

Efficacy and Safety of Mono Antiplatelet Treatment for Cardioembolic and Undetermined Etiological Stroke after Receiving Successful Mechanical Thrombectomy

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Research article

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Abstract

Background Periprocedural antithrombotic medication after mechanical thrombectomy (MT) for acute intracranial large vessel occlusion (LVO) is still controversial. Recent studies have indicated that majority of stroke with undetermined etiology (SUE), as defined by the TOAST classification, showed strong overlap with cardioembolic stroke (CE). We intended to determine the efficacy of the mono antiplatelet (MA) therapy in both stroke types after receiving successful MT recanalization in the acute stage.

Methods 178 consecutive stroke patients who received MT treatment were retrospectively analyzed. CE and SUE type stroke patients were chosen to receive MA therapy. Aspirin 100mg or clopidogrel 75 mg was added immediately for patients who didn't receive intravenously recombinant tissue plasminogen activator (IV-rtPA) and after 24 hours for those received IV-rtPA if symptomatic intracranial hemorrhage (sICH) was not found. MA treatment outcomes included recanalized artery patency, subsequent sICH and functional independence (mRS score of 0-2) were compared between two stroke types.

Results Successful recanalization (TICI 2b/3) was achieved in 75 CE stroke patients and 50 SUE patients without hemorrhagic transformation were included into final analysis. Target artery at 7 days after recanalization was confirmed 100% patency in the CE group and 97.5% in the SUE group. Hemorrhagic transformation after 24h was found in 26% patients in the SUE group and in 26.7% patients in the CE group ($P > 0.05$). sICH was confirmed in 3 patients in the SUE group and in 10 patients in the CE group. At 90 days, 45.8% in the SUE group and 46.5% in the CE group of patients had achieved good outcomes (mRS 0-2) ($P=1.00$). However, accumulative death was higher in the CE group than in the SUE group (21% vs. 15%; $P=0.47$)

Conclusion Mono antiplatelet strategy for the treatment of accurate stage of cardioembolic stroke received mechanical thrombectomy is safe and effective. Meanwhile, for patients considered SUE stroke type, mono antiplatelet therapy after thrombectomy achieved similar treatment outcomes as compared to cardioembolic stroke patients.

Background

Cardioembolic (CE) stroke accounts for 14–30% of all ischemic strokes, which often indicate high loaded thrombus, large vessel occlusion and poor response to intravenous thrombolysis, thus requires immediate intervention. Cardioembolic stroke is characterized by embolus occlusion and a non-arteriosclerotic cerebral arterial wall thus complete recanalization and good blood flow restoration can be achieved once the thrombus was removed. Re-occlusion is less while hemorrhagic transformation may more frequently observed in CE cases than in arteriosclerotic stroke cases^[1–2]. Medicine strategy for CE stroke after mechanical thrombectomy (MT) remains controversial as balance should be considered between re-occlusion risk and hemorrhage transformation. Early anticoagulation does not reduce the recurrence of ischemic stroke; rather, it significantly increased symptomatic intracranial hemorrhage (sICH) in CE patients^[3]. An observational study showed that the optimal time for anticoagulation initiation to prevent cardioembolic stroke recurrence was 4–14 days after stroke onset^[4], and during the accurate stage after MT, anti-platelet treatment required because stent retriever thrombectomy or catheter aspiration was likely to result in artery wall injury^[5]. Unfortunately, very limited information of periprocedural antithrombotic medication for patients received MT is available in present. Based on previous experiment study, we had found injuries associated with thrombectomy devices to normal arterial wall was minimal and mainly restricted to endothelial cell and internal elastic lamina^[6]. Thus, based on these findings, we believe mono antiplatelet (MA) therapy might become an appropriate treatment for CE stroke, which may balance the stroke recurrence risk and risk of hemorrhage transformation.

Based on TOAST classification, up to 39% of acute ischemic strokes are of undetermined etiology (SUE)^[7]. Recent studies had indicated a similar pathological findings of thrombi composition between SUE and CE^[8, 9], which indicating a substantial overlap between SUE and CE stroke types. Possible SUE etiology may involve artery-to-artery embolism from large artery atherosclerotic plaques without causing lumen stenosis^[10], thrombus from a thrombogenic atrial substrate^[11], paroxysmal or insidious atrial fibrillation^[12]. Based on these findings, periprocedural antithrombotic medication strategy for the cardioembolic stroke can be applied to cryptogenic stroke.

In present study, we intended to determine whether using MA therapy in SUE and CE strokes after receiving MT recanalization could be used as a safe and effective treatment in the acute stage.

