI score ≤60, with BI ≤20 indicating total disability. Adverse events, including hemorrhage, thrombocytopenia, allergic reactions, and mortality within 90 days, were documented to assess the safety of tirofiban arterial administration.

Statistical analysis

Categorical variables were analyzed using the χ^2 test and presented as percentages. In contrast, continuous variables following a normal distribution were assessed with the t-test and displayed as mean ± standard deviation. Statistical significance was established at $p < 0.05$. The statistical analyses were executed utilizing SPSS 25.0 software.

RESULTS

Changes in NIHSS scores

Before treatment, there was no statistically significant difference in NIHSS scores between the two groups ($p > 0.05$). After treatment, both groups demonstrated a significant reduction in NIHSS scores. Upon intergroup comparison, the treatment group displayed notably lower NIHSS scores at 24h than the control group (4.92±1.16 vs. 8.06±1.24, t=3.725, $p = 0.034$); the treatment group displayed notably lower NIHSS scores at 72h than the control group (3.23±1.26 vs. 5.80±1.35, t=6.574, $p = 0.021$); and the treatment group displayed notably lower NIHSS scores at 14 days than the control group (2.02±0.57 vs. 4.18±0.65, t=9.862, $p = 0.015$). These results indicate a clinically meaningful improvement beyond the statistical significance noted in all instances.

Tab. 1. Comparison of NIHSS scores at different time points

Group	Cases (n)	Pre-treatment	24h Post-treatment	72h Post-treatment	14 day Post-treatment
Treatment	30	11.25±2.28	4.92±1.16	3.23±1.26	2.02±0.57
Control	30	10.81±2.42	8.06±1.24	5.80±1.35	4.18±0.65
t		0.146	3.725	6.574	9.862
P		0.883	0.034	0.021	0.015

Tab. 2. Comparison of clinical outcomes between two patient groups

Group	Cases (n)	Recovery (n)	Marked Improvement	Improvement (n)	No Response (n)	Total Effective Rate (%)
Treatment	30	13	18	10	4	91.11
Control	30	5	15	16	9	80.00

Evaluation of treatment efficacy

After a 14-day treatment period, the treatment group showed a significantly higher efficacy rate of 91.11% compared to the control group's rate of 80.00% ($\chi^2 = 4.872$, $p = 0.039$, Table 2).

Comparison of mRS and BI scores

Before therapy, there was no statistically significant difference in mRS and BI scores between the two treatment groups ($p > 0.05$). Following 90 days of treatment, both groups experienced significant reductions in mRS scores and notable improvements in BI scores than pre-treatment ($p < 0.05$). Upon intergroup analysis, the treatment group exhibited a significantly lower median mRS score compared to the control group (0.92±0.32 vs. 1.88±0.26, t=4.297, $p = 0.031$), while the treatment group showed a significantly higher median BI score than the control group (95.42±4.38 vs. 76.43±3.82, t=8.726, $p = 0.018$) (Table 3).

Assessment of treatment safety

Over the 90-day follow-up period, the control group reported one case of hematuria, three cases of gingival bleeding, and one case of subcutaneous bleeding, amounting to five adverse events (16.66%). Conversely, the treatment group documented three cases of gingival bleeding and one case of subcutaneous bleeding, totaling four adverse events (13.33%). The comparison of adverse reaction incidence rates between the two groups exhibited no statistical significance ($\chi^2 = 0.246$, $p = 0.674$).

DISCUSSION

AIS poses a significant global health challenge, highlighting the need for effective neurological treatments. Tirofiban, a selective non-peptide glycoprotein IIb/IIIa platelet receptor antagonist, is increasingly acknowledged for its potential in AIS therapy (Wang *et al.* 2024). Tirofiban plays a crucial role in inhibiting platelet activation and halting clot progression by targeting the glycoprotein IIb/IIIa receptors essential for platelet aggregation and thrombus formation (Sharifi-Rad *et al.* 2023, Hassan *et al.* 2019). Its rapid onset of action and short half-life allow for effective platelet inhibition with minimal risk of prolonged bleeding, as platelet function typically returns to baseline levels within eight hours post-discontinuation (Sharifi-Rad *et al.* 2023, Hassan *et al.* 2019). This pharmacokinetic profile positions tirofiban as a promising option for stroke management, particularly in situations where standard reperfusion strategies such as intravenous thrombolysis or mechanical thrombectomy are not viable or ineffective.

