



Impact of a continuous multidisciplinary rehabilitation pathway on clinical outcomes in patients with acute ischemic stroke after mechanical thrombectomy

Uticaj kontinuiranog multidisciplinarnog programa rehabilitacije na kliničke ishode kod bolesnika sa akutnim ishemijskim moždanim udarom nakon mehaničke trombektomije

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Abstract

Background/Aim. Acute ischemic stroke remains a major cause of long-term disability, and optimal rehabilitation following mechanical thrombectomy is still being researched. The aim of this prospective randomized controlled study was to evaluate whether the continuous multidisciplinary rehabilitation (CMR) program, initiated within 24–72 hrs after mechanical thrombectomy and maintained for 3 months, was associated with improved neurological and functional outcomes. **Methods.** A total of 100 patients with acute ischemic stroke who underwent mechanical thrombectomy between October 2021 and October 2024 were randomly assigned (1 : 1) to either the CMR group or the control group (CG) (50 patients each). Patients in CG received routine post-procedural medical treatment and nursing care, whereas the patients in the CMR group received a structured multidisciplinary rehabilitation program in addition to routine care. The primary outcome was the National Institutes of Health Stroke Scale (NIHSS) score at 3 months. Secondary outcomes included Fugl-Meyer Assessment (FMA), Barthel Index (BI), Montreal Cognitive Assessment (MoCA), Motor

Assessment Scale (MAS), patient satisfaction, complication incidence, and favorable prognosis. Longitudinal changes were analyzed using mixed-design repeated-measures analysis of variance – ANOVA. **Results.** Baseline demographic and clinical characteristics were comparable between groups (all $p > 0.05$). Compared with CG, the CMR group demonstrated significantly greater improvements in MoCA, MAS, FMA, BI, and NIHSS scores at 1 and 3 months post-intervention (all $p < 0.05$). Furthermore, the CMR group demonstrated a significantly higher patient satisfaction rate and favorable prognosis rate, as well as a lower incidence of complications ($p < 0.05$). **Conclusion.** A CMR program initiated within 24–72 hrs after mechanical thrombectomy and maintained for 3 months was associated with improved short-term neurological, cognitive, motor, and functional recovery. The observed benefits should be interpreted as the cumulative effects of sustained rehabilitation rather than early initiation alone.

Keywords:

endovascular procedures; ischemic stroke; neurology; physical and rehabilitation medicine; rehabilitation.

Apstrakt

Uvod/Cilj. Akutni ishemijski moždani udar ostaje značajan uzrok dugotrajne onesposobljenosti, a optimalna rehabilitacija nakon mehaničke trombektomije je i dalje predmet istraživanja. Cilj ove prospektivne randomizovane kontrolisane studije bio je da proceni da li je kontinuirani multidisciplinarni program rehabilitacije (*continuous multidisciplinary rehabilitation* – CMR program), započet u roku od 24–72 sata nakon mehaničke trombektomije i nastavljen tokom 3 meseca, povezan sa poboljšanim neurološkim i

funkcionalnim ishodima. **Metode.** Ukupno 100 bolesnika sa akutnim ishemijskim moždanim udarom, koji su podvrgnuti mehaničkoj trombektomiji između oktobra 2021. i oktobra 2024. godine, nasumično je raspoređeno (1 : 1) ili u CMR grupu ili u kontrolnu grupu (*control group* – CG) (obe po 50 bolesnika). Bolesnici u CG primali su rutinski postproceduralni tretman i medicinsku negu, dok su bolesnici u CMR grupi, pored rutinske nege, primali i strukturirani multidisciplinarni program rehabilitacije. Primarni ishod bio je rezultat na skali *National Institutes of Health Stroke Scale* – NIHSS nakon 3 meseca. Sekundarni

ishodi uključivali su Fugl-Majerovu procenu (*Fugl-Meyer Assessment* – FMA), Bartelov indeks (*Barthel Index* – BI), Montrealsku kognitivnu procenu (*Montreal Cognitive Assessment* – MoCA), Skalu za procenu motorike (*Motor Assessment Scale* – MAS), zadovoljstvo bolesnika, učestalost komplikacija i povoljnu prognozu. Longitudinalne promene analizirane su korišćenjem analize varijanse (*analysis of variance* – ANOVA) mešovito dizajna sa ponovljenim merenjima. **Rezultati.** Demografske i kliničke karakteristike na početku istraživanja bile su ujednačene između grupa (sve $p > 0,05$). U poređenju sa CG, CMR grupa je pokazala značajno veća poboljšanja u MoCA, MAS, FMA, BI i NIHSS rezultatima nakon 1 i 3 meseca od intervencije (sve $p < 0,05$). Pored toga, u CMR

grupi zabeležena je značajno veća stopa zadovoljstva bolesnika i povoljne prognoze, kao i značajno niža incidencija komplikacija ($p < 0,05$). **Zaključak.** CMR program započet u roku od 24–72 sata nakon mehaničke trombektomije i održavan tokom 3 meseca bio je povezan sa poboljšanim kratkoročnim neurološkim, kognitivnim, motoričkim i funkcionalnim oporavkom. Uočena poboljšanja treba tumačiti kao kumulativne efekte kontinuirane rehabilitacije, a ne samo kao posledicu njenog ranog započinjanja.

Ključne reči:

endovaskularne procedure; moždani udar, ishemijski; neurologija; medicina, fizikalna; rehabilitacija.

Introduction

Acute ischemic stroke (AIS) is a major ischemic cerebrovascular disorder characterized by sudden onset, rapid progression, and high rates of neurological disability. AIS occurs due to occlusion of cerebral arteries, resulting in cerebral ischemia, hypoxia, and subsequent neuronal necrosis¹. These pathological changes frequently lead to cognitive impairment, motor dysfunction, and other neurological deficits that substantially impair activities of daily living (ADLs) and quality of life². Mechanical thrombectomy (MT) has become the standard minimally invasive intervention for selected patients with AIS caused by large vessel occlusion, as it can rapidly restore cerebral perfusion, reduce infarct progression, and improve clinical outcomes³. However, despite successful recanalization, many patients continue to experience persistent neurological and functional impairments. Without timely post-procedural rehabilitation, patients remain at risk for muscle atrophy, joint stiffness, cognitive decline, and long-term disability⁴.

Continuous multidisciplinary rehabilitation (CMR) initiated during the early post-thrombectomy period, guided by the principle of neuroplasticity, is designed to support neurological recovery throughout both the acute and subacute phases after stroke⁵. Comprehensive rehabilitation strategies, including cognitive training, motor rehabilitation, and ADLs training, may promote recovery of neurological function and improve patient independence⁶. Although several studies have investigated rehabilitation following MT, available evidence remains methodologically heterogeneous, with variations in rehabilitation protocols, outcome measures, and follow-up assessments⁷. Furthermore, comprehensive evaluations encompassing neurological, cognitive, motor, and daily living domains remain scarce in the current literature.

To date, evidence specifically evaluating CMR initiated within 24–72 hrs after MT is exceptionally sparse. In addition, most previous studies have primarily focused on single functional domains rather than comprehensive multidimensional recovery outcomes. Therefore, the aim of this study was to evaluate whether a CMR pathway initiated within 24–72 hrs after MT and maintained over a 3-month

period was associated with improved neurological and functional recovery. Given the multicomponent nature of rehabilitation interventions and the methodological limitations of existing evidence, the findings of this study should be interpreted as exploratory and association-based rather than definitive evidence of causal therapeutic efficacy.

