Mechanical Thrombectomy for Acute Intracranial Internal Carotid Artery Occlusion Compared with Middle Cerebral Artery Occlusion

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Objective: We evaluated outcomes after mechanical thrombectomy for intracranial internal carotid artery occlusion (ICO) in comparison with middle cerebral artery occlusion (MCO), and evaluated its pathophysiology and future problems.

Methods: A retrospective study was performed in 28 patients (14 patients with intracranial ICO and 14 with MCO) who underwent mechanical thrombectomy using the Penumbra System, TrevoProvue, or Solitaire FR in 2014 and 2015. Assessment was performed mainly using the modified Rankin scale after 30 days and at the time of discharge.

Results: The interval from onset to arrival at the hospital (onset to door) and the findings of imaging techniques did not differ between the groups with intracranial ICO or MCO, but the National Institutes of Health Stroke Scale (NIHSS) score on hospital arrival was higher in the former group (21 vs 16, p = 0.028). The favorable recanalization rate was 78% in each group. However, the rates of favorable outcomes were 14.3% and 42.9%, and the mortality rates were 29% and 7.1% in the group with internal carotid artery cerebral artery occlusion and that with MCO, respectively, showing poor outcomes in the former (p = 0.04).

Conclusion: In the patients with intracranial ICO, although favorable recanalization was achieved by mechanical thrombectomy, the functional outcome was poor. These results suggest more rapid progression of neurological deficits in the patients with intracranial ICO than those with MCO and the need for even earlier favorable recanalization in the former.

Keywords ▶ mechanical thrombectomy, internal carotid artery occlusion, stroke

Introduction

Randomized controlled trials (RCTs)¹–³ have shown that mechanical thrombectomy for acute cerebral infarction due to major artery occlusion within 6h after onset improves patients’ outcomes. After these RCTs, mechanical thrombectomy has been extensively performed. However, in these RCTs, about 70% of the subjects had middle cerebral artery occlusion (MCO), and only 25%–30% had internal carotid artery occlusion (ICO). The outcomes in patients with acute cerebral infarction due to ICO, particularly intracranial ICO, were extremely poor.⁴,⁵ Even at present when mechanical thrombectomy is performed, poor outcomes are often observed.⁶ Therefore, we clarified the pathology of intracranial ICO by comparing outcomes after mechanical thrombectomy between ICO and MCO, and evaluated problems in the future.

Materials and Methods

The subjects consisted of 28 patients with acute cerebral infarction due to intracranial ICO (ICO group) or MCO (MCO group) who underwent mechanical thrombectomy in our hospital or associated institutions between June 2014 and May 2015 after excluding those showing an Alberta Stroke Program Early CT Score (ASPECTS) <5 or multiple lesions (tandem occlusion).
Table 1  Patient’s background on admission

<table>
<thead>
<tr>
<th>Variable</th>
<th>ICO (N = 14)</th>
<th>MCO (N = 14)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr) - Median (IQR)</td>
<td>72.5 (67–81.5)</td>
<td>76 (72–83)</td>
<td>0.46</td>
</tr>
<tr>
<td>Male sex - n (%)</td>
<td>12 (85.7)</td>
<td>4 (28.5)</td>
<td>0.006</td>
</tr>
<tr>
<td>NIHSS score - Median (IQR)</td>
<td>21 (14–22)</td>
<td>16 (10–18)</td>
<td>0.028</td>
</tr>
<tr>
<td>ASPECTS score - Median (IQR)</td>
<td>8 (6–8)</td>
<td>8 (7–10)</td>
<td>0.28</td>
</tr>
<tr>
<td>Location of stroke</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in left hemisphere - n (%)</td>
<td>7 (50)</td>
<td>3 (21.4)</td>
<td>0.24</td>
</tr>
<tr>
<td>Treatment with IV alteplase - n (%)</td>
<td>11 (78.5)</td>
<td>9 (64.3)</td>
<td>0.68</td>
</tr>
</tbody>
</table>

Despite no difference in the ASPECTS on hospital arrival between the ICO and MCO groups, a significant difference was already observed in the NIHSS score. ASPECTS: alberta stroke program early CT score; ICO: internal carotid artery occlusion; IQR: interquartile range; MCO: middle cerebral artery occlusion; NIHSS: national institutes of health stroke scale.

According to our treatment protocol, after confirmation of major artery occlusion using head MRI, endovascular treatment was immediately performed when the duration after onset was within 4.5h, or all the following three criteria were fulfilled: the duration after onset ≤8h, diffusion-perfusion mismatch, and a diffusion-weighted imaging (DWI)-ASPECTS ≥6. Assessment to determine DWI-ASPECTS was performed by at least two physicians (one of them was a stroke specialist). When the assessment results of lesions were inconsistent (such as low- or high-intensity signals), the interpretation by the stroke specialist was adopted. When MRI could not be performed, CT was used for assessment and diagnosis. Intravenous recombinant tissue-type plasminogen activator (rt-PA) therapy was performed immediately after hospital arrival in the absence of contraindications, but no special period for the determination of its effects was established to prevent delays in mechanical thrombectomy.