Several studies have explored tirofiban's effectiveness and safety in AIS. It has been demonstrated that combining tirofiban with intravenous thrombolysis

Tab. 3. Comparison of mRS and BI scores before and after treatment

Group	Cases (n)	mRS		BI	
		Pre-treatment	90 day Post-treatment	Pre-treatment	90 day Post-treatment
Treatment	30	4.08±0.27	0.92±0.32	41.73±1.36	95.42±4.38
Control	30	4.14±0.25	1.88±0.26	42.12±1.25	76.43±3.82
t		0.559	4.297	0.674	8.726
P		0.728	0.031	0.483	0.018

within the thrombolytic time window reduced infarct volume and improved neurological deficits, indicating a synergistic effect (Yang *et al.* 2019). Tang *et al.* investigated perioperative tirofiban usage in endovascular therapy, observing increased recanalization rates alongside a heightened risk of intracranial hemorrhage in select patients (Tang *et al.* 2021). Xing *et al.* examined the effectiveness and safety of intravenous tirofiban post-endovascular therapy in individuals with acute intracranial large atherosclerotic stroke. They found that administering intravenous tirofiban to these patients following endovascular therapy significantly enhances clinical outcomes 90 days post-procedure without elevating the risk of symptomatic intracranial hemorrhage (XING *et al.* 2022). These findings underscore tirofiban's potential as an adjunct therapy in AIS, particularly when administered intra-arterially to augment local drug concentration at the ischemic site.

Our study's treatment and control groups exhibited significant reductions in NIHSS scores after treatment, with efficacy rates of 91.11% and 80%, respectively. The treatment group, which received intra-arterial tirofiban, displayed superior neurological recovery compared to the control group. Both groups experienced significant improvements in daily activities and overall functional independence at the 90-day follow-up after treatment. The group that received intra-arterial administration showed even better results, likely because of the localized delivery of tirofiban, which led to higher drug concentrations in the affected area. This targeted delivery aids rapid platelet inhibition promotes microvascular reperfusion, and decreases secondary ischemic injury. Consequently, it facilitates quicker restoration of cerebral perfusion, enhances neurological function, and presents a promising option for AIS patients who are not eligible for traditional thrombolytic therapy.

The decision to use DAPT in this study, which includes aspirin and clopidogrel, was based on previous findings showing its effectiveness in reducing the risk of recurrent stroke and improving early neurological recovery in high-risk patients (He *et al.* 2015, Chen *et al.* 2024). Short-term DAPT has been found to significantly decrease the chances of early stroke recurrence compared to aspirin alone (Ge *et al.* 2016). Our study indicated that adding intra-arterial tirofiban to DAPT enhanced neurological recovery, suggesting a potential synergistic effect that warrants further investigation.

No severe adverse reactions, such as intracranial hemorrhage or significant allergic responses, were found in either group in our study, indicating the safety of tirofiban. Minor bleeding events, like gastrointestinal bleeding, subcutaneous hemorrhage, and hematuria, occurred at similar rates in both groups, demonstrating a favorable safety profile of tirofiban. Importantly, intra-arterial administration did not significantly increase hemorrhagic complications, supporting its feasibility as a localized intervention for AIS. These results align with previous research suggesting that tirofiban, when given at appropriate doses and with careful patient selection, can enhance stroke outcomes without significantly raising the risk of bleeding-related complications (Liu *et al.* 2022, Zhao *et al.* 2024, Tang *et al.* 2021).

