Rapid Recanalization of Stent Retriever Compared with That of Old-type Aspiration Catheter for Acute Ischemic Stroke

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Objective: In mechanical thrombectomy for acute ischemic stroke, a positive outcome depends on short workflow time and successful recanalization. In this study, we retrospectively compared the recanalization times and rates in our initial experience of mechanical thrombectomy with stent retrievers and the old-type aspiration catheter system.

Methods: We retrospectively reviewed patients who underwent mechanical thrombectomy in author's hospital from November 2012 to April 2015, and compared parameters between patients treated with each device.

Results: Thirty patients who underwent mechanical thrombectomy in the following order were divided into three chronologically sequential groups (n = 10 patients in each) for evaluating interval trends: the first group of patients underwent thrombectomy using the old aspiration catheter system; second, first stent retrievers; and third, second stent retrievers. Although successful recanalization rates (thrombolysis in cerebral infarction score ≥2b) were not significantly different among the three groups (p = 0.122), puncture-to-recanalization duration or duration of final digital subtraction angiography was significantly longer for patients recanalized using the old aspiration catheter system compared with that of patients recanalized using stent retrievers (143, 59.5, and 51.5 min, respectively; p = 0.004).

Conclusion: Although both thrombectomy systems showed no significant differences in successful recanalization rates, the stent system permitted more rapid recanalization than the old aspiration catheter system.

Keywords: acute stroke, thrombectomy, large vessel occlusion, stent retriever, aspiration catheter

Introduction

The Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands (MR CLEAN) trial, in addition to the other halted studies that yielded positive results, has established intravenous administration of tissue plasminogen activator following mechanical thrombectomy as the first-line treatment for acute ischemic stroke.1–5)

For all novel endovascular procedures, a key aspect for the deployment of novel techniques is the rapidity of the learning curve for operators and the endovascular team. In this observational study, we aimed to compare the workflow time and successful recanalization rates in our initial experience of mechanical thrombectomy using the stent retriever with those of mechanical thrombectomy using the old-generation aspiration catheter systems.

Materials and Methods

This study is reported on the basis of criteria from the Strengthening the Reporting of Observational Study in Epidemiology (STROBE) statement.6)

Study design and ethics

This retrospective observational study was approved by the institutional ethics committee, and informed consent was obtained from all patients or their nearest kin before enrollment.

Study population

We retrospectively enrolled consecutive patients who underwent mechanical thrombectomy for acute ischemic stroke in
the authors’ hospital from November 2012 to April 2015. Patients with strokes in both anterior and posterior circulation were included. The database included information on patient- and treatment-specific characteristics, such as sex, age, National Institutes of Health Stroke Scale (NIHSS) score on admission, the place at the onset of stroke (in the hospital or outside), target occlusion site (carotid terminal, internal carotid artery [ICA], M1, M2, or basilar artery), whether the patients were administered intravenous alteplase, and neurological status (modified Rankin Scale [mRS]) at 90 days from the onset. The following intervals were measured from time-stamped image archiving and medical records: stroke onset to hospital arrival (“onset-to-door” time), hospital arrival to baseline imaging (“door-to-picture” time), baseline imaging to groin puncture (“picture-to-puncture” time), and groin puncture to final DSA or revascularization (“puncture-to-final DSA” time). Hospital arrival was defined as the time at arrival in the emergency department. If a stroke occurred during hospitalization, the stroke onset to hospital arrival was defined as 0 min. Recanalization was assessed using the thrombolysis in cerebral infarction (TICI) score. Successful recanalization was defined as TICI scores 2b and 3.

### Devices

Before the Solitaire FR (Covidien, Dublin, Ireland) and the Trevo ProVue (Stryker, Kalamazoo, MI, USA) stent retrieval systems were introduced in our hospital in July 2014, we were using the Penumbra system (Penumbra, Alameda, CA, USA). In this cohort, we only used Penumbra original and Penumbra MAX series, referred to as “old aspiration catheter system.” Penumbra MAX ACE series were not used in this study.