Methods

Study population

This single-center prospective randomized controlled study was conducted at the Second Affiliated Hospital and Yuying Children's Hospital of Wenzhou Medical University, China, between October 2021 and October 2024. The study aimed to evaluate the association between a CMR pathway initiated early after MT and short-term neurological and functional recovery.

The study protocol, including the routine-care control condition and the structured multidisciplinary rehabilitation intervention, was reviewed and approved by the Ethics Committee of the Second Affiliated Hospital and Yuying Children's Hospital of Wenzhou Medical University, Wenzhou, China (No. 243/CI/08/2020) before participant enrollment. Written informed consent was obtained from all participants or their legal representatives prior to study enrollment. All study procedures were conducted in accordance with the Declaration of Helsinki and institutional ethical standards. The study was not prospectively registered in a public clinical trial registry.

A total of 100 patients with AIS who underwent MT during the study period were prospectively enrolled according to predefined eligibility criteria. No formal *a priori* sample size calculation was performed before study initiation. The sample size was determined pragmatically based on the number of eligible patients treated during the study period and the feasibility of completing the planned 3-month follow-up assessments. Consequently, this study should be considered an exploratory randomized clinical study. Patients were randomly assigned in a 1 : 1 ratio to either the CMR group or the control group (CG) (50 *per* group) using a computer-generated random allocation

sequence generated by the principal investigator before study initiation (Figure 1). Eligible participants were enrolled by the treating neurologist, rehabilitation physician, research nurse, or principal investigator. Allocation concealment was ensured through a centralized procedure. After confirming participant eligibility and obtaining written informed consent, treatment assignment was performed through the centralized allocation system according to the predetermined computer-generated randomization sequence. The assigned treatment group was communicated to the clinical team responsible for implementing the intervention. Investigators

responsible for participant enrollment did not have access to the randomization sequence before allocation, thereby minimizing selection bias.

Due to the nature of the rehabilitation intervention, blinding of participants and therapists was not feasible. However, outcome assessments were performed by trained rehabilitation personnel who were not involved in delivering the intervention and were blinded to treatment allocation throughout the study. Outcome assessors did not have access to participants' group assignments, minimizing the risk of assessment bias.

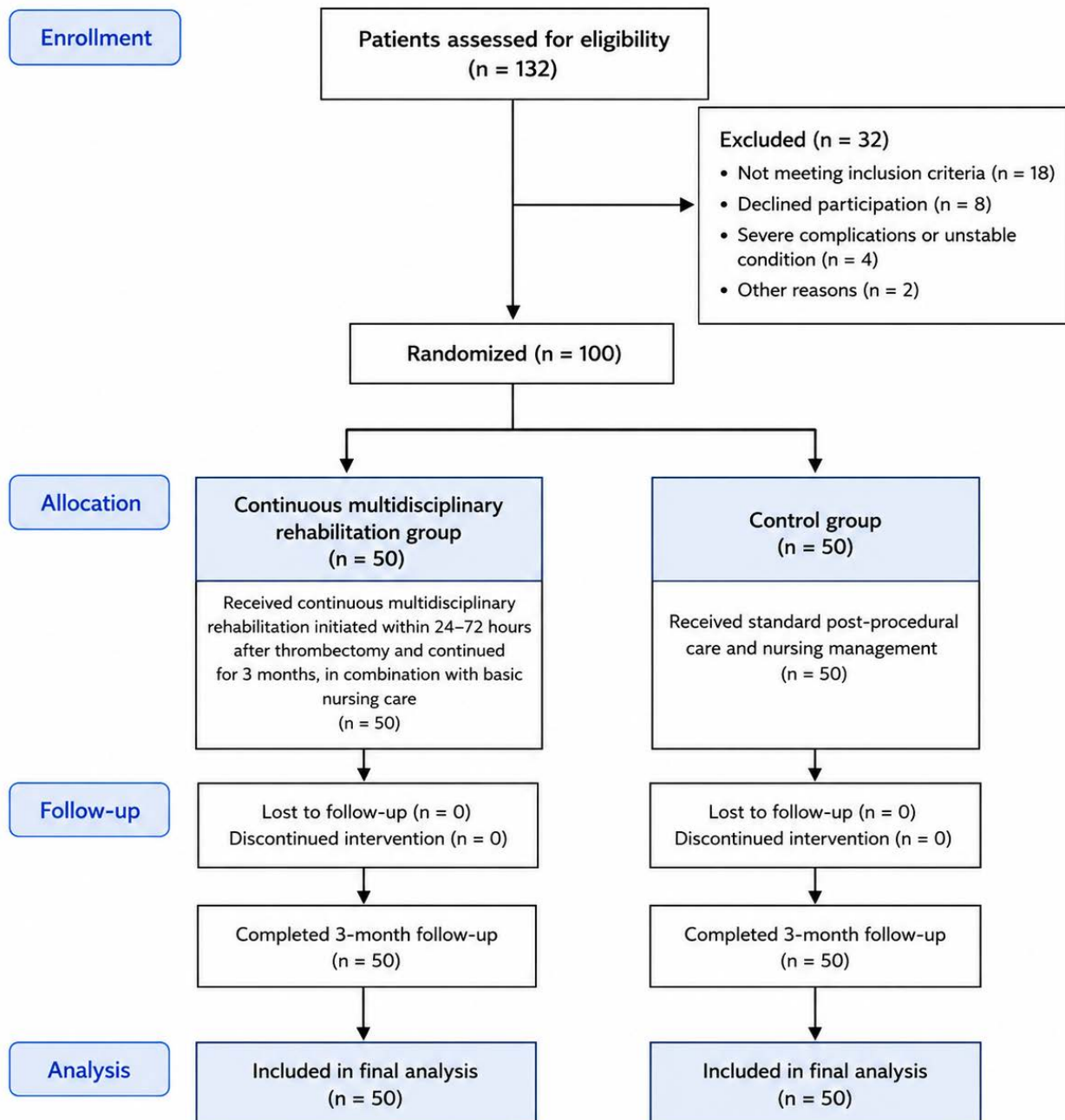


Fig. 1 – CONSORT-style flow diagram illustrating patient screening, randomization, intervention allocation, follow-up, and final analysis.
n – number; CONSORT – Consolidated Standards of Reporting Trials.

All randomized participants completed the 3-month follow-up and underwent all scheduled outcome assessments. There were no participants who withdrew consent, discontinued the intervention, or were lost to follow-up. Consequently, no outcome data were missing, and all randomized participants were included in the final analyses, which were performed according to the complete-case principle.

Inclusion criteria were as follows: patients diagnosed with AIS according to the Chinese Guidelines for the Diagnosis and Treatment of Acute Ischemic Stroke (2023 Edition)⁸, confirmed by cranial computer tomography – CT or magnetic resonance imaging – MRI examination; successful completion of MT, with stable vital signs and clear consciousness after the procedure; onset-to-puncture time < 8 hrs; written informed consent obtained from all patients or their legal representatives prior to enrolment; ability to cooperate with the full course of rehabilitation intervention and outcome assessments.

Exclusion criteria included the following: presence of severe dysfunction of major organs, including the heart, liver, kidneys, or lungs; presence of other neurological disorders, including intracerebral hemorrhage, brain tumors, or Parkinson's disease; severe cognitive impairment, psychiatric illness, or communication disorders preventing participation in rehabilitation training or assessments; limb deformities, fractures, severe arthritis, or other conditions affecting motor rehabilitation; development of severe post-procedural complications, including intracranial hemorrhage or severe infection, requiring termination of rehabilitation intervention; loss to follow-up or withdrawal during the study period.