This study has limitations, including a small sample size, which may impact the generalizability of results and treatment outcomes. Unmeasured confounding variables like vascular anatomy variations, collateral circulation differences, and thrombus characteristics could have influenced treatment effectiveness (Ginsberg, 2018). Future research should address these limitations through large-scale, multicenter randomized controlled trials to evaluate the long-term efficacy and safety of intra-arterial tirofiban. Efforts should also focus on optimizing dosage regimens, identifying subpopulations that may benefit most, and exploring the integration of tirofiban with other stroke therapies.

In summary, the use of intra-arterial tirofiban in AIS patients has demonstrated positive clinical outcomes, including improved neurological function and independence. This targeted approach offers promise for patients who cannot undergo traditional reperfusion therapies, highlighting the need for further research to confirm its effectiveness.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE:

This study was adhered to the Declaration of Helsinki and approved by the institutional ethical review board of the 922nd Hospital (No. 2022-10). All participants provided written informed consent.

CONSENT FOR PUBLICATION:

Not applicable.

AVAILABILITY OF DATA AND MATERIALS:

The datasets analysed during the current study are available from the corresponding author on reasonable request.

COMPETING INTERESTS:

The authors declare that they have no competing interests.

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AUTHORS' CONTRIBUTIONS:

Lin Qiu: Guarantor of integrity of the entire study; Study concepts; Study design; Statistical analysis.
Minfen Xiong: Definition of intellectual content; Literature research; Manuscript editing.
Xinwu Li: Experimental studies; Data analysis; Manuscript review.
Lingxu Xu: Data acquisition; Manuscript preparation.
Zhongqiu Li: Study design; Statistical analysis.
Ping Ouyang: Data analysis; Manuscript review.

All authors approve the final version of the manuscript.

