Clinical outcomes after endovascular thrombectomy in different triage methods

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Research Article

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Abstract

Objective: We compare three treatment strategies for acute ischemic stroke (AIS) for effectiveness and safety: 1) patients seen at a primary stroke center (PSC), started on emergency intravenous thrombolysis (IVT) and then transported to a comprehensive stroke center (CSC) ["drip and ship" (DS)]; 2) patients immediately transferred to CSC without starting IVT, for mechanical thrombectomy (MT) ["non-drip and ship" (non-DS)]; and 3) patients admitted directly to the CSC for assessment and subsequent bridging thrombolysis (BT) ["mothership" (MS)].

Methods: We retrospectively reviewed the data of patients that underwent MT for AIS from November 2020 to November 2021 at our institution. Patients were divided into three groups: DS, non-DS, and MS, as defined above. Time course, multimodal CT features and clinical results were compared among the three groups, including onset-to-needle time (OTN), onset-to-groin time (OGT), onset-to-PSC time (OTP), PSC-to-groin-puncture time (PTG), door to needle time (DNT), door to puncture time (DPT), intravenous thrombolysis to puncture time (IVT-P), volumes of ischemic core and ischemic penumbra, postoperative modified thrombolysis in cerebral infarction (mTICI) score, postoperative hemorrhagic transformation and malignant edema, 90-day modified Rankin scale (mRS) score and mortality.

Results: The study included 41 patients, with 12, 12, and 17 patients in DS, non-DS, and MS groups, respectively. Baseline characteristics, such as age, gender, past history, and National Institutes of Health Stroke Scale (NIHSS) score, did not differ among the three groups. OGT differed among the three groups \((P<0.001)\). The DS group had a significantly longer OGT than the MS group (DS median, 390 minutes; interquartile range [IQR], 326-500 minutes versus MS median, 235 minutes; IQR, 159-270 minutes; \(P<0.001\)), a significantly shorter OTP than the non-DS group (DS median, 94 minutes; IQR, 82-116 minutes versus non-DS median, 463 minutes; IQR, 335-787 minutes; \(P<0.001\)), and a longer PTG than the non-DS group (DS median, 271 minutes; IQR, 204-364 minutes versus non-DS median, 162 minutes; IQR, 111-240 minutes; \(P=0.002\)). OTN was longer in the MS group than the DS group (MS, 150.9 ± 48.8 minutes versus DS, 111.7 ± 47.7 minutes; \(P=0.041\)). IVT-P was shorter in the MS group compared with DS (MS median, 56 minutes; IQR, 39.5-102 min versus DS median, 275 minutes; IQR, 186-390.75 min, \(P<0.001\)). No significant differences were present among groups in volume of the ischemic core, ischemic penumbra, rate of recanalization, malignant edema, hemorrhage transformation, number with mRS \(\leq 2\) at 3 months, or mortality at 3 months.

Conclusions: DS is a safe and effective method, with no increased risk of postoperative hemorrhage transformation, malignant edema or death compared to non-DS and MS methods.

Introduction

For patients with acute ischemic stroke (AIS), early cerebral reperfusion is key to successful treatment. Emergency intravenous thrombolysis (IVT) within 4.5 hours of symptom onset is recommended in guidelines and has been shown to be safe and effective. However, the efficacy of IVT in patients with
large vessel occlusion (LVO) is limited[1]. In recent years, with the advancement of materials and concepts, mechanical thrombectomy (MT) has gradually become a meaningful method of cerebral reperfusion in patients with LVO. In 2018, the time window for MT was broadened after the DAWN and DEFUSE-3 trials were published, greatly increasing the potential number of patients that could benefit from MT[2, 3]. In China, most primary stroke centers (PSCs) cannot perform MT due to equipment and emergency management method restrictions. Patients who have suspected LVO need to be transferred to a comprehensive stroke center (CSC) for further evaluation and possible MT. For patients seen within an onset time < 4.5 hours, PSCs can perform IVT prior to transporting patients to the CSC, a method referred to as drip and ship (DS). Patients beyond the time window or in whom IVT is contraindicated, may be transferred to CSC directly (non-DS). Our CSC retrospectively summarized cases from November 2020 to November 2021 and explored the efficacy and safety of DS.