Of the 100 enrolled patients, 57 were male and 43 were female, with ages ranging from 45–78 years and a mean age of 62.35 ± 8.72 years. The sites of arterial occlusion included the middle cerebral artery in 68 cases, the anterior cerebral artery in 17 cases, and the vertebrobasilar artery in 15 cases. The onset-to-puncture time ranged from 2.5 to 7.8 hrs, with a mean duration of 5.12 ± 1.36 hrs. The interval between thrombectomy and initiation of rehabilitation ranged from 1 to 3 days, with a mean duration of 1.85 ± 0.42 days. Intravenous thrombolysis prior to MT was administered according to institutional stroke management protocols when clinically indicated.

Patients in CG received routine post-procedural treatment and standard nursing care following MT. Routine medical management included antiplatelet therapy, treatment to improve cerebral circulation, neurotrophic therapy, blood pressure and blood glucose control, infection prevention, and other supportive therapies according to institutional stroke management protocols. Standard nursing care included clinical condition monitoring, positional care, oral care, skin care, nutritional support, and general health education.

During the 3-month follow-up period, patients in CG did not participate in the structured CMR program evaluated in this study. Accordingly, they did not receive the scheduled rehabilitation sessions incorporated into the intervention protocol, including structured cognitive rehabilitation, motor

rehabilitation, ADLs training, low-frequency electrical stimulation, acupuncture, massage therapy, or other supervised rehabilitation sessions delivered by the multidisciplinary rehabilitation team.

At the time this study was conducted, a structured multidisciplinary rehabilitation pathway following MT had not been routinely implemented as part of standard post-procedural care at our institution. Therefore, CG reflected the prevailing institutional standard of care rather than an intentional withholding of rehabilitation. All participants in CG received the routine medical management and standard nursing care that were routinely available at our institution throughout the study period but did not receive the additional structured multidisciplinary rehabilitation program evaluated in this trial.

In addition to standard medical management and routine nursing care identical to that received by CG, patients in the CMR group underwent a structured CMR program initiated within 24–72 hrs after MT following clinical stabilization and subsequently continued throughout the 3-month study period.

The CMR program was delivered over 3 months under the supervision of trained rehabilitation personnel. Rehabilitation was provided 5 days *per* week and consisted of multiple supervised sessions scheduled according to each patient's neurological status, functional tolerance, and clinical stability. The total daily rehabilitation time was approximately 90–120 min and included cognitive rehabilitation, motor rehabilitation, ADLs training, and adjunctive rehabilitation therapies. The duration and intensity of each component were individualized according to patient tolerance and recovery progression to ensure patient safety and maximize adherence. All participants allocated to the CMR group completed the scheduled multidisciplinary rehabilitation program during the study period, and no participant discontinued the intervention because of rehabilitation-related adverse events.

The rehabilitation program was initiated during hospitalization and continued on an outpatient basis following discharge under the supervision of trained rehabilitation personnel.

Cognitive function rehabilitation training

Targeted cognitive rehabilitation training was performed under the supervision of trained personnel and individualized according to patient tolerance and neurological status. The intervention included multiple structured components aimed at improving attention, memory, executive function, language ability, and visuospatial perception.

Attention training consisted of number cancellation tasks and auditory attention exercises, in which patients identified designated numbers or responded to specific auditory stimuli.

For memory training, patients engaged in short-term and long-term memory rehabilitation exercises, including recall of past events, word repetition, and picture memorization.

Executive function training utilized graphic sequencing, simple calculations, and object classification exercises to enhance logical thinking and executive control.

Language rehabilitation training targeted speech impairment through pronunciation exercises, verbal expression training, and reading comprehension activities, which progressed gradually from simple syllables and words to complex sentence-level tasks.

Visuospatial ability training utilized jigsaw puzzles, block assembly tasks, and clock-drawing exercises to improve visuospatial perception and constructional coordination.

Each of these given sessions lasted approximately 15–20 min and were delivered as part of the scheduled daily multidisciplinary rehabilitation program. Training intensity and progression were adjusted according to individual patient tolerance to minimize excessive fatigue and ensure rehabilitation safety.

Motor function and limb motor function rehabilitation training

Motor rehabilitation was implemented progressively according to the principle of gradual advancement from low-intensity passive training to active functional rehabilitation. The rehabilitation protocol was individualized based on patient recovery status and tolerance.

During the acute phase, spanning 1 to 2 weeks post-MT, passive rehabilitation exercises were primarily performed to reduce the risk of joint stiffness and muscle atrophy. Rehabilitation therapists assisted patients with passive limb movements, including flexion, extension, rotation, adduction, and abduction exercises. Each movement was maintained for approximately 10–15 sec and repeated 10–15 times *per* joint during scheduled rehabilitation sessions, with progression according to individual recovery status and patient tolerance. Deep breathing and coughing exercises were additionally encouraged to reduce the risk of pulmonary complications.

During the recovery phase, spanning 3 to 6 weeks post-MT, rehabilitation was gradually transitioned to active functional training. Patients underwent transfer training from supine-to-sitting and sitting-to-standing positions to improve balance and limb control. Active limb flexion, extension, and elevation exercises were also performed to enhance motor recovery. For patients capable of standing independently, wall-standing exercises and supervised walking training were conducted, with progressive increases in walking duration and distance. Each session lasted approximately 15–20 min and was performed during scheduled rehabilitation sessions, with progression according to each individual's recovery status and patient tolerance.

During the late rehabilitation phase, spanning 7 to 12 weeks post-MT, rehabilitation intensity was further increased according to patient tolerance and functional recovery. Stair-climbing exercises and obstacle-crossing activities were performed to improve coordination, balance, and exercise endurance. Fine motor rehabilitation, including object grasping

and bead-stringing exercises, was conducted to improve hand motor function and dexterity. Each session lasted approximately 20–30 min and was performed during scheduled rehabilitation sessions, with progression based on individual recovery status and patient tolerance.

The rehabilitation protocol was adjusted according to individual patient tolerance and neurological recovery to ensure safety and avoid excessive physical fatigue.

Rehabilitation training for activities of daily living

Structured ADLs rehabilitation training was performed to improve patient independence and functional self-care ability. Training protocols were individualized according to each patient's neurological status and recovery progression.

For eating training, patients were instructed to use spoons and chopsticks during feeding activities. Training initially focused on slow eating with small food portions and gradually progressed according to swallowing safety and coordination to reduce the risk of choking.

For personal hygiene training, patients underwent supervised training in washing, hair combing, shaving, and dressing activities. Rehabilitation initially involved assisted performance and progressively transitioned toward independent completion as functional ability improved.

For bowel and bladder training, patients were guided to establish regular bowel and urination habits and received training aimed at improving voluntary bowel and bladder control.

For walking and stair-climbing training, progressive walking and stair-climbing training were conducted in combination with motor rehabilitation exercises to enhance mobility, balance, and independent living capacity.

Each rehabilitation session lasted approximately 20–30 min and was delivered as part of the scheduled multidisciplinary rehabilitation program. Training intensity and rehabilitation content were individualized according to each patient's recovery status, functional tolerance, and safety considerations.

Adjuvant rehabilitation for neurological function

In addition to the primary rehabilitation program, adjunctive physical rehabilitation therapies were administered to support neurological recovery and functional improvement. These interventions included low-frequency pulsed electrical stimulation, acupuncture, and rehabilitation massage.