Methods

Patients

The ethics committee of Shanghai Jiaotong university affiliated sixth people

shospital approved this study. Consecutive patients with acute ischemic stroke who were referred for endovascular treatment in our hospital between

medical history, EKG, emergency laboratory reports and more importantly by CT angiogram and intra-procedure DSA images, which decided following MA therapy in acute stage. Then stroke subtypes were further determined using magnetic resonance imaging, duplex sonography of the cervical arteries, coagulation tests, long-term electrocardiography, and transthoracic or transesophageal echocardiography. Patency of target vessel received treatment was checked seven days after procedure using computed tomograph angiography (CTA) or magnetic resonance angiography (MRA).

Thrombectomy procedure

Stent retriever thrombectomy was preferred and was used as first line technique as compared to catheter-based aspiration technique in our center. Solitaire stent retriever device (ev3 Neurovascular, Irvine, California) was mostly frequently applied in our center. The retrieval attempt repeated up to 3 times per target

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artery. If stent thrombectomy failed, we prefer to use catheter aspiration as a supplementary method. Meanwhile, if large-artery atherosclerosis caused stenosis was confirmed during thrombectomy and re-occlusion happened, then salvage balloon dilation or stent insertion was used.

Medication protocol

IV rtPA (Alteplase, Boehringer Ingelheim, Ingelheim, Germany, 0.9-mg/kg) was given only for eligible patients if it could be initiated within 4.5 hours of symptom onset. Ten percent of the dose was infused as a bolus, with the remainder infused during 1 hour. In the acute stage, these patients were treated with standard mono antiplatelet therapy using aspirin 100 mg/day or clopidogrel 75 mg/day 24 hours after IV thrombolysis or immediately after direct MT. For patients with cardiac or other diseases require anticoagulation therapy, they were bridged to oral warfarin or dabigatran if warfarin intolerant 7–14 days after treatment based on its infarction size and risk of hemorrhage transformation. Systemic heparinization was not used in patients during MT procedure in our center. Antiplatelet aggregation or anticoagulation therapy was stopped if sICH was determined. Intravenous tirofiban administration was used if distal embolization occurred by escaped thrombus, unsatisfied blood flow restoration, stenotic lumen restricting forward flow or when balloon dilation or stent insertion required. Intravenous tirofiban administration was then bridged to anti-platelet treatment after 8–24 hours.

Data Collection

Patients' onset to groin puncture time, hospital arrival to groin puncture time, room arrival to groin puncture time, Recanalization time and occurrence time/Puncture to reperfusion were recorded. The baseline characters, stroke severity (NIHSS score) at admission, pre-operation and 24 hours, and 7 days after endovascular treatment were evaluated by an independent neurologist. Detailed thrombectomy procedure information like number of retriever device passages were recorded. Image data of CT, MR and DSA of all patients underwent mechanical thrombectomy were stored and analyzed using the picture archiving and communication system (PACS) database system. Images were evaluated by an experienced radiologist. Meanwhile, Modified Rankin Scale (mRS) at 90 days were also documented.

Definitions

Blood reperfusion was determined use the modified thrombolysis in cerebral infarction (mTICI) grading system. mTICI grade 2b (antegrade reperfusion of more than half of the previously occluded target artery ischemic territory) and grade 3 (complete antegrade reperfusion) were defined as good blood flow. Recanalization was defined if the target arterial achieved the good blood flow on the DSA or CTA or MRA. Intracranial hemorrhage (ICH) transformation was defined as hyperintensity on the CT scan. Haemorrhagic infarction 1 (HI1) was defined as small petechiae along the margins of the infarct; haemorrhagic infarction 2 (HI2) as confluent petechiae within the infarcted area but no space-occupying effect; parenchymal haemorrhage (PH1) as blood clots in 30% or less of the infarcted area with some slight space-occupying effect; and parenchymal haemorrhage (PH2) as blood clots in more than 30% of the infarcted area with substantial space-occupying effect^[13]. Symptomatic ICH (sICH) was defined as its radiologic appearance plus an increase in National Institutes of Health Stroke Scale score of ≥ 4 points according to ECASS criteria grading^[13]. Re-occlusion of the target artery was defined as a blood flow interruption determined by CT or MR angiography.

Statistical analysis

GraphPad Prism 5.0 software (San Diego, CA, USA) was used for statistical analysis. Data were expressed as the mean \pm standard deviation for continuous variables, and as counts or proportions (%) for categorical variables. Fisher's exact test was used to compare categorical data. Grouped t-tests were used to compare the continuous variables. One-way ANOVA test was used to compare the difference of NIHSS changes at different time points. All tests were two tailed and statistical significance was defined as $P < 0.05$.