Materials And Methods

Study design

We retrospectively reviewed the Beijing Chaoyang hospital databases of picture archiving and communication systems and the clinical information system for patients who presented to our institution with AIS for MT between November 2020 and November 2021. (Patients who were admitted directly to Beijing Chaoyang hospital for MT only were excluded). The approval for this study was obtained from the institutional ethics committee. According to whether the patient transferred from a PSC and whether they received IVT before MT, they were divided into three groups: 1) patients who received IVT in a PSC and then transferred to the CSC for MT (DS); 2) patients who were directly transferred to CSC for MT after preliminary evaluation in a PSC without IVT (non-DS); and 3) patients who were admitted to CSC for bridging thrombolysis (MS). Inclusion criteria were: 1) age ≥ 18; 2) demonstrated presence of LVO by multimodal CT; 3) ischemic core volume of less than 70 ml, a ratio of volume of ischemic tissue to ischemic core of 1.8 or more, and an absolute volume of penumbra of 15 ml or more; 4) no hemorrhagic stroke observed in CT scan; and 5) good baseline functional status (modified Rankin scale (mRS) score ≤ 2). There are two PSCs in the health alliance, and both hospitals are ~ 1 hour drive away from our CSC hospital (about 55 km). We evaluated and compared the three groups in onset-to-needle time (OTN), onset-to-groin time (OGT), onset-to-PSC time (OTP), PSC-to-groin-puncture time (PTG), door-to-needle time (DNT), door-to-puncture time (DPT), IVT to puncture time (IVT-P), as well as ischemic core volume, ischemic penumbra volume, postoperative complications including hemorrhagic transformation and malignant edema based on multimodal CT, admission and discharge National Institutes of Health Stroke Scale (NIHSS) scores; 90-day mRS scores, and mortality. Data were collected during 3–6 months follow-up.

Therapeutic processes

DS patients
Patients went to the PSC within 4.5 hours of AIS onset. The PSC emergency doctor and neurologist evaluated and recommended standard IVT therapy based on a non-contrast CT (NCCT) scan, clinical symptoms, and guidelines. If the neurological deficiency was not resolved or worsened during the observation process, the transfer mechanism to our hospital began, and the relevant information and treatment process conveyed to CSC doctors at the same time. During transport, the patient was monitored closely for any changes in symptoms. Once patients arrived at the CSC, the green channel integrated management strategy began immediately[4]. Multimodal CT was performed as soon as possible to evaluate cerebral vessel lesions. Patients who met the indications for MT were immediately bridged for MT.

**non-DS patients**

Patients arrived at the PSC beyond 4.5 hours of AIS onset. The transfer mechanism to the CSC began immediately. The admission process in the CSC after transfer was the same as the DS group.

**MS patients**

Patients were directly admitted to the CSC emergency within 4.5 hours of AIS onset. Once patients arrived at CSC, the green channel integrated management strategy began immediately. Multimodal CT was performed immediately to evaluate cerebral vessel lesions. Patients who met the indications for bridging thrombolysis (BT) immediately received BT therapy.

**Evaluation before operation**

All patients were assessed using the NIHSS score on admission. The patient’s perfusion of brain tissue and intracranial blood vessels was evaluated through multimodal CT, including NCCT, CT angiography (CTA), and CT perfusion (CTP). Images were acquired using the GE Revolution Frontier CT (GE Healthcare, Waukesha, Wisconsin, USA) with 64 slices. In CTP, the ischemic core was defined as the region of reduced CBF (< 30% of that in normal tissue) and the ischemic penumbra was defined as the tissue for which there was delayed arrival of an injected tracer agent (Tmax > 6 seconds). The volume of ischemic core and ischemic penumbra were calculated with the use of the eStroke software (Neusoft, Shenyang, China).

**Evaluation after operation**

All patients were re-assessed with an NIHSS score on discharge. Safety outcomes were assessed by dual-energy CT (DE CT), and hemorrhagic transformation was defined as a mismatch between the high-density shadows in the iodine overlay map (IOM) and virtual non-contrast imaging (VNC). Malignant edema was defined as a syndrome of clinical worsening with imaging evidence of brain swelling (or requirement for decompressive hemicraniectomy or death)[5]. A modified Thrombolysis in Cerebral Infarction (mTICI) score of 2b or 3 after thrombectomy was considered successful recanalization[6]. Functional independence was assessed by mRS, with a score of 0–2 defined as having a good functional outcome.
Statistical analysis