Low-frequency electrical stimulation was applied to selected muscle groups and affected limbs to facilitate neuromuscular activation and improve motor responsiveness. Trained personnel also performed acupuncture and rehabilitation massage to alleviate limb stiffness, muscle spasticity, and sensory discomfort, while potentially promoting neurological recovery and improved circulation.

Each adjunctive rehabilitation session lasted approximately 20 min and was administered as part of the scheduled multidisciplinary rehabilitation program according to the patient's clinical condition and rehabilitation needs.

These adjunctive therapies were incorporated as supportive components of the comprehensive multidisciplinary rehabilitation program and were not evaluated as isolated therapeutic modalities.

Outcome measures

All outcome assessments were performed by professionally trained rehabilitation therapists and medical staff using standards-based evaluation procedures to improve assessment consistency and reliability. Outcome measurements were obtained at baseline, 1 month, and 3 months after intervention unless otherwise specified.

The primary outcome was the change in National Institutes of Health Stroke Scale (NIHSS) score at 3 months after intervention.

Outcomes

The primary outcome was neurological impairment evaluated using NIHSS⁸, which assesses 11 domains with total scores ranging from 0 to 42 points. Higher scores indicate more severe neurological deficits.

Secondary outcomes comprised assessments of cognitive function, motor recovery, ADLs, patient satisfaction, complication incidence, and favorable prognosis. Cognitive function was evaluated using the Montreal Cognitive Assessment (MoCA)⁹ at baseline, 1 month, and 3 months post-intervention. The MoCA assesses multiple cognitive domains including attention, memory, executive function, language, and visuospatial ability, with total scores ranging from 0 to 30 points. Higher scores indicate better cognitive performance, and scores < 26 points indicate cognitive impairment.

Motor recovery was measured using the Motor Assessment Scale (MAS), a validated functional assessment instrument designed to evaluate motor performance after stroke. The MAS assesses eight functional motor tasks, including supine-to-side lying, supine-to-sitting, balanced sitting, sitting-to-standing, walking, upper-arm function, hand movements, and advanced hand activities. Higher scores indicate better motor function and recovery¹⁰.

Limb motor function was evaluated using the Fugl-Meyer Assessment (FMA)¹¹ at baseline, 1 month, and 3 months after intervention. The FMA includes upper- and lower-extremity motor function assessments with total scores ranging from 0 to 100 points. Higher scores indicate better limb motor recovery.

Functional independence in ADLs was assessed using the Barthel Index (BI)¹² at baseline, 1 month, and 3 months after intervention. The BI covers 10 functional domains, including feeding, dressing, personal hygiene, walking, and stair climbing, with total scores ranging from 0 to 100 points. Higher scores indicate greater independence in daily living activities.

Patient satisfaction was evaluated at 3 months after intervention using a self-designed institutional satisfaction questionnaire consisting of 8 items related to rehabilitation

effectiveness, therapist service quality, rehabilitation protocol satisfaction, and nursing care quality. Each item was scored on a 5-point Likert scale, with total scores ranging from 8 to 40. Satisfaction rates were calculated as the proportion of patients classified as “extremely satisfied” or “satisfied”. The questionnaire demonstrated acceptable internal consistency reliability (Cronbach $\alpha = 0.86$)¹³. Because the questionnaire was developed for institutional use and has not undergone external validation, patient satisfaction was considered a secondary exploratory outcome and was interpreted with appropriate caution.

Complications occurring during hospitalization were prospectively recorded, including pressure ulcers, pulmonary infection, deep vein thrombosis, and joint stiffness. Pressure ulcers were diagnosed according to the National Pressure Injury Advisory Panel – NPIAP criteria during routine skin examinations. Pulmonary infection was diagnosed by the treating physician based on compatible clinical symptoms, laboratory findings, and chest imaging. Deep vein thrombosis was confirmed using compression Doppler ultrasonography when clinically suspected. Joint stiffness was diagnosed by rehabilitation physicians based on reduced passive joint range of motion during standardized physical examinations. Complications were assessed throughout hospitalization by treating physicians and rehabilitation staff who were not directly involved in delivering the rehabilitation intervention¹⁴. Outcome assessors responsible for data collection were blinded to treatment allocation whenever feasible. All complications were identified through routine clinical monitoring and standardized daily assessments rather than being recorded only when clinically apparent.

Favorable prognosis at 3 months was defined as an exploratory composite functional outcome based on predefined thresholds of cognitive and motor recovery, including a MoCA score ≥ 26 points, MAS score ≥ 30 points, and FMA score ≥ 85 points¹⁵. Patients meeting all three predefined criteria were classified as having a favorable prognosis. Because no universally accepted composite endpoint incorporating these functional assessments has been established for patients undergoing MT, this outcome was considered exploratory and was used to provide an integrated assessment of short-term neurological and functional recovery. It was not intended to replace the standard 90-day modified Rankin Scale (mRS), which should be incorporated in future prospective studies to facilitate comparison with the broader stroke literature¹⁶.

Because multiple functional domains were evaluated, repeated measurements were analyzed longitudinally to assess changes over time and differences between treatment groups. The exploratory composite favorable prognosis endpoint was analyzed separately to provide an overall assessment of multidimensional functional recovery.

Statistical analysis

Statistical analyses were performed using the SPSS version 26.0 software (IBM Corp., Armonk, NY, USA). Continuous variables were initially assessed for normality using

the Shapiro–Wilk test. Normally distributed continuous variables are presented as mean $\pm$ standard deviation – SD, whereas non-normally distributed variables are presented as median and interquartile range – IQR. Repeated outcome measurements obtained at baseline, 1 month, and 3 months were analyzed using two-way repeated-measures analysis of variance (ANOVA), with time as the within-subject factor and treatment group as the between-subject factor. Main effects of time and group, as well as time $\times$ group interaction effects, were evaluated to assess differential longitudinal treatment responses between groups. When significant main effects or interaction effects were identified, Bonferroni-adjusted *post hoc* pairwise comparisons were performed to compare the three assessment time points (baseline vs. 1 month, baseline vs. 3 months, and 1 month vs. 3 months) within each predefined outcome measure (MoCA, MAS, FMA, BI, and NIHSS). The reported *p*-values for the repeated-measures ANOVA represent the overall model effects, whereas Bonferroni-adjusted *p*-values were used for the *post hoc* pairwise comparisons. Categorical variables are presented as frequencies and percentages. Comparisons between groups were performed using the chi-square test or Fisher's exact test, as appropriate. Effect sizes were additionally evaluated using partial eta squared (η^2) for repeated-measures analyses where applicable. A two-sided *p*-value < 0.05 was considered statistically significant.

Results

Demographic and clinical characteristics

As shown in Figure 1, 132 patients were assessed for eligibility, of whom 100 met the eligibility criteria and

were randomly assigned in a 1 : 1 ratio to the CMR group ($n = 50$) or CG ($n = 50$). All randomized participants completed the 3-month follow-up, and no participants were lost to follow-up, discontinued the intervention, or had missing outcome data. Consequently, all randomized participants were included in the final analysis. The participant enrollment, randomization, follow-up, and analysis process is illustrated in Figure 1.

Baseline demographic and clinical characteristics are summarized in Table 1. No statistically significant differences were observed between the groups with respect to age, sex distribution, body mass index, vascular risk factors, baseline NIHSS score, occlusion location, intravenous thrombolysis rate, onset-to-puncture time, or time from thrombectomy to rehabilitation initiation (all $p > 0.05$). Effect size analyses demonstrated negligible-to-small between-group differences (Cohen $d \leq 0.09$; Cramér $V \leq 0.051$), confirming excellent baseline comparability between the two groups (Table 1).