Results

Patient characteristics

A total of 191 consecutive stroke patients received MT treatment in our center, and 178 patients received MT in the anterior circulation were retrospectively enrolled into analyzed in present study. Fifty-three patients were excluded before MA therapy from this study, include i) 32 patients with stroke caused by large-artery atherosclerosis or other etiology such as arterial dissections; ii) 2 patients confirmed immediate sICH; iii) 17 patients recanalization with poor flow reperfusion (mTICI 0-2a) and iv) 2 cases died shortly after thrombectomy. Successful recanalization (mTICI 2b/3) achieved in 125 patients were included into final analyzed, and were divided into a SUE stroke group ($n = 50$) and a CE stroke group ($n = 75$). (Fig. 1)

The two groups were comparable in terms of demographics, use of intravenous thrombolysis and clinical severity on presentation, except more frequent atrial fibrillation occurrence rate ($P < 0.01$), older age ($P = 0.04$), and hypertension occurrence rate ($P = 0.03$) in the CE group than those in the SUE group (Table 1). There was no difference in the previous stroke, baseline mRS, ASPECT score on CT and occlusion site on CTA between the two groups. The onset to groin puncture time was significant longer in the SUE group as compared to that in the CE group ($p = 0.003$), however the hospital arrival to groin puncture time and Room arrival to groin puncture time revealed no difference between the two groups.

Mechanical thrombectomy

MT technical feasibility (clot engagement) was 100% in both groups and 90.4% patients received good flow restoration after MT. For patients received good flow reperfusion, TICI 2b and 3 achieved in 16% and 84% of patients in the SUB group and 14.7% and 85.3% in the CE group. Stent retriever technique was considered a first line choice in in 94% and 94.7% patients received successful recanalization in the SUE and CE groups. The mean stent retriever time was no difference between the two groups (1.68 ± 0.1905 in the SUE vs. 2.16 ± 0.1918 in the CE group; $P = 0.09$). The puncture to reperfusion time was 53.48 ± 5.792 minutes and 55.26 ± 4.568 minutes in the SUE and CE groups respectively ($P = 0.81$). (Figs. 2 & 3)

Efficacy and safety of mono antiplatelet treatment

CTA or MRA follow up at 7 days performed in 41 patients in the SUE group and in 56 patients in CE group. A total of 97.6% and 100% recanalized artery in the SUE and CE group was confirmed patency by either CTA or MRA examinations. (Figs. 2 & 3) The only one patient in the SUE group was found recanalized artery occlusion may due to second embolism occurrence as the symptom suddenly deteriorated the occlusion site was distal M1 as compared to distal ICA embolism firstly. Also, CTA and MRA examination didn't revealed other cerebral artery occlusion happened within 7 days in the acute stage.

Hemorrhagic transformation occurred in 13 patients in the SUE group and in 20 patients in the CE group respectively ($P = 1.00$). Hemorrhagic infarction was found in 3 patients (type I in 1 and Type II in 2) in the SUE group and in 6 patients (type I in 3 and Type II in 3) in the CE group. Parenchymal hematoma was found in 10 patients (type I in 5 and Type II in 5) in the SUE group and in 14 patients (type I in 3 and Type II in 11) in the CE group. Among them, sICH was confirmed in 3 and 10 patients in the SUE and CE groups ($P = 0.24$).

The NIHSS score was similar between the SUE group (17.8 ± 1.07) and CE group (17.2 ± 0.69) ($P = 0.62$). The NIHSS score decrease significantly to 15.83 ± 1.59 at 24 hours post MT and to 10.95 ± 1.72 at 7 days post MT in the SUE group ($P < 0.01$). Similarly, NIHSS score decrease significantly to 15.62 ± 1.16 at 24 hours post MT and to 10.71 ± 1.30 at 7 days post MT in the CE group ($P < 0.01$). However, at every follow up time point, there was no significant of the NIHSS score between the two groups. (Fig. 4)

At 3 months follow up, good clinical outcomes (mRS 0–2) was revealed in 45.8% patients in the SUE group, and in 46.5% patients in the CE group ($P = 1.00$). However, the accumulative death rate was higher in the CE group than in the SUE group (21% vs. 15%; $P = 0.47$). (Table 2) (Fig. 4)

Discussion

In this study, mono antiplatelet therapy strategy was used for the treatment of a group of ACS patients caused by cardioembolic and undetermined etiological stroke who underwent successful good flow restoration. Our main findings revealed that: i) mono antiplatelet therapy can effectively maintain the target artery patency; ii) mono antiplatelet therapy did not resulting in higher risk of sICH in the acute stage; iii) mono antiplatelet therapy presented similar treatment outcomes between the cardioembolic stroke and undetermined etiological stroke.

Previous animal studies reported that the use of stent retriever thrombectomy devices may cause arterial wall damages from the intimal to medial layers in rabbit carotid arteries [5]. However, our results indicated that the use of stent retriever devices in canine external carotid arteries resulted in damage to the vessel wall is mainly restricted to the endothelium/intimal and occasionally involves the internal elastic lamina (IEL), which indicating that multiple passes with a stent retriever device may slightly increase the risk of arterial wall damage [6]. The canine models behave more like healthy human cerebral vessels than other small animal models, with respect to histological structure, vasospasm, recoil, neointimal proliferation and thrombotic potential. Consequently, we believe reequipping for antithrombotic therapy after stent thrombectomy may not so strong in a health vessel condition.