All analyses were performed using SPSS Statistics software, version 26.0 (IBM Corporation, New York, NY). Continuous variables are presented as mean ± SD or median values and interquartile range (IQR). Categorical variables are reported as frequency. Continuous variables such as age, NIHSS score, time course, and imaging characteristics were analyzed with an independent sample t-test, one-way ANOVA with Bonferroni post-hoc test, or Mann-Whitney test. Rank variables such as mTICI scores and postoperative mRS scores were analyzed with a rank sum test. Categorical variables such as past history, hemorrhage transformation, malignant edema and 90-day mortality were analyzed with a Chi-square test. Outcomes with \( P \) values < 0.05 were considered significant.

Results

From November 2020 to November 2021, 212 patients were treated in our hospital for MT, of which 52 patients were transferred from a PSC to our hospital for evaluation, and 160 patients were directly treated in our hospital. Of the 52 patients transferred, 28 were excluded, 19 that received IVT before transport and nine that did not. Of the 19 patients that received IVT, 17 were excluded because they had no LVO, and two were excluded because of the large volume of core infarction. Of the nine patients who did not receive IVT, five were excluded because they had no LVO, and four were excluded due to large volume of core infarction. For the 160 patients treated directly at our hospital, 17 patients that underwent BT were included and 143 patients treated with MT alone were excluded. Thus, there are final dataset included 41 patients: 12 DS, 12 non-DS and 17 MS (Fig. 1). Details of the three groups are shown in Table 1. Baseline characteristics such as age, gender, past history, and preoperative NIHSS scores did not differ among the three groups.
### Table 1
Baseline and clinical characteristics, safety outcomes and time course of patients in drip-and-ship, non-drip-and-ship, and mothership.

<table>
<thead>
<tr>
<th></th>
<th>DS</th>
<th>non-DS</th>
<th>MS</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>72.7 ± 10.7</td>
<td>68.5 ± 12.5</td>
<td>61.5 ± 15.1</td>
<td>0.084</td>
</tr>
<tr>
<td>Male</td>
<td>10</td>
<td>8</td>
<td>14</td>
<td>0.526</td>
</tr>
<tr>
<td>Hypertension</td>
<td>9 (75%)</td>
<td>9 (75%)</td>
<td>12 (70.6%)</td>
<td>0.952</td>
</tr>
<tr>
<td>Diabetes</td>
<td>5 (41.7%)</td>
<td>4 (33.3%)</td>
<td>4 (23.5%)</td>
<td>0.580</td>
</tr>
<tr>
<td>CHD</td>
<td>3 (25%)</td>
<td>5 (41.7%)</td>
<td>3 (17.6%)</td>
<td>0.350</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>2 (16.7%)</td>
<td>3 (25%)</td>
<td>3 (17.6%)</td>
<td>0.848</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>3 (25%)</td>
<td>5 (41.7%)</td>
<td>3 (17.6%)</td>
<td>0.351</td>
</tr>
<tr>
<td>Stroke</td>
<td>5 (41.7%)</td>
<td>3 (25%)</td>
<td>4 (23.5%)</td>
<td>0.531</td>
</tr>
<tr>
<td>Smoking</td>
<td>6 (50%)</td>
<td>3 (25%)</td>
<td>9 (52.9%)</td>
<td>0.289</td>
</tr>
<tr>
<td>Drinking</td>
<td>5 (41.7%)</td>
<td>1 (8.3%)</td>
<td>7 (41.2%)</td>
<td>0.118</td>
</tr>
<tr>
<td>Admission NIHSS</td>
<td>13.25 ± 8.1</td>
<td>13.25 ± 7.2</td>
<td>11.65 ± 4.4</td>
<td>0.74</td>
</tr>
<tr>
<td>Discharge NIHSS</td>
<td>7.58 ± 7.6</td>
<td>11.75 ± 11.68</td>
<td>11.82 ± 10.35</td>
<td>0.483</td>
</tr>
<tr>
<td>mTICI</td>
<td></td>
<td></td>
<td></td>
<td>0.316</td>
</tr>
<tr>
<td>0-2a</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2b-3</td>
<td>12</td>
<td>10</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Hemorrhage transformation</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>0.732</td>
</tr>
<tr>
<td>Malignant edema</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>0.997</td>
</tr>
<tr>
<td>90-day motality</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0.234</td>
</tr>
<tr>
<td>mRS after operation</td>
<td></td>
<td></td>
<td></td>
<td>0.316</td>
</tr>
<tr>
<td>0–2</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>3–6</td>
<td>8</td>
<td>7</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Time course (min)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DPT</td>
<td>110.6 ± 35.1</td>
<td>111.5 ± 36.1</td>
<td>124.9 ± 42.5</td>
<td>0.531</td>
</tr>
<tr>
<td>OGT</td>
<td>390 (326–500)</td>
<td>441.5 (398.5–635.25)</td>
<td>235 (159–270)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>OTN</td>
<td>111.7 ± 47.7</td>
<td></td>
<td>150.9 ± 48.8</td>
<td>0.041</td>
</tr>
</tbody>
</table>
In terms of time course, DPT did not differ among the three groups ($P = 0.531$). OGT did vary among groups ($P < 0.001$), with the DS group being significantly longer than the MS group (DS median, 390 minutes; IQR, 326–500 minutes versus MS median, 235 minutes; IQR, 159–270 minutes; $P < 0.001$). The DS group had a shorter OTP than the non-DS group (DS median, 94 minutes; IQR, 82–116 minutes versus non-DS median, 463 minutes; IQR, 335–787 minutes; $P < 0.001$), but a longer PTG than the non-DS group (DS median, 271 minutes; IQR, 204–364 minutes versus non-DS median, 162 minutes; IQR, 111–240 minutes; $P = 0.002$). OTN was significantly longer in the MS group ($150.9 ± 48.8$ minutes) than in the DS group ($111.7 ± 47.7$ minutes, $P = 0.041$). IVT-P was shorter in the MS group compared to the DS group (MS median, 56 minutes; IQR, 39.5–102 minutes versus DS median, 275 minutes; IQR, 186-390.75 minutes, $P < 0.001$).