Longitudinal functional outcomes

Baseline scores for all functional assessments (MoCA, MAS, FMA, BI, and NIHSS) were comparable between the two groups (all $p > 0.05$). During the 3-month follow-up, both groups demonstrated progressive improvements in neurological and functional recovery; however, improvements were consistently greater in the CMR group. Compared with CG, patients in the CMR group achieved significantly higher MoCA scores at both follow-up assessments (all $p < 0.001$) (Table 2). Similarly, MAS scores were significantly higher in the CMR group throughout the follow-up (all $p < 0.001$) (Table 3). Limb motor recovery, assessed using FMA, also

Table 1

Baseline demographic and clinical characteristics of the study participants

Variable	Group		Test statistic (<i>df</i>)	<i>p</i> -value	Effect size
	CMR	control			
Age, years	62.18 $\pm$ 8.65	62.52 $\pm$ 8.81	$t(98) = 0.194$	0.847	Cohen $d = 0.04$
Male/female	29/21	28/22	$\chi^2(1) = 0.041$	0.839	Cramér $V = 0.020$
Body mass index, kg/m ²	24.85 $\pm$ 3.12	25.13 $\pm$ 3.26	$t(98) = 0.438$	0.662	Cohen $d = 0.09$
Hypertension	31 (62.0)	29 (58.0)	$\chi^2(1) = 0.167$	0.683	Cramér $V = 0.041$
Diabetes mellitus	18 (36.0)	20 (40.0)	$\chi^2(1) = 0.170$	0.680	Cramér $V = 0.042$
Hyperlipidemia	16 (32.0)	18 (36.0)	$\chi^2(1) = 0.178$	0.673	Cramér $V = 0.043$
Smoking history	22 (44.0)	24 (48.0)	$\chi^2(1) = 0.161$	0.688	Cramér $V = 0.041$
Previous stroke history	9 (18.0)	11 (22.0)	$\chi^2(1) = 0.251$	0.616	Cramér $V = 0.051$
Intravenous thrombolysis before thrombectomy	14 (28.0)	16 (32.0)	$\chi^2(1) = 0.190$	0.663	Cramér $V = 0.044$
Baseline NIHSS score	18.75 $\pm$ 3.26	18.96 $\pm$ 3.18	$t(98) = 0.305$	0.761	Cohen $d = 0.07$
Middle cerebral artery occlusion	34 (68.0)	34 (68.0)	$\chi^2(1) = 0.000$	1.000	Cramér $V = 0.000$
Anterior cerebral artery occlusion	8 (16.0)	9 (18.0)	$\chi^2(1) = 0.071$	0.790	Cramér $V = 0.027$
Vertebrobasilar artery occlusion	8 (16.0)	7 (14.0)	$\chi^2(1) = 0.078$	0.780	Cramér $V = 0.028$
Onset-to-puncture time, hrs	5.12 $\pm$ 1.36	5.08 $\pm$ 1.29	$t(98) = 0.151$	0.880	Cohen $d = 0.04$
Time from thrombectomy to rehabilitation initiation, days	1.86 $\pm$ 0.43	1.83 $\pm$ 0.41	$t(98) = 0.356$	0.722	Cohen $d = 0.08$

CMR – continuous multidisciplinary rehabilitation; *df* – degrees of freedom; NIHSS – National Institutes of Health Stroke Scale.

Note: Data are presented as mean $\pm$ standard deviation or numbers (percentages). Continuous variables were compared using the independent-samples *t*-test, and categorical variables were compared using the chi-square test. Effect sizes are reported as Cohen d for continuous variables and Cramér V for categorical variables.

Table 2

**Longitudinal changes in Montreal Cognitive Assessment (MoCA)
scores between the continuous multidisciplinary rehabilitation (CMR) and control groups**

Group/effect	Baseline MoCA	1 month after intervention	3 months after intervention	<i>F</i> (<i>df</i> 1, <i>df</i> 2)	<i>p</i> -value	Partial η^2
CMR group	20.15 ± 2.36 (19.36–20.94)	24.32 ± 2.18 (23.62–25.02)	27.56 ± 1.89 (26.94–28.18)	–	–	–
Control group	20.32 ± 2.28 (19.55–21.09)	22.15 ± 2.05 (21.47–22.83)	24.23 ± 2.01 (23.53–24.93)	–	–	–
Time effect	–	–	–	<i>F</i> (2, 196) = 56.82	< 0.001	0.290
Group effect	–	–	–	<i>F</i> (1, 98) = 24.19	< 0.001	0.200
Time × group interaction	–	–	–	<i>F</i> (2, 196) = 18.35	< 0.001	0.160

df – degrees of freedom.

Note: Data are presented as mean ± standard deviation (SD) with 95% confidence intervals (CIs). Longitudinal changes were analyzed using a mixed-design repeated-measures analysis of variance (ANOVA). *F* values, *df*, exact *p*-values, and partial eta squared (η^2) are reported for the main effects of time, group, and the time × group interaction. MoCA scores are given as mean ± SD (95% CI).

Table 3

**Longitudinal changes in Motor Assessment Scale (MAS)
scores between the continuous multidisciplinary rehabilitation (CMR) and control groups**

Group/effect	Baseline MAS	1 month	3 months	<i>F</i> (<i>df</i> 1, <i>df</i> 2)	<i>p</i> -value	Partial η^2
CMR group	18.23 ± 3.15 (17.34–19.12)	25.46 ± 3.02 (24.60–26.32)	32.15 ± 2.78 (31.36–32.94)	–	–	–
Control group	18.45 ± 3.08 (17.58–19.32)	21.32 ± 2.89 (20.50–22.14)	27.56 ± 2.91 (26.73–28.39)	–	–	–
Time effect	–	–	–	<i>F</i> (2, 196) = 56.42	< 0.001	0.365
Group effect	–	–	–	<i>F</i> (1, 98) = 40.78	< 0.001	0.294
Time × group interaction	–	–	–	<i>F</i> (2, 196) = 14.53	< 0.001	0.129

df – degrees of freedom.

Note: Data are presented as mean ± standard deviation (SD) with 95% confidence intervals (CIs). Longitudinal changes were analyzed using a mixed-design repeated-measures analysis of variance (ANOVA). *F* values, *df*, *p*-values, and partial eta squared (η^2) are reported for the main effects of time, group, and the time × group interaction. MAS scores are given as mean ± SD (95% CI).

Table 4

**Longitudinal changes in Fugl-Meyer Assessment (FMA)
scores between the continuous multidisciplinary rehabilitation (CMR) and control groups**

Group/effect	Baseline FMA	1 month after intervention	3 months after intervention	<i>F</i> (<i>df</i> 1, <i>df</i> 2)	<i>p</i> -value	Partial η^2
CMR group	48.65 ± 8.72 (46.17–51.13)	69.32 ± 7.85 (67.09–71.55)	88.75 ± 6.54 (86.89–90.61)	–	–	–
Control group	49.12 ± 8.56 (46.69–51.55)	60.15 ± 7.62 (57.99–62.31)	76.32 ± 7.18 (74.28–78.36)	–	–	–
Time effect	–	–	–	<i>F</i> (2, 196) = 153.32	< 0.001	0.623
Group effect	–	–	–	<i>F</i> (1, 98) = 81.34	< 0.001	0.452
Time × group interaction	–	–	–	<i>F</i> (2, 196) = 110.34	< 0.001	0.521

df – degrees of freedom.