Recent studies based on histological analysis of the retrieved thrombi have revealed that cardioembolic and undetermined etiological strokes have similar histological thrombus features, with higher proportions of fibrin/platelets, less erythrocytes, and more leucocytes than large artery atherosclerosis thrombi [8, 9]. These findings may indicate that underlying cause of most undetermined etiological strokes may derived from cardia embolism and the effected cerebral vessels are under healthy condition. Consequently, the medication strategy after thrombectomy for patients with undetermined etiological stroke can be borrowed from the cardioembolic stroke.

For in acute minor stroke, CHANCE study has confirmed that double antiplatelet therapy, with a combination of clopidogrel and aspirin, was superior to mono-antiplatelet therapy alone for reducing the risk of stroke in the first 90 days [14]. However, further the POINT study found despite double antiplatelet therapy can reduce stroke recurrence risk for patients with minor stroke, but did increase higher risk of major hemorrhage at 90 days than those who received mono-antiplatelet therapy alone [15]. Although anticoagulation therapy has been well established to prevent stroke in atrial fibrillation patients, no consensus was found in the optimal time of initiation for anticoagulation after stroke [16–17]. In patients with a large stroke or high risk of hemorrhagic conversion, aspirin is recommended, followed by anticoagulant for long-term secondary prevention [12]. Thus based on above knowledges, we believed that patients underwent successful thrombectomy recanalization with good flow restoration and a healthy vessel condition should be conservatively administered mono-antiplatelet therapy alone to get the maximum benefit, possible reasons may include: i) good flow restoration often means elevated reperfusion associated with an increased ICH risk; ii) cardioembolic or undetermined etiological stroke often indicated a relatively normal arterial wall and thrombectomy may cause little damage to the vessel wall; iii) acute stroke patient with large-vessel occlusion has a high chance to develop large area ischemic infarction and hemorrhage transformation, and iv) aspirin alone were associated with a similar reduction in recurrent stroke within 7 to 14 days and reduction of sICH as compared to anticoagulants application [12].

The target vessel patency rate was a key important index for the evaluation of whether mono-antiplatelet alone can keep patency of the recanalized artery. Our results showed that the target vessel patency rate was 97.6% and 100% respectively in the SUE and CE group. Which indicate that mono-antiplatelet could well inhibit further thrombosis event in the artery subject to thrombectomy damage; moreover, this strategy also could prevent further embolism occurrence during the acute stage period before bridged to anticoagulation therapy. Moreover, this medication strategy may minimize the risk of cerebral hemorrhage transformation as compared to other medication plans.

The limitations of our study are as follows: firstly, this is a retrospective, single arm analyzed study with limited sample size, thus a randomized, double-blind, placebo-controlled trial may further need to fully investigate its efficacy and safety; secondly, we only focused on patients who received good blood flow

restoration without sICH thus this imitated its wide clinical application; thirdly, the diagnosis of stroke type may not be accurate before, during or immediate after the thrombectomy treatment when antiplatelet strategy need to be decided.

Conclusions

Mono antiplatelet therapy is safe and effective for maintaining flow patency in ACS patients who received stent thrombectomy recanalization in the acute stage before the initiation of anticoagulation therapy. However, further randomized controlled trials are needed to provide more reliable evidence for the antithrombotic strategy for ACS patients who received endovascular MT.

Abbreviations

SUE: undetermined etiology

CE: cardioembolic

MA: mono antiplatelet

MT: mechanical thrombectomy

sICH: symptomatic intracranial hemorrhage

CTA: tomograph angiography

MRA: magnetic resonance angiography

PACS: picture archiving and communication system

mRS: Modified Rankin Scale

mTICI: modified thrombolysis in cerebral infarction

HI: Haemorrhagic infarction

PH: parenchymal haemorrhage

Declarations

Ethics approval and consent to participate

The ethics committee of Shanghai Jiaotong university affiliated sixth people`s hospital approved this study.

Consent for publication

Not applicable

Availability of data and material

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

Competing interests

We declare there in no competing interests in this study.