In terms of multimodal CT features, the three groups did not differ statistically in volume of ischemic core (DS median, 2.89 ml; IQR, 0-13.72 ml versus non-DS median, 0 ml; IQR, 0-2.91 ml versus MS median, 3.37 ml; IQR, 0-9.31 ml; $P = 0.448$) or ischemic penumbra (DS median, 23.91 ml; IQR, 2.51–94.06 ml versus non-DS median, 0 ml; IQR, 0-19.18 ml versus MS median, 35.05 ml; IQR, 0-59.71 ml; $P = 0.158$).

No significant differences among the three groups were observed in post-operative variables measured. All three groups obtained high rates of successful recanalization (DS: 100%; non-DS: 83.3%; MS: 82.4%; $P = 0.316$). The MS group had the greatest number of patients with hemorrhagic transformation (5/17, 29.4%); there were fewer in the DS group (3/12, 25%) and the non-DS group (2/12, 16.7%), but no significant difference among the three groups ($P = 0.732$). Postoperative malignant cerebral edema did not differ among the three groups (DS: 2/12; non-DS: 2/12; MS: 3/17; $P = 0.997$). The 90-day mortality did not differ among groups (DS: 1/12; non-DS: 2/12; MS: 0/17; $P = 0.234$). Finally, the rates of good outcome among DS (33.3%), non-DS (41.7%) and MS (41.2%) groups did not significantly differ ($P = 0.316$).

The results of analyses are shown in Fig. 2. Figure 3 shows clinical outcomes of patients between three groups.
Discussion

In this study, we explored the safety and efficacy of thrombolysis in the process of transport and treatment by comparing the two transport methods of DS and non-DS. In the non-DS group, most patients did not receive thrombolysis because the thrombolytic time window had passed, so the OTP was significantly longer in these patients than in the DS group (non-DS median, 463 minutes; IQR, 335–787 minutes versus DS median, 94 minutes; IQR, 82–116 minutes; \(P < 0.001\)). After the patients in the DS group were admitted to the PSC, the process of IVT and observation after thrombolysis prolonged the time patients received endovascular therapy, resulting in a longer PTG in the DS group than in the non-DS group (DS median, 271 minutes; IQR, 204–364 minutes versus non-DS median, 162 minutes; IQR, 111–240 minutes; \(P = 0.002\)). The above two points combined may be the reason no statistical difference in OGT was observed between the two groups, although a trend for OGT in the non-DS group to be longer than that in the DS group was present (non-DS median, 441.5 minutes; IQR, 398.5–635.25 minutes versus DS median, 390 minutes; IQR, 326–500 minutes; \(P = 0.807\)). There was also no significant difference in prognosis between the DS and non-DS groups. Currently, most PSCs cannot perform multimodal CT evaluation. Patients who meet the conditions for thrombolysis, are transferred to the CSC for imaging evaluation and MT after receiving IVT. Transport did not appear to increase the risk of post-thrombolytic cerebral hemorrhage, postoperative malignant cerebral edema, or death, as all groups were similar for these outcomes.