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REFERENCES

1 Bacigaluppi M, Semerano A, Gullotta GS, Strambo D. (2019). Insights from thrombi retrieved in stroke due to large vessel occlusion. J Cereb Blood Flow Metab. **39**(8): 1433–1451.
2 Berge E, Whiteley W, Audebert H, et al. (2021). European Stroke Organisation (ESO) guidelines on intravenous thrombolysis for acute ischaemic stroke. Eur Stroke J. **6**(1): I–LXII.
3 Brake A, Heskett C, Alam N, et al. (2024). Glycoprotein inhibitors as a first line rescue treatment after unsuccessful recanalization of endovascular thrombectomy: A systematic review and meta-analysis. Interv Neuroradiol. 15910199241226470.
4 Chen H-S, Cui Y, Wang X-H, et al. (2024). Clopidogrel plus aspirin vs aspirin alone in patients with acute mild to moderate stroke: the ATAMIS randomized clinical trial. JAMA Neurol. **81**(5): 450–460.
5 Davis KA, Miyares MA, Dietrich E. (2015). Dual antiplatelet therapy with clopidogrel and aspirin after ischemic stroke: a review of the evidence. Am J Health Syst Pharm. **72**(19): 1623–1629.
6 Figueiredo R, Castro C, Fernandes JB. (2024). Nursing interventions to prevent secondary injury in critically ill patients with traumatic brain injury: a scoping review. J Clin Med. **13**(8): 2396.
7 Ge F, Lin H, Liu Y, et al. (2016). Dual antiplatelet therapy after stroke or transient ischaemic attack–how long to treat? The duration of aspirin plus clopidogrel in stroke or transient ischaemic attack: a systematic review and meta-analysis. Eur J Neurol. **23**(6): 1051–1057.
8 Ginsberg MD. (2018). The cerebral collateral circulation: relevance to pathophysiology and treatment of stroke. Neuropharmacology. **134**: 280–292.
9 Hassan AM, Prasad V, Fidelis N. (2019). Drugs used in thromboembolic disorders: an insight into their mechanisms. Asian Journal of Cardiology Research. **2**(1): 54–65.
10 He F, Xia C, Zhang J-H, et al. (2015). Clopidogrel plus aspirin versus aspirin alone for preventing early neurological deterioration in patients with acute ischemic stroke. J Clin Neurosci. **22**(1): 83–86.
11 Lee H-L, Kim J-T, Lee JS, et al. (2020). Comparative effectiveness of dual antiplatelet therapy with aspirin and clopidogrel versus aspirin monotherapy in mild-to-moderate acute ischemic stroke according to the risk of recurrent stroke: an analysis of 15 000 patients from a nationwide, multicenter registry. Circ Cardiovasc Qual Outcomes. **13**(11): e006474.
12 Lee I-H, Ha S-K, Lim D-J, Choi J-I. (2024). Risk Factors and Clinical Outcomes of Arterial Re-Occlusion After Successful Mechanical Thrombectomy for Emergent Intracranial Large Vessel Occlusion. J Clin Med. **13**(24): 7640.
13 Liu J, Yang Y, Liu H. (2022). Efficacy outcomes and safety measures of intravenous tirofiban or eptifibatide for patients with acute ischemic stroke: a systematic review and meta-analysis of prospective studies. J Thromb Thrombolysis. 1–13.
14 Mohamad T, Kanaan E, Ogieuhi IJ, et al. (2024). Thrombolysis vs Anticoagulation: Unveiling the Trade-Offs in Massive Pulmonary Embolism. Cureus. **16**(1).
15 Mulder MJ, Cras TY, Shay J, Dippel DW, Burke JF. (2024). Comparison of American and European Guideline Recommendations for Diagnostic Workup and Secondary Prevention of Ischemic Stroke and Transient Ischemic Attack. Circulation. **150**(10): 806–815.
16 Powers W, Rabinstein A, Ackerson T, et al. 2019 AHA/ASA Updated Guidelines for the Early Management of Acute Ischemic Stroke: Changes.
17 Seners P, Turc G, Maïer B, et al. (2016). Incidence and predictors of early recanalization after intravenous thrombolysis: a systematic review and meta-analysis. Stroke. **47**(9): 2409–2412.
18 Sharifi-Rad J, Sharopov F, Ezzat SM, et al. (2023). An updated review on glycoprotein IIb/IIIa inhibitors as antiplatelet agents: basic and clinical perspectives. High Blood Press Cardiovasc Prev. **30**(2): 93–107.
19 Singh RK, Sachin SS, Yunus N, Kumar M, Sinha RI. (2023). Acute ischemic stroke: management approach. Int J Basic Clin Pharmacol. **12**(2): 324.
20 Tang L, Tang X, Yang Q. (2021). The application of tirofiban in the endovascular treatment of acute ischemic stroke: a meta-analysis. Cerebrovasc Dis. **50**(2): 121–131.
21 Wang J, Zhao M, Qiao Y, et al. (2025). Neurological deterioration after acute ischemic stroke: A common phenomenon with important implications. Cerebrovasc Dis.
22 Wang M, Li J, Zhang L, et al. (2024). The efficacy and safety of continuous intravenous tirofiban for acute ischemic stroke patients treated by endovascular therapy: a meta-analysis. Front Neurol. **15**: 1286079.
23 Widimsky P, Snyder K, Sulzenko J, Hopkins LN, Stetkarova I. (2023). Acute ischaemic stroke: recent advances in reperfusion treatment. Eur Heart J. **44**(14): 1205–1215.
24 Xing J, Zhang X, Xu Y, Huang R, Li J. (2022). Efficacy and safety of intravenous tirofiban after endovascular therapy in patients with intracranial atherosclerotic stroke. International Journal of Cerebrovascular Diseases. 890–896.
25 Yang M, Huo X, Miao Z, Wang Y. (2019). Platelet glycoprotein IIb/IIIa receptor inhibitor tirofiban in acute ischemic stroke. Drugs. **79**(5): 515–529.
26 Yenari MA, Han HS. (2012). Neuroprotective mechanisms of hypothermia in brain ischaemia. Nat Rev Neurosci. **13**(4): 267–278.
27 Zhao W, Li S, Li C, et al. (2024). Effects of Tirofiban on Neurological Deterioration in Patients With Acute Ischemic Stroke: A Randomized Clinical Trial. JAMA Neurol. **81**(6): 594–602.