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Authors' contributions

1. D.J. and H.G.: Acquisition of data, analysis and interpretation of data and drafting of the manuscript
2. Z.Y. and Z.Y.: Study concept and design, critical revision of the manuscript for important intellectual content and study supervision
3. L.H., L.Y. and W.L.: acquisition of data and statistical analysis.
4. L.M.: critical revision of the manuscript for important intellectual content

All authors consent for publication of this study

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None

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Tables

Table 1: baseline characteristics of the SUE and CE groups			
	SUE group (n=50)	CE group (n=75)	P Value
Age	68 ± 1.459	72.03 ± 1.26	0.04
Sex			
Male	23 (46%)	36 (48%)	0.8566
Female	27 (54%)	39 (52%)	
Medical history			
Hypertension	23 (46%)	50 (66.7%)	0.0267
Diabetes	7 (14%)	18 (24%)	0.2535
Hyperlipidaemia or hypercholesterolaemia	10 (20%)	13 (17.3%)	1.00
Atrial fibrillation	4 (8%)	64 (85.3%)	<0.01
Cardiovascular disease	4 (8%)	4 (8%)	0.7124
Current smoker	11 (22%)	20 (26.7%)	0.6735
Ischaemic stroke	5 (10%)	12 (16%)	0.4292
Haemorrhagic stroke	1 (2%)	2 (2.7%)	1.00
Current stroke event (pre-morbid modified Rankin score)			
0	43 (86%)	67 (89.3%)	0.5861
1	6 (12%)	5 (6.7%)	
2	1 (2%)	3 (4%)	
3	0 (0%)	0 (0%)	
4	0 (0%)	0 (0%)	
Median NIHSS score	17	17	
Mean NIHSS score	17.8 ± 1.066	17.2 ± 0.6928	0.6246
Median ASPECT score	10	10	
Mean ASPECT score	9.86 ± 0.45	9.89 ± 0.38	0.6606
Site of occlusion			
MCA-M1	29 (58%)	38 (50.7%)	0.7229
MCA-M2	4 (8%)	7 (9.3%)	
ICA	17 (34%)	30 (40%)	
Intravenous tissue plasminogen activator pre-procedure	18 (36%)	35 (46.7%)	0.2708
Onset to groin puncture time (min)	280.4 ± 18.12	223.7 ± 9.583	0.0031
Hospital arrival to groin puncture time (min)	101.4 ± 3.863	105.5 ± 4.75	0.5383
Room arrival to groin puncture time (min)	13.75 ± 0.9712	13.4 ± 0.6961	0.7653
Note- data were expressed as the mean ± standard deviation for continuous variables, and as counts or proportions (%) for categorical variables, percentage was provided in the brackets. CE: cardioembolic stroke; SUE: undetermined etiological stroke; NIHSS: the National Institutes of Health Stroke Scale; MCA: middle cerebral artery; ICA: internal carotid artery; ASPECT: Alberta Stroke Program Early CT Score.			

	SUE group (n=50)	CE group (n=75)	P value
Median NIHSS score [Pre]	17	17	
Mean NIHSS score [Pre]	17.8 ± 1.066	17.2 ± 0.6928	0.6246
Median NIHSS score [24h]	16	15	
Mean NIHSS score [24h]	15.83 ± 1.587	15.62 ± 1.16	0.9126
Median NIHSS score [7d]	7	9	
Mean NIHSS score [7d]	10.95 ± 1.724	10.71 ± 1.298	0.9115
Puncture-reperfusion time	53.48 ± 5.792	55.26 ± 4.568	0.8094
Occurrence-perfusion time	333.8 ± 17.61	279 ± 11.04	0.0064
Hemorrhagic transformation	13 (26%)	20 (26.7%)	1.00
Hemorrhagic transformation Type			
<i>Hemorrhagic infarction</i>			
<i>I type</i>	1 (2%)	3 (4%)	
<i>II type</i>	2 (4%)	3 (4%)	
Parenchymal hematoma			
<i>I type</i>	5 (10%)	3 (4%)	
<i>II type</i>	5 (10%)	11 (14.7%)	
sICH	3	10 (13.3%)	0.2403
Thrombectomy			
<i>Stent retriever</i>	47 (94%)	71 (94.7%)	1.00
<i>Catheter aspiration</i>	3 (6%)	4 (5.3%)	
Stent retriever times	1.68 ± 0.1905	2.16 ± 0.1918	0.091
Reperfusion			
<i>mTICI 2b</i>	8	11	1.00
<i>mTICI 2b or 3</i>	42	64	

Note- data were expressed as the mean ± standard deviation for continuous variables, and as counts or proportions (%) for categorical variables, percentage was provided in the brackets. CE: cardioembolic stroke; SUE: undetermined etiological stroke; NIHSS: the National Institutes of Health Stroke Scale; sICH: symptomatic intracranial haemorrhage; mTICI: Modified treatment in cerebral ischemia.