Note: Data are presented as mean ± standard deviation (SD) with 95% confidence intervals (CIs). Longitudinal changes were analyzed using a mixed-design repeated-measures analysis of variance (ANOVA). *F* values, *df*, *p*-values, and partial eta squared (η^2) are reported for the main effects of time, group, and the time × group interaction. FMA scores are given as mean ± SD (95% CI).

showed significantly greater improvement in the CMR group than in CG (all $p < 0.001$) (Table 4). ADLs, measured using BI, improved significantly in both groups but were consistently higher in the CMR group at the 1- and 3-month follow-up assessments (all $p < 0.001$) (Table 5). Furthermore, neurological impairment assessed using NIHSS decreased significantly in both groups, with significantly lower NIHSS scores ob-

served in the CMR group throughout follow-up (all $p < 0.001$) (Table 6, Figure 2). Mixed-design repeated-measures ANOVA demonstrated significant main effects of time and group, together with significant time × group interaction effects for all longitudinal outcome measures (all $p < 0.001$), with moderate-to-large effect sizes, indicating significantly greater recovery trajectories in the CMR group than in CG (Tables 2–6).

Table 5

**Longitudinal changes in Barthel Index (BI) scores between
the continuous multidisciplinary rehabilitation (CMR) and control groups**

Group/effect	Baseline BI	1 month after intervention	3 months after intervention	<i>F</i> (<i>df</i> ₁ , <i>df</i> ₂)	<i>p</i> -value	Partial η^2
CMR group	38.25 ± 7.62 (36.09–40.41)	59.68 ± 7.35 (57.59–61.77)	86.75 ± 6.89 (84.79–88.71)	–	–	–
Control group	38.76 ± 7.45 (36.64–40.88)	50.12 ± 7.18 (48.08–52.16)	72.35 ± 7.02 (70.36–74.34)	–	–	–
Time effect	–	–	–	<i>F</i> (2, 196) = 45.12	< 0.001	0.316
Group effect	–	–	–	<i>F</i> (1, 98) = 38.55	< 0.001	0.280
Time × group interaction	–	–	–	<i>F</i> (2, 196) = 22.79	< 0.001	0.190

df – degrees of freedom.

Note: Data are presented as mean ± standard deviation (SD) with 95% confidence intervals (CIs). Longitudinal changes were analyzed using a mixed-design repeated-measures analysis of variance (ANOVA). *F* values, *df*, *p*-values, and partial eta squared (η^2) are reported for the main effects of time, group, and the time × group interaction. BI scores are given as mean ± SD (95% CI).

Table 6

**Longitudinal changes in the National Institutes of Health Stroke Scale (NIHSS)
scores between the continuous multidisciplinary rehabilitation (CMR) and control groups**

Group/effect	Baseline NIHSS	1 month after intervention	3 months after intervention	<i>F</i> (<i>df</i> ₁ , <i>df</i> ₂)	<i>p</i> -value	Partial η^2
CMR group	18.75 ± 3.26 (17.82–19.68)	10.23 ± 2.89 (9.41–11.05)	5.12 ± 2.15 (4.51–5.73)	–	–	–
Control group	18.96 ± 3.18 (18.06–19.86)	13.65 ± 2.76 (12.87–14.43)	9.87 ± 2.36 (9.20–10.54)	–	–	–
Time effect	–	–	–	<i>F</i> (2, 196) = 112.35	< 0.001	0.53
Group effect	–	–	–	<i>F</i> (1, 98) = 34.67	< 0.001	0.26
Time × group interaction	–	–	–	<i>F</i> (2, 196) = 23.14	< 0.001	0.19

df – degrees of freedom.

Note: Data are presented as mean ± standard deviation (SD) with 95% confidence intervals (CIs). Longitudinal changes were analyzed using a mixed-design repeated-measures analysis of variance (ANOVA). *F* values, *df*, *p*-values, and partial eta squared (η^2) are reported for the main effects of time, group, and the time × group interaction. NIHSS scores are given as mean ± SD (95% CI).

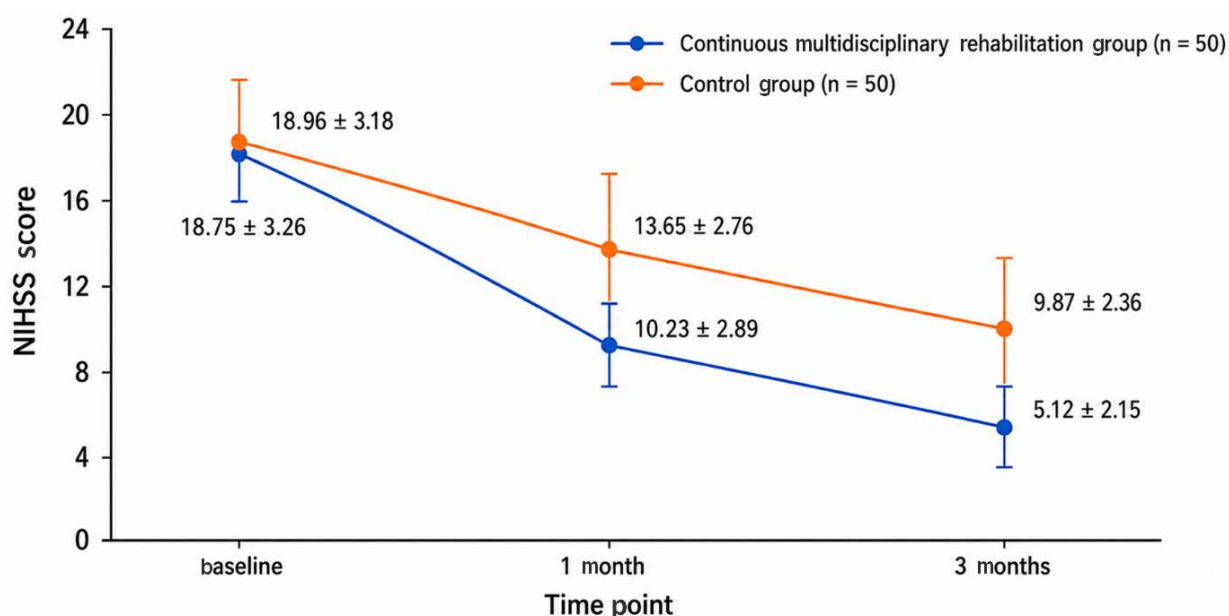


Fig. 2 – Longitudinal changes in neurological recovery between the continuous multidisciplinary rehabilitation group and the control group following mechanical thrombectomy.

Data are presented as mean ± standard deviation (SD). Repeated-measures ANOVA was used to evaluate longitudinal changes over time. Significant time × group interaction effects indicated different recovery trajectories between groups during follow-up.

NIHSS – National Institutes of Health Stroke Scale; n – number; ANOVA – analysis of variance.

Patient satisfaction and complication incidence

At the 3-month follow-up, the patient satisfaction rate, assessed using the institutional questionnaire, was significantly higher in the CMR group than in CG (94.0% vs. 74.0%, $\chi^2(1) = 6.353$, $p = 0.012$). As this represented an exploratory secondary outcome based on a non-externally validated questionnaire, the findings should be interpreted cautiously (Table 7).

Similarly, the incidence of complications during the intervention period was significantly lower in the CMR group than in CG (8.0% vs. 24.0%, $\chi^2(1) = 5.004$, $p = 0.025$). Recorded complications included pressure ulcers, pulmonary infection, deep vein thrombosis, and joint stiffness, which were prospectively identified through routine clinical monitoring and standardized daily assessments throughout the intervention period. The corresponding effect size and odds ratio further supported the clinical significance of the reduction in complication incidence (Table 7).