The procedure was performed under local anesthesia in all patients. In principle, a 9-Fr balloon guiding catheter was placed in the common or internal carotid artery via the femoral artery, and one of the Penumbra System (Penumbra, Oakland, CA, USA), TrevoProVue (Stryker, Fremont, CA, USA), or Solitaire FR (ev3, Irvine, CA, USA) was used. When the Penumbra System was used, a direct aspiration first pass technique (ADAPT) was performed using the Penumbra 5 MAX ACE/3 MAX catheter. When the Stent-Retriever was used, the stent was expanded with the balloon of the guiding catheter being inflated, and the thrombus was retrieved by aspiration. The operator selected the device, and changed the device when favorable recanalization could not be achieved. Only when intravenous rt-PA therapy was not performed, systemic heparinization was performed to prolong and maintain the activated coagulation time to twice the control value.

The major evaluation items were the modified Rankin scale (mRS) score after 30 days or at discharge. Favorable outcomes were defined as an mRS score of 0–2. Favorable recanalization was defined as a Thrombosis in Cerebral infarction (TICI) scale ≥2b.

Statistical analysis

The Mann-Whitney U test was used to compare the ICO and MCO groups and Fisher’s exact test to compare rates between the two groups, and p < 0.05 was regarded as significant.

Results

The ICO and MCO groups consisted of 14 patients each (Table 1). Of the 14 patients in the ICO group, 12 (85.7%) had IC terminus occlusion (T-occlusion). The mean age of the patients did not significantly differ between the two groups, but the male ratio was higher in the ICO group (p = 0.006). The DWI-ASPECTS was 8 in both groups, but the median National Institutes of Health Stroke Scale (NIHSS) score was 21 in the ICO group and 16 in the MCO group, being 5 points higher in the former (p = 0.028). Intravenous rt-PA therapy was performed in 11 (78.5%) in the ICO group and 9 (64.3%) in the MCO group. Collateral circulation could not be evaluated in four patients with T-occlusion and one with MCO. However, of the other eight patients with T-occlusion in whom collateral circulation could be evaluated, three (37.5%) showed slight leptomeningeal anastomosis from the temporal branch of the posterior cerebral artery. In the other two patients in the ICO group, the middle cerebral artery including its peripheral portion was visualized despite delayed circulation caused by cross flow via the anterior communicating artery and via the posterior communicating artery, respectively. In the MCO group, leptomeningeal anastomosis from the posterior cerebral artery to middle cerebral artery was observed in 12 (92.3%) of the 13 patients in whom collateral circulation could be evaluated, allowing visualization to M3 in one patient (7.7%) and to M2 in three (23.1%).
The time course until the completion of mechanical thrombectomy is shown in Table 2. In the ICO and MCO groups, the intervals from the onset to hospital arrival (onset to door) were 50 and 55 min, respectively, and those from onset to recanalization were 293.5 and 290.5 min, respectively, without significant differences. In patients who could undergo intravenous rt-PA therapy, the intervals from onset to the initiation of this therapy were 135 and 115 min, respectively (p = 0.68). No significant difference was observed in the other time course items between the two groups.

The mRS score at the time of discharge or after 1 month was 4.4 in the ICO group and 3.1 in the MCO group, showing poorer outcomes in the former (p = 0.04). In the ICO and MCO groups, the rates of favorable outcomes were 14.3 and 42.9%, respectively, and the death rates were 29 and 7.1%, respectively. In each group, favorable recanalization was achieved in 78.6%, and symptomatic intracranial hemorrhage occurred in one (7.1%) (Table 3). Concerning devices, the Penumbra System was used as the first choice in four patients (28.6%) in the ICO group and six (42.9%) in the MCO group. In the ICO and MCO groups, thrombectomy was successful using this device alone in three patients (30%) and two (33.3%), respectively, and the mean procedure times were 62 and 50.5 min, respectively. The Stent-Retriever was used as the first choice in four patients (28.6%) in the ICO group and six (42.9%) in the MCO group. In the ICO and MCO groups, thrombectomy was successful using this device alone in two patients (50%) and two (33.3%), respectively, and the mean procedure times were 80 and 64 min, respectively. No statistical differences were observed using each device between the two groups.