Figures

Figure 1

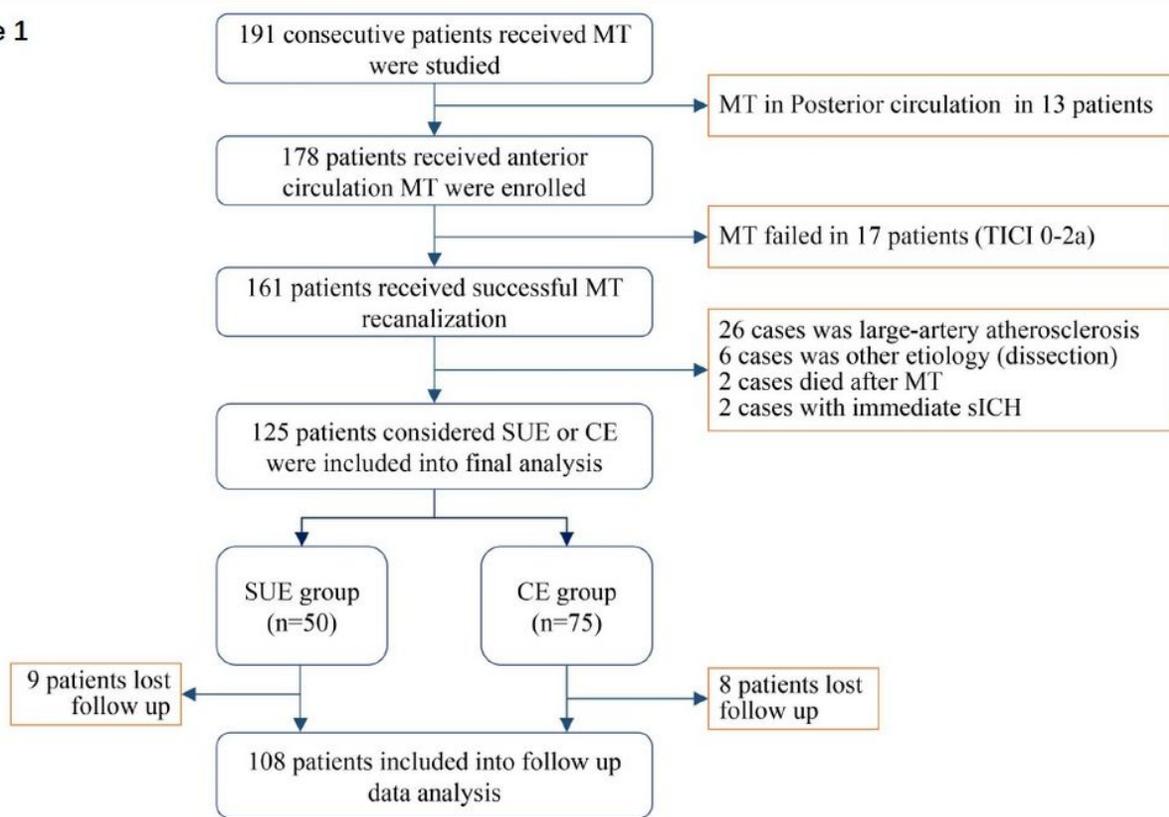


Figure 1

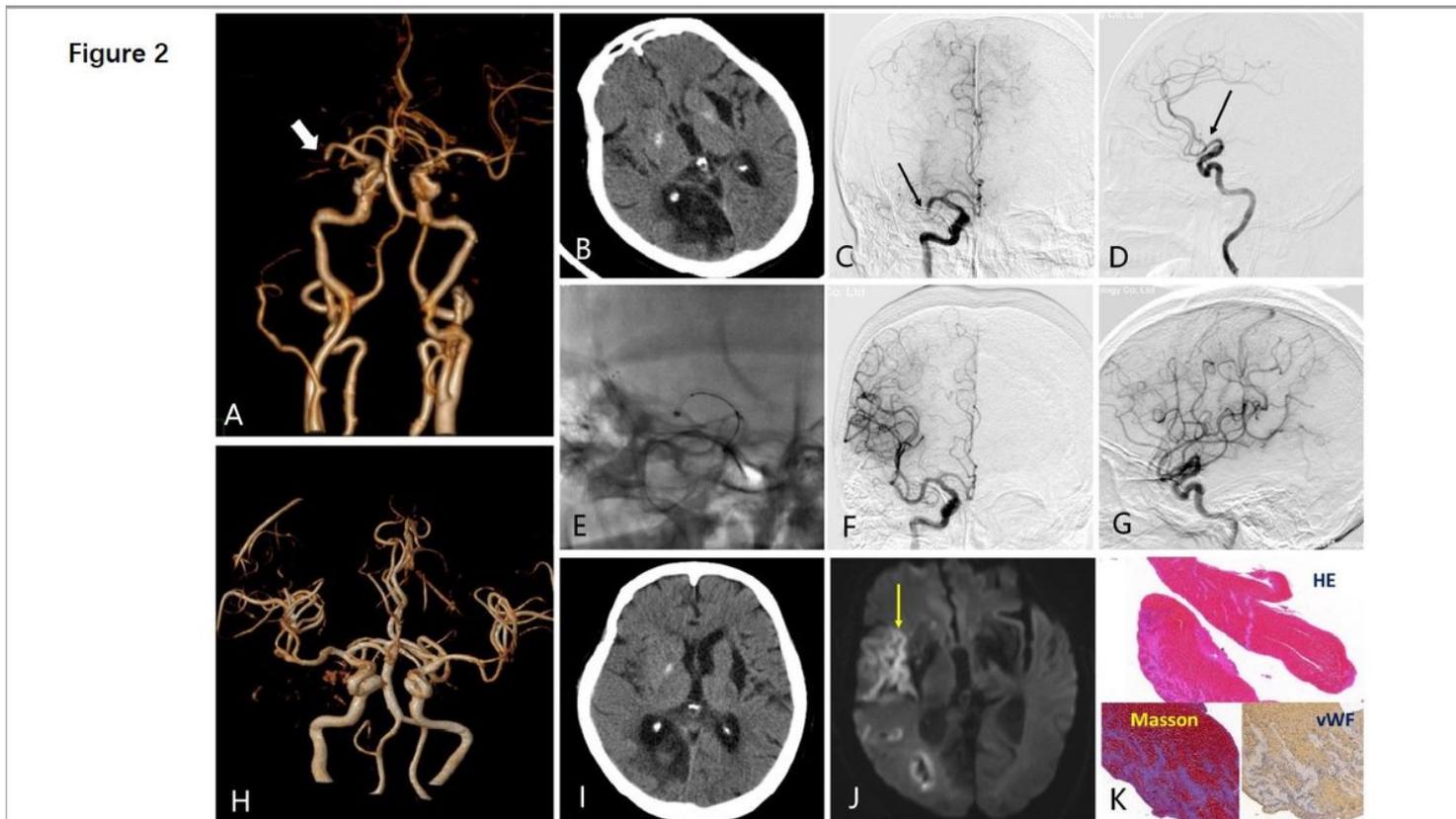


Figure 2

A patient with sudden onset of left limb hemiplegia and gaze (NIHSS score 16) had a history of atrial fibrillation and was considered for cardioembolic stroke. A,B: initial CT and CTA showed previous cerebral infarction and right M1 of MCA occlusion; C,D: angiograms confirmed M1 segment occlusion; E-G: thrombectomy treatment achieved mTICI 3 flow restoration; H-J, follow up MRA (7 days), CT (3 days) and MR (5 days) revealed mono antiplatelet therapy kept well patency of the recanalized artery and left limited infarction; K, thrombus pathological stain revealed a mixed thrombus composed of red blood cells, platelets, and fibrin. (white wide arrow and black narrow arrows show the occlusion site; yellow narrow arrow shows the limited infarction area; NIHSS: the National Institutes of Health Stroke Scale; CT: computed tomography; CTA: computed tomography angiography; mTICI: Modified treatment in cerebral ischemia; MCA: middle cerebral artery; MR: magnetic resonance; MRA: magnetic resonance angiography)