Previous retrospective studies show that patients in the MS group present a higher chance of functional independence\[7–9\]. Adams et al.\[10\] provide an exception, having found similar outcomes after thrombectomy in the MS and DS groups. According to our data, the DS group had a longer OGT than the MS group (DS median, 390 minutes; IQR, 326–500 minutes versus MS median, 235 minutes; IQR, 159–270 minutes; \(P < 0.001\)), but this did not coincide with any significant difference in the rates of hemorrhagic transformation, malignant cerebral edema, or 90-day mortality. Studies have shown that the most important factor for obtaining good functional outcomes is rapid cerebral reperfusion and the shorter the OGT, the better the prognosis\[11\]. In our study, the OGT in the DS group was longer, but the thrombectomy effect was enhanced without increasing the complication rate; this may reflect benefits of thrombolysis before transport. In comparison, the DS group had shorter OTN than the MS group (111.7 ± 47.7 versus 150.9 ± 48.8, \(P = 0.041\)), which we attribute to the smaller scope of services offered by PSCs and smooth traffic in remote areas. In addition, patients in the DS group received IVT earlier than the MS group, which is also an important factor in patient prognosis. Finally, although the two groups did not significantly differ in DPT, the DS group tended to have a shorter DPT than the MS group (110.6 ± 35.1 versus 124.9 ± 42.5, \(P = 0.346\)). The early warning by the PSC before transfer may lead to the shorter DPT in the DS group and in timely treatment of patients transferred to CSC; this is consistent with results of previous studies\[12, 13\].

Early IVT can be more effective for distal vascular occlusion caused by small thrombi than for LVO\[14\]. A meta-analysis of 13 studies showed that only 11% of patients with LVO who received IVT achieved recanalization\[15\]. In our data, all patients in the DS group achieved successful recanalization, whereas
two patients in the non-DS group and three patients in the MS group did not. In addition, 17 patients with no LVO detected by multimodal CT after transport to our hospital may have benefitted from thrombolysis before transport. After completion of the cerebrovascular imaging examination in the CSC, only two patients in the DS group had an ischemic core volume exceeding 70 ml. Since the PSC did not complete the cerebral vascular imaging evaluation, we cannot obtain an accurate measure of cerebral perfusion before transfer; we are thus unable to assess the effect of thrombolytic therapy in patients prior to transport. Since thrombolysis has limitation on the recanalization of LVO, we speculate while thrombolysis likely failed to achieve the recanalization of vessels in patients with LVO in the DS group, it may have led to the establishment of collateral circulation\[16\]. This response delays the progression of the ischemic core without increasing the probability of hemorrhagic transformation, and is thus beneficial for brain tissue reperfusion and postoperative neurological recovery.