Favorable prognosis outcomes

Using the predefined exploratory composite functional outcome, the favorable prognosis rate was significantly higher in the CMR group than in CG (76.0% vs. 48.0%, $\chi^2(1) = 7.111$, $p = 0.008$) (Table 8). The corresponding effect size analysis demonstrated a clinically meaningful between-group difference, further supporting the beneficial effect of the CMR pathway on short-term functional recovery.

Overall, longitudinal mixed-design repeated-measures ANOVA demonstrated significant main effects of time, group, and time $\times$ group interaction for neurological, cognitive, motor, and ADLs outcomes (all $p < 0.001$), with moderate to large effect sizes indicating significantly greater recovery trajectories in the CMR group than in CG.

Discussion

AIS remains a major cause of neurological disability and functional dependence worldwide. MT has become a standard treatment for selected patients with large vessel occlusion because of its ability to rapidly restore cerebral perfusion and improve clinical outcomes¹⁷. However, despite successful recanalization, many patients continue to experience persistent neurological, motor, and cognitive impairments, highlighting the importance of structured post-procedural rehabilitation strategies¹⁸. In the absence of timely rehabilitation intervention, patients remain at risk for complications including muscle atrophy, joint stiffness, cognitive decline, and deep vein thrombosis, which may adversely affect long-term recovery and quality of life^{19, 20}. Therefore, identifying clinically feasible rehabilitation strategies following MT remains an important area of investigation.

The potential benefits of early rehabilitation are commonly explained through the concept of neuroplasticity, whereby repetitive functional stimulation may facilitate neural reorganization and functional adaptation after ischemic injury²¹. In addition, restoration of cerebral perfusion after MT may create a favorable physiological environment for neurological recovery²². Initiating multidisciplinary rehabilitation early after thrombectomy, followed by continuation throughout the subsequent rehabilitation pathway, may support neurological and functional recovery across both the acute and subacute phases after stroke²³. However, because the present intervention incorporated multiple rehabilitation components, including cognitive training, motor rehabilitation, ADLs training, electrical stimulation, acupuncture, massage, and adjunctive physical therapies, the study design does not permit identification of the relative contribution or mechanistic effect of individual therapeutic modalities.

Table 7

Comparison of exploratory patient satisfaction outcomes and complication incidence between the continuous multidisciplinary rehabilitation (CMR) and control groups

Variable	Group		χ^2 (df)	p-value	Odds ratio (95% CI)
	CMR	control			
Patient satisfaction	47 (94.0)	37 (74.0)	$\chi^2(1) = 6.353$	0.012	5.50 (1.42–21.28)
Complication incidence	4 (8.0)	12 (24.0)	$\chi^2(1) = 5.004$	0.025	0.28 (0.08–0.93)

df – degrees of freedom; CI – confidence interval.

Note: Data are presented as numbers (percentages). Comparisons between groups were performed using the Chi-square test. Odds ratios with 95% CIs are reported for between-group comparisons. Patient satisfaction was assessed using an institutionally developed questionnaire and should be interpreted as an exploratory secondary outcome.

Table 8

Comparison of favorable prognosis rates between groups at 3 months after intervention

Group	Favorable prognosis	Unfavorable prognosis	χ^2 (df)	p-value	Effect size (Cramér V)	Odds ratio (95% CI)
CMR	38 (76.0)	12 (24.0)	$\chi^2(1) = 7.111$	0.008	0.267	3.43 (1.46–8.08)
Control	24 (48.0)	26 (52.0)	–	–	–	–

CMR – continuous multidisciplinary rehabilitation; *df* – degrees of freedom; CI – confidence interval.

Note: Data are presented as numbers (percentages). Comparisons between groups were performed using the chi-square test. Effect size is reported as Cramér V. Odds ratio with 95% CI represents the likelihood of achieving a favorable prognosis in the continuous multidisciplinary rehabilitation group relative to the control group. Favorable prognosis was defined according to the predefined functional recovery criteria based on Montreal Cognitive Assessment (MoCA), Motor Assessment Scale (MAS), and Fugl-Meyer Assessment (FMA) outcomes.

In the present study, no statistically significant baseline differences were observed between groups for major functional indicators, suggesting acceptable comparability between groups prior to intervention. During follow-up, patients in the CMR group demonstrated significantly greater improvements in MoCA, MAS, FMA, BI, and NIHSS scores than those in CG, with significant time $\times$ group interaction effects observed across all longitudinal outcome measures. These findings suggest that CMR may be associated with improved short-term neurological and functional recovery following MT. Similar findings have been reported in previous rehabilitation studies involving patients with AIS^{24,25}. However, because the intervention comprised multiple rehabilitation components delivered as an integrated package, the results should be interpreted as exploratory and association-based rather than as evidence of the efficacy of any specific rehabilitation modality. The observed improvements may also have been influenced by greater treatment intensity, increased therapist–patient interaction, closer clinical supervision, and other nonspecific effects^{26,27}. Therefore, the findings support the potential clinical value of a CMR pathway but do not establish a causal relationship between any individual rehabilitation component and the observed outcomes.

An important consideration when interpreting these findings is that the intervention extended well beyond the acute post-stroke period. Although the multidisciplinary rehabilitation program was initiated within 24–72 hrs after MT, it continued as a structured rehabilitation pathway throughout the subsequent 3-month follow-up period. Therefore, the superior neurological and functional outcomes observed at 3 months should be interpreted as reflecting the cumulative effects of sustained multidisciplinary rehabilitation initiated early after stroke, rather than the isolated effect of early rehabilitation alone. This distinction matters clinically because recovery after AIS is a dynamic process spanning the acute and subacute phases and shaped by ongoing rehabilitation exposure over time.

An additional consideration is that rehabilitation practices following MT vary across institutions and healthcare systems. At our center, a structured multidisciplinary rehabilitation pathway was not routinely available as part of standard post-procedural care during the study period. Consequently, CG reflected the prevailing institutional standard of care rather than an intentional withholding of rehabilitation. In healthcare settings where structured multidisciplinary rehabilitation is routinely incorporated into standard care, the magnitude of the treatment effect observed in the present study may differ. Therefore, our findings should be interpreted within the context of the local rehabilitation practice in which the study was conducted.

The CMR group demonstrated significantly greater improvement in MoCA scores than CG during follow-up. These findings were associated with participation in the comprehensive multidisciplinary rehabilitation program. Because cognitive rehabilitation was delivered together with multiple other rehabilitation components, including motor

rehabilitation, ADLs training, electrical stimulation, acupuncture, massage, and other adjunctive therapies, the present study cannot determine the independent contribution of cognitive training to the observed cognitive improvements²⁸. Therefore, these findings should be interpreted as reflecting the overall multidisciplinary rehabilitation program rather than the effect of any individual rehabilitation component.

Motor dysfunction is a common sequela following AIS and frequently contributes to long-term disability and reduced independence in ADLs²⁹. In the present study, patients in the CMR group demonstrated significantly improved MAS and FMA scores compared with CG during follow-up, suggesting potential benefits of progressive multidisciplinary motor rehabilitation after MT. The staged rehabilitation protocol incorporated passive mobilization, active motor exercises, balance training, gait rehabilitation, and fine motor training according to patient recovery status. This structured progression may have supported motor recovery while minimizing excessive physical burden during the early rehabilitation period³⁰.