### Data analysis and statistical evaluation

Values are presented as mean ± SD or the number (%) of patients. Fisher’s exact test was used for categorical variables. All times are reported as medians (with interquartile range). The Kruskal–Wallis test was used to compare the median time values, with adjustment for multiple comparisons by the Holm method, where applicable. Significance level was set at p < 0.05. All statistical analyses were performed with R (The R Foundation for Statistical Computing, v.3.1.2).

### Results

In all, 30 patients with acute ischemic stroke (mean age: 72.2 ± 10.4 years; 20 male patients and 10 female patients) underwent mechanical thrombectomy in the hospital from November 2012 to April 2015. The median NIHSS score was 17.5. In all, 14 patients (46.7%) received intravenous alteplase administration before mechanical thrombectomy. Successful recanalization was achieved in 20 (66.7%) patients, of which, 10 (33.3%) achieved TICI 2b and 10 (33.3%), TICI 3.

Since the type of thrombectomy device was changed after the introduction of stent retrievers in July 2014, the initial 10 consecutive thrombectomies were performed using the old aspiration catheter system and the subsequent 20 using stent retrievers. With the old aspiration catheter system, we used two original Penumbra models, followed by eight Penumbra MAX devices; the stent retrievers used were Solitaire FR (n = 18) and Trevo ProVue (n = 2). To evaluate interval trends, patients who underwent thrombectomy were divided into three chronologically sequential groups (n = 10 patients in each) as follows: 1) old aspiration catheter system, 2) first stent group, and 3) second stent group. Baseline characteristics of each group are summarized in Table 1.

All 30 patients had TICI scores of zero on initial angiography. Although successful recanalization was achieved in

### Table 1 Baseline characteristics of the patients in each group

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Old aspiration</th>
<th>Stent (first)</th>
<th>Stent (second)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>70.3 ± 9.8</td>
<td>71.9 ± 11.7</td>
<td>74.5 ± 10.3</td>
<td>0.68</td>
</tr>
<tr>
<td>Male sex</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>NIHSS</td>
<td>19.4 ± 9.1</td>
<td>16.1 ± 7.2</td>
<td>23.0 ± 8.8</td>
<td>0.20</td>
</tr>
<tr>
<td>Onset during hospitalization</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>0.075</td>
</tr>
<tr>
<td>Intravenous thrombolysis</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>0.53</td>
</tr>
<tr>
<td>Target occlusion location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carotid terminal</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>ICA</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>M1</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>M2</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>BA</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Values are the mean ± SD or number (%) of patients. BA: basilar artery; ICA: internal carotid artery; M1: first segment of middle cerebral artery; M2: second segment of middle cerebral artery; NIHSS: National Institutes of Health Stroke Scale.
four patients (40.0%) with the old aspiration catheter system, eight (80.0%) in the first stent group, and eight (80.0%) in the second stent group, there was no significant difference in the recanalization success rate among these groups ($p = 0.122$). The mean number of deployments of stent retrievers or navigations of old aspiration catheter until successful recanalization or stopping thrombectomy was achieved was $3.2 \pm 1.8$ in the first 10 patients recanalized with the old aspiration catheter system, $1.5 \pm 0.7$ in the first stent group, and $1.6 \pm 0.7$ in the second stent group, indicating a significant difference ($p = 0.004$).

The total duration from stroke onset to final DSA or successful reperfusion revealed a statistically significant decrease over time ($p = 0.014$) (Fig. 1). This difference was significant between old aspiration catheter system usage and the last 10 cases of stent usage (362.5 and 210.0 min, respectively). Improvement in puncture-to-final DSA time contributed maximally to this continuous decrease in duration along with the devices ($p = 0.004$), decreasing from a median of 143 min in the first 10 patients recanalized with old aspiration catheter system, to 59.5 min in the second (first stent) group, to 51.5 min in the third (second stent) group. Post hoc analysis revealed that this difference was significant between the old aspiration catheter system-recanalized patients and both the first ($p = 0.014$) and second ($p = 0.005$) stent-recanalized patients.