With the publication of the DAWN and DEFUSE-3 studies, imaging-based physiological information may shift the treatment paradigm from a rigid time-based model to a more flexible and individualized, issue-based approach, increasing the proportion of patients considered appropriate for treatment. Multimodal CT includes NCCT, CTA, and CTP. It can achieve rapid and accurate assessment of LVO, collateral circulation, volume of ischemic penumbra and volume of ischemic core\[17\]. However, in China and other developing countries, most PSCs can only preliminarily assess patients using NCCT to assess whether bleeding lesions and severe cerebral infarction are present; such facilities cannot assess the presence of LVO and abnormal cerebral perfusion accurately. The first multimodal CT assessment can only be completed after transported to the CSC. NCCT is widely used in the evaluation of neurocritical care as it has the benefits of being fast and effective. It can provide information for the identification of hemorrhage and ischemic lesions quickly, but it has limitations in detection of early ischemic lesions\[18\]. The Alberta Stroke Programme Early CT (ASPECT) score is an important method to quantify early ischemic changes based on NCCT imaging, and it is widely used in clinical practice for its simplicity and effectiveness. However, clinical decisions can differ from one clinician to the other\[19\]. In addition, the prediction of the prognosis of AIS patients based on the ASPECT score is controversial. The results of the MR CLEAN study showed that a higher ASPECT score predicts good prognosis of patients\[20\]. However, the SWIFT PRIME and ESCAPE studies found no significant difference in prognosis, intracranial hemorrhage and mortality between patients with ASPECT scores 4–6 and those with ASPECT scores 7–10\[21, 22\]. Insensitivity to the diagnosis of early ischemic lesions limits the role of NCCT in thrombectomy decision-making. In the present study, multimodal CT assisted us to screen patients who were transferred from a PSC to our hospital. A total of 28 patients without LVO or with large volume of ischemic core were excluded from our study. Among the enrolled patients, multimodal CT also helped us to identify the location of the LVO, the status of collateral circulation and the perfusion of brain tissue, and provided guidance and help for MT methods. If PSCs are able to perform multimodal CT evaluation, the vascular occlusion and cerebral tissue perfusion can be evaluated and screened at the first visit of the patient, thereby reducing the potential safety hazards caused by unnecessary transport, improving economic benefits, and achieving more precise treatment.
According to map data calculations, the distance from the PSCs to our hospital is 55 kilometers, and the estimated transit time is 60 minutes, but the actual transit time is greatly prolonged, resulting in the median OGT time of the DS group being 155 minutes longer than that of the MS group and leading to delayed recanalization in DS patients. There are two reasons for this delay. First, the patients did not start the referral system immediately after IVT in the PSC but instead continued to be observed during IVT. The referral program was only started when it was determined that the thrombolysis was ineffective or if patient conditioned worsened after thrombolysis. This increased the time patients received endovascular therapy. Second, after the doctor and patient made the decision to transfer to the CSC for evaluation, waiting for the ambulance to arrive delayed the patient’s transfer. Another study found that MS patients have a higher chance of functional independence, especially when the distance between the PSC and the CSC is > 12.5 miles or when the time between cerebral imaging and groin puncture is ≥ 140 minutes[12].

There was no statistically significant difference in the prognosis between DS and MS patients in our study, although the proportion of patients in the MS group who achieved functional independence did tend to be higher (7/17 or 41.2% versus 4/12 or 33.3%), consistent with the above findings. Therefore, optimizing the admission and treatment process of the PSC is necessary for AIS. Once IVT is given, the transport mechanism to CSC should be activated immediately to accelerate the cerebral reperfusion and improve the prognosis of patients.

In conclusion, the DS method is safe and effective, with no increased risk of postoperative hemorrhage transformation, malignant edema or death compared to non-DS and MS methods. A limitation of our study is the small size sample and that it included cases in the past year only. In future, we will include more cooperative medical institutions, and prospectively collect a larger sample to verify conclusions. Another limitation is the restrictions of equipment in PSCs. AIS patients cannot receive multimodal CT in the PSC, and thus we cannot ascertain whether thrombolysis achieves recanalization of occluded vessels, or whether the thrombus dissolves and migrates.

**Declarations**

**Ethical approval and consent to participate** This retrospective study was approved by the ethics committee of Beijing Chaoyang Hospital (2022-D-218) according to the principles expressed in the Declaration of Helsinki. Written informed consent was obtained from individual participants.

**Human and animal ethics** Not applicable

**Consent for publication** Not applicable

**Availability of supporting data** The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Competing of interests** The authors declare no competing interest.

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**Authors’ contribution** Fucheng Jiang collected the data and wrote the manuscript. He Liu proofreaded the manuscript. All authors have edited and contributed to critical review of the manuscript, and approved the final manuscript.

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**References**


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Figures

Figure 1

Schematic of three acute ischemic stroke triage decision model
Figure 2

Results of between groups comparison with Bonferroni correction in DPT (A), OGT (B), admission and discharge NIHSS (G, H), ischemic core volume (I), ischemic penumbra volume (J), hemorrhage transformation (K), malignant edema (L), and 90-day mortality (M). And time course between groups such as OTN (C), IVT-P (D), OTP (E), and PTG (F) compared by unpaired t test and Mann-Whitney test.
Figure 3

Distribution of the mRS score at 3 months in patients treated with DS paradigm, non-DS paradigm, and MS paradigm