Figure 3

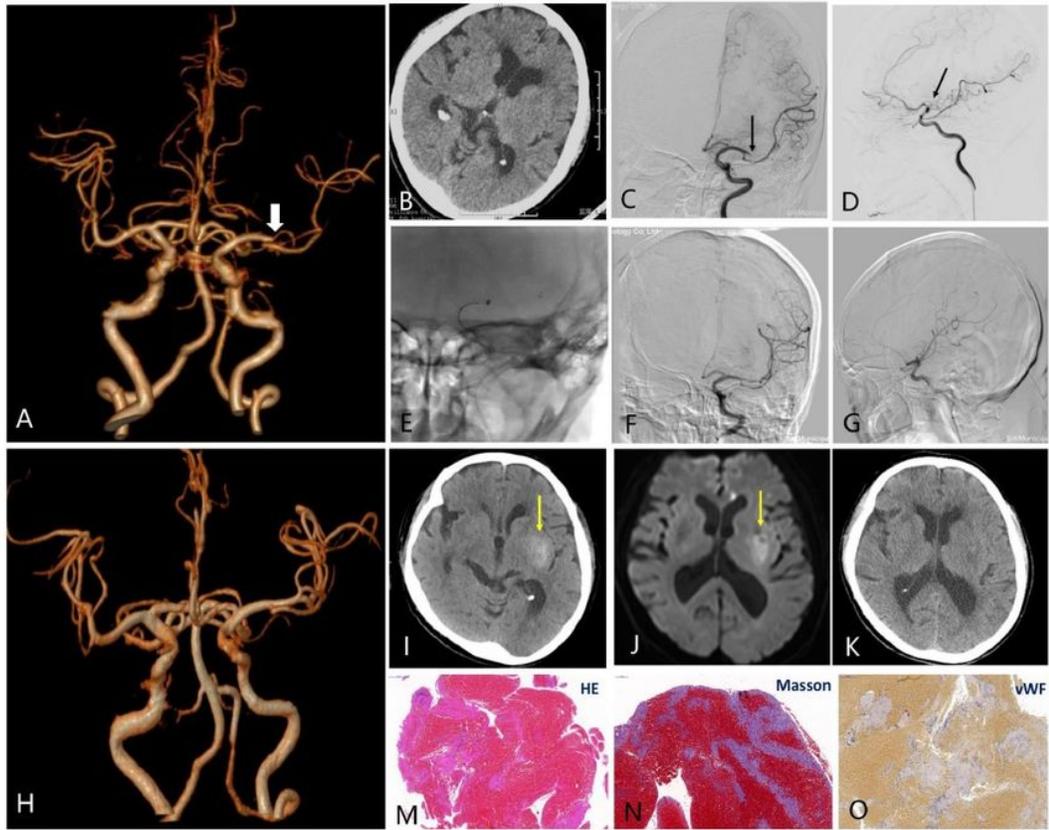


Figure 3

A patient with sudden onset of right limb hemiplegia, slurred speech and gaze (NIHSS score 18) was considered undetermined etiological stroke. A,B: initial CT revealed normal and CTA showed superior trunk of MCA occlusion; C-G: angiograms confirmed occlusion and mTICI 3 flow restoration was achieved after thrombectomy treatment; H-K, follow up MRA (7 days), CT (24 hours), MR (5 days) and CT (9 days) reveal mono antiplatelet therapy keeps well patency of the recanalized artery and leaves limited infarction; M-O, thrombus pathological stain reveals a mixed thrombus composed of red blood cells, platelets, and fibrin. (white wide arrow and black narrow arrows show the occlusion site; yellow narrow arrow shows the limited infarction area; NIHSS: the National Institutes of Health Stroke Scale; CT: computed tomography; CTA: computed tomography angiography; mTICI: Modified treatment in cerebral ischemia; MCA: middle cerebral artery; MR: magnetic resonance; MRA: magnetic resonance angiography)

Figure 4

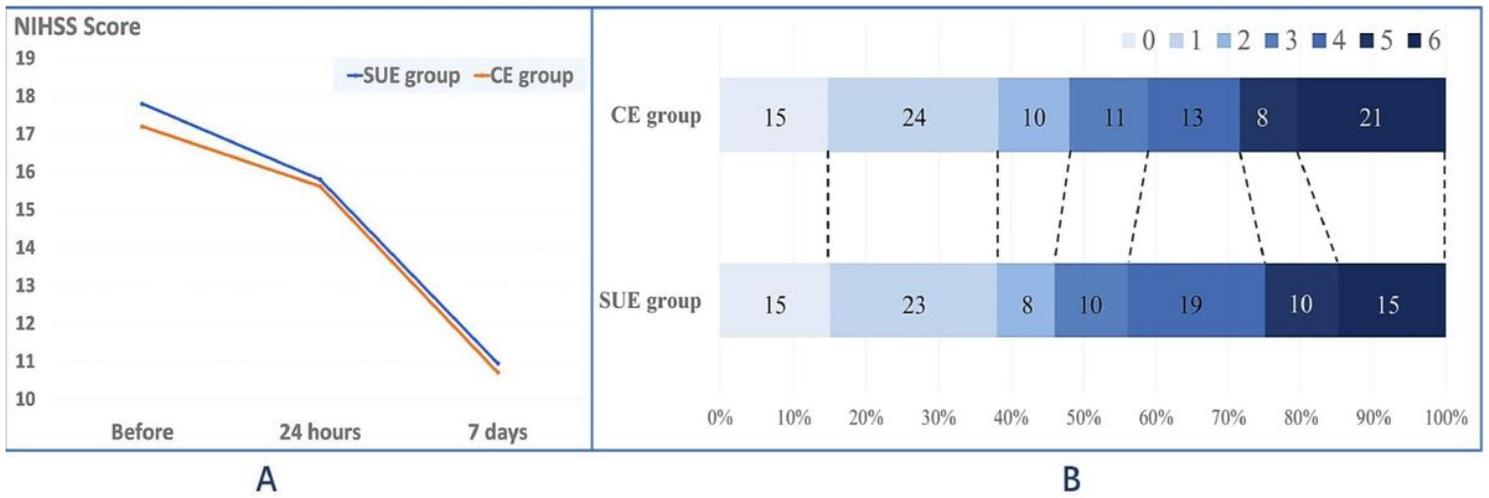


Figure 4

NIHSS score changes before, 24-hour and 7-day after thrombectomy and modified Rankin Scare at 90 days of the CE and SUE groups.