## Discussion

The main favorable prognostic factor in ICO that caused cerebral infarction is recanalization.10 Previous studies have shown a recanalization rate after intravenous rt-PA therapy of only 4.4%–12.5% for ICO11,12 but 51.7% for MCO.13 To improve the recanalization rate, intra-arterial thrombolytic therapy5,11,16 and surgical thrombectomy15 have been performed, but there has been no report that these methods markedly improved the prognosis of ICO, particularly T-occlusion. In this study, the recanalization rate for ICO was 78.5%, which was higher than the previously reported rates using intra-arterial thrombolytic therapy (62%–63%).14,16 However, the rate of favorable outcomes was 14.3%, and the death rate was 29%. These rates were similar to those in previous studies rates using...
intra-arterial thrombolytic therapy (rate of favorable outcomes, 16.6%–19.2%; mortality rate, 30.8%–41.7%). Thus, functional outcomes were poor in the ICO group although the time course from onset and favorable recanalization rate were similar between the two groups. These results suggest that favorable recanalization alone is inadequate to obtain favorable outcomes. In addition, neurological deficits assessed using the NIHSS score were already severe at the time of hospital arrival, which suggests rapid progression to irreversible neurological deficits after onset in patients with ICO compared with those with MCO.

The presence of collateral circulation from the anterior or posterior cerebral artery, extending to the middle cerebral artery area via leptomeningeal anastomosis, has also been reported to be a favorable prognostic factor. In this study, in the patients with T-occlusion in the ICO group in whom collateral circulation could be evaluated, slight leptomeningeal anastomosis (the cortical branch was slightly observed) was visualized in only 37.5%, showing poor collateral formation. In the MCO group, most patients showed leptomeningeal anastomosis, which reached the M2/3 area in about 30%. A previous study showed an increase in the cerebral infarct volume in patients showing poor collateral formation after recanalization by endovascular treatment. Therefore, this difference in leptomeningeal anastomosis formation may be a factor associated with the progression of neurological deficits and poor functional outcomes. In addition, in T-occlusion, since the anterior choroidal artery and lenticulostriate arteries are also occluded, severe neurological deficits occur due to infarction of the basal ganglia and internal capsule. This may also be a factor associated with the above.

The guidelines in western countries recommend that the intervals from hospital arrival (door) to diagnostic imaging (picture), from door to puncture, and from puncture to recanalization should be within 25, 120, and 90 min, respectively. In this study, these intervals were 33, 143, and 64 min, respectively. This study was performed in the early period after the introduction of various devices with experience of only a few cases treated by mechanical thrombectomy in institutions. Considering this, the results of this study may be reasonable. However, In EXTEND-IA as an RCT that showed the effectiveness of thrombectomy on acute cerebral infarction, the above intervals were 20, 113, and 43 min, respectively. There was a 50-min difference in the interval from door to recanalization between this RCT and our study. In general, a 30-min delay in the time until recanalization increases the incidence of early intracranial bleeding and mortality rate, and leads to poor outcomes. Since the progression of neurological deficits may be rapid particularly in patients with ICO as described above, further shortening of the time is necessary. In this study, the procedure time was about 60 min, and the success rate using only the device as the first choice was about 50%. However, studies with favorable results of treatment have shown an operative time of 33–43 min and a success rate of 78%–82% using the Penumbra or Stent-Retriever alone. Thus, further technical improvement is necessary. The door-to-puncture interval should also be shortened. However, since the optimal medical care system differs according to the hospital scale, equipment, line of flow, and staff, a system based on the actual status of each institution should be established.

The number of cases was small in this study, and further evaluation in additional cases is necessary. In addition, functional outcomes were assessed 30 days after onset in this study, which is early compared with other studies. Long-term follow up is required to determine functional outcomes. However, the mortality rate and rate of severe cases were already markedly high 30 days after onset for ICO, and remarkable improvement thereafter was unlikely. At least, the short-term functional prognosis of intracranial ICO may be poor even after mechanical thrombectomy.

Therefore, although favorable recanalization is indispensable to improve the prognosis of intracranial ICO, recanalization as early as possible compared with MCO is also important.

## Conclusion

The functional outcomes of acute cerebral infarction caused by intracranial ICO were poor even when favorable recanalization was achieved by mechanical thrombectomy. These results suggest the rapid progression of neurological deficits in ICO compared with MCO. To improve the functional prognosis, even earlier recanalization is necessary.

## Disclosure Statement

The first author and co-authors have completed a self-report of their conflicts of interest to the Japan Neurosurgical Society. Concerning this paper, the principle author has no potential conflicts of interest to disclose. Co-author Hidenori Oishi has conflicts of interest to disclose. He receives 1,000,000 yen/corporation/year from Stryker Japan and Medtronic Japan for the expense of attending
conferences (presentations), more than 2,000,000 yen/year as the representative of a course through donations from Stryker Japan, and more than 2,000,000 yen/year as a research donation for the course through donations. The other co-authors have no conflicts of interest.

References