ADLs recovery is an important determinant of functional independence and social reintegration after AIS³¹. In the present study, patients receiving the CMR program showed significantly higher BI scores than controls at follow-up, suggesting improved daily living performance. The rehabilitation protocol incorporated individualized training related to feeding, dressing, personal hygiene, mobility, and bowel and bladder management³². Although patients receiving the CMR program demonstrated better ADLs outcomes than CG, these findings should be interpreted as reflecting the overall multidisciplinary rehabilitation program rather than the isolated effect of ADLs training³³.

Patients in the CMR group additionally demonstrated significantly lower NIHSS scores during follow-up, indicating less severe neurological impairment than CG. However, because multiple rehabilitation modalities were delivered simultaneously as part of a comprehensive multidisciplinary rehabilitation program, the present study cannot determine which intervention components, if any, were primarily responsible for the observed neurological improvements³⁴. Furthermore, patients in the CMR group received greater therapist contact, structured supervision, and rehabilitation intensity than those receiving routine care alone³⁵. Therefore, some of the observed benefits may have been influenced by nonspecific treatment effects, increased patient engagement, or attention-related factors rather than the effects of any individual rehabilitation modality³⁶.

Complication prevention represents an important component of post-stroke rehabilitation management because complications may delay recovery, prolong hospitalization, and adversely affect prognosis¹⁹. In the present study, the incidence of complications including pressure ulcers, pulmonary infection, deep vein thrombosis, and joint stiffness was significantly lower in the CMR group. This finding may be related to earlier mobilization, structured nursing support, rehabilitation monitoring, and continuous supervised physical activity during follow-up³⁷.

Patients in the CMR group reported higher satisfaction than those in CG. However, this finding should be interpreted cautiously because satisfaction was assessed using an institutional questionnaire that has not undergone external validation. Furthermore, greater therapist contact, increased rehabilitation intensity, closer clinical supervision, and enhanced patient engagement in the CMR group may have contributed to higher satisfaction ratings independent of the specific rehabilitation intervention. Therefore, patient satisfaction should be regarded as an exploratory secondary outcome rather than definitive evidence of treatment superiority. In addition, the favorable prognosis rate at 3 months was significantly higher in the CMR group than in CG.

Overall, the findings of the present study suggest that a CMR pathway initiated after MT may be associated with improved short-term neurological, motor, cognitive, and ADLs outcomes in patients with AIS. These findings are generally consistent with previous rehabilitation studies involving stroke populations¹⁹. Nevertheless, given the multicomponent intervention design and methodological limitations of the present study, further rigorously controlled multicenter studies are required to clarify causal relationships and determine the independent contribution of specific rehabilitation strategies.

Limitations of the study

Several limitations of this study should be acknowledged. First, this was a single-center study with a relatively small sample size, which may limit the generalizability of the findings. Second, the follow-up period was limited to 3 months, precluding evaluation of long-term neurological recovery, functional outcomes, and recurrence. Third, the rehabilitation protocol comprised a multicomponent multidisciplinary intervention, making it difficult to determine the independent contribution of each rehabilitation modality. Fourth, because blinding of participants and therapists was not feasible, nonspecific treatment effects, including attention bias, increased therapist contact, enhanced patient engagement, closer clinical monitoring, and differences in rehabilitation intensity, may have influenced the observed outcomes. Consequently, part of the observed treatment benefit may reflect enhanced therapeutic attention rather than the specific effects of the rehabilitation program. Future randomized controlled trials incorporating attention-matched CGs are warranted to better distinguish the effects of rehabilitation intensity from those of individual rehabilitation interventions. Furthermore, although rehabilitation was initiated during the acute phase, the intervention continued throughout the subacute recovery period. Therefore, the present study was not designed to distinguish the independent effect of early rehabilitation initiation from the cumulative effect of sustained multidisciplinary rehabilitation over the 3-month intervention period. Fifth, no formal *a priori* sample size calculation was performed. Instead, the sample size was determined by the number of eligible patients recruited during the study period and the feasibility of completing the trial. Consequently, the study may have been underpowered to detect smaller between-

group differences, and the findings should be interpreted as exploratory. Sixth, the study was not prospectively registered in a public clinical trial registry before participant enrollment. Although the study protocol, including the routine-care control condition and the structured multidisciplinary rehabilitation intervention, was prospectively reviewed and approved by the Institutional Ethics Committee before recruitment, and the intervention protocol, outcome measures, and statistical analysis plan were predefined, the absence of prospective trial registration limits independent verification of the prespecified protocol and should be considered an important methodological limitation. Seventh, because structured multidisciplinary rehabilitation was not routinely incorporated into standard post-thrombectomy care at our institution during the study period, the comparator reflected the prevailing local standard of care. Consequently, the findings may not be directly generalizable to healthcare systems in which comprehensive multidisciplinary rehabilitation is routinely provided following MT. Future multicenter randomized controlled trials comparing structured multidisciplinary rehabilitation with contemporary standard rehabilitation across different healthcare settings are warranted to confirm the external validity of our findings. In addition, several clinically relevant thrombectomy-related variables, including pre-stroke mRS score, baseline Alberta Stroke Program Early CT Score – ASPECTS, stroke etiology, reperfusion success measured by the modified Thrombolysis in Cerebral Infarction – mTICI score, and time to recanalization, were not systematically collected. Consequently, residual confounding related to baseline stroke severity and procedural characteristics cannot be completely excluded. Future prospective studies should incorporate these variables to enable more comprehensive adjustment for potential confounders. Furthermore, the favorable prognosis endpoint was based on an exploratory composite functional outcome rather than the standard 90-day mRS, which remains the most widely accepted functional outcome measure in the AIS research. Therefore, these findings should be interpreted cautiously and confirmed in future prospective multicenter studies. Similarly, patient satisfaction was assessed using an institutionally developed questionnaire that demonstrated acceptable internal consistency but lacked external validation. Accordingly, these findings should also be considered exploratory until validated using standardized, validated patient-reported outcome measures. Future multicenter randomized studies with larger sample sizes, longer follow-up durations, prospective clinical trial registration, standardized rehabilitation protocols, formal *a priori* sample size calculations, and attention-matched CGs are warranted to further evaluate the long-term safety and effectiveness of CMR pathways initiated early after MT in patients with AIS and to confirm the present findings.

Conclusion

A continuous multidisciplinary rehabilitation program initiated within 24–72 hrs after mechanical thrombectomy and maintained throughout a 3-month rehabilitation pathway was associated with improved short-term

neurological, cognitive, motor, and activities of daily living outcomes in patients with acute ischemic stroke. Patients receiving this structured rehabilitation program also demonstrated lower complication rates and higher favorable prognosis rates during short-term follow-up. Because the intervention extended beyond the acute phase into the subacute recovery period, the observed benefits should be interpreted as reflecting the cumulative effects of sustained multidisciplinary rehabilitation rather than the isolated effect of early initiation alone. Furthermore, given the comprehensive multicomponent nature of the rehabilitation program and the methodological limitations

of this exploratory single-center study, these findings should be regarded as hypothesis-generating and association-based rather than definitive evidence of the efficacy of a specific rehabilitation protocol. The present findings support the potential clinical value of a continuous multidisciplinary rehabilitation pathway following mechanical thrombectomy. Further rigorously designed, prospectively registered, multicenter randomized controlled trials with standardized rehabilitation protocols are warranted to confirm these findings and to determine the independent contribution of individual rehabilitation components.

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