The rate of positive clinical outcome of the modified Rankin score $\leq 2$ (define scale) at day 90 was achieved for 10% of the patients using the old aspiration catheter system, 20% in the early stent group, and 30% in the later stent group. However, no significant difference was found between these groups ($p = 0.847$).

**Discussion**

In our initial experience, we found that the stent retriever system allowed a more rapid recanalization time than the old aspiration catheter system. A significant improvement was found in the time from groin puncture to final DSA or successful reperfusion.

Stent retrievers have been reported to have a tendency of a shorter length of puncture to recanalization time compared with those of Penumbra and Merci systems in 51 cases (58.5 min vs 70.8 min, $p = 0.08$); however, no significant difference was found.\(^8\) The procedure time of stent retriever was almost the same as that in our results (median: 59.5 min in first stent group); however, the procedure time using the old aspiration catheter system in our study was longer compared to that in the aforementioned study (median: 143 min). Since Hann et al.\(^8\) were experienced in using the aspiration device, this may also have affected the difference in the results.

On the contrary, a direct comparison of stent retrievers with aspiration catheters in treating an acute basilar artery occlusion showed that the total procedure time was significantly shorter in patients treated with Penumbra aspiration catheter than in those treated with stent retrievers.\(^9\) This could be attributed to anatomical differences between anterior and posterior circulation. The basilar artery is relatively less convoluted than the intracranial ICA. In Penumbra thrombectomy, an aspiration catheter with a larger profile diameter must be navigated through the convoluted intracranial artery, especially at the carotid siphon. Although, theoretically, navigability of aspiration catheters has improved since the launch of newer versions,\(^10\) larger
catheters still confer difficulty during delivery to the intracranial arteries. A larger profile can also often create a gap between the guide wire and the reperfusion catheter, resulting in the “ledge effect,” whereby the catheter tip can be caught on the orifice of branch vessels arising just distal to sharp turns, where the catheter tends to be captured in the outer curvature of the vessels.\textsuperscript{11)} To overcome these difficulties, experienced surgeons may be needed and this could result in the longer procedural time of aspiration catheterization in this cohort.

The number of procedures is another important issue in achieving rapid recanalization. In our experience, the time for deployment of the device in the old aspiration catheter series was double of that for stent retrieval, and was significant. A recent trial of the a direct aspiration first pass technique (ADAPT) technique using Penumbra MAX/ACE catheters reported that recanalization rates and clinical outcomes were similar to those achieved using stent retrievers.\textsuperscript{10)} We first used the standard technique with a separator, which was recommended by the manufacturer. Thereafter, we started using the ADAPT technique. We used this technique for only four cases. These details may have affected the results of the group using the old Penumbra system.

However, some limitations of this study may be considered. These include retrospective data collection, single-center experience, and fewer patients. We also used two different stent retrievers (Solitaire and Trevo). In the old aspiration catheter system group, the Penumbra MAX series was mainly used. The study was not performed over a specific period. As mentioned previously, we initially used mechanical thrombectomy featuring old aspiration devices. In the old aspiration catheter system period, our interventional skills about mechanical thrombectomy, including intracranial access and proper device use, may not have been as efficient. The radiological findings were mainly obtained on the basis of self-evaluation (TICI) scores. Despite enrolling fewer patients, we achieved workflow times comparable to those of other trials in stent thrombectomy.

\section*{Conclusion}

The stent retriever system could permit more rapid recanalization time compared with the old aspiration catheter system.

\section*{Acknowledgment}

None

\section*{Disclosure Statement}

None of the first or coauthors has a conflict of interest.

\section*{References}