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Original Article

Efficacy of Mechanical Thrombectomy Using an Aspiration Catheter Compared with a Stent Retriever Alone for Middle Cerebral Artery M2 Occlusion

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Objective: Mechanical thrombectomy (MT) for middle cerebral artery M2 occlusion (M2O) is challenging because the procedure is performed in a narrow and tortuous artery. In this study, we compared MT using an aspiration catheter (AC) versus a stent retriever (SR) used alone, and retrospectively evaluated the efficacy and safety of MT using an AC for M2O.
Methods: Seventy-four consecutive patients who underwent MT for M2O at our institution between April 2016 and April 2020 were evaluated. The subjects were classified into those treated by AC (AC group) or SR alone (SR group). The AC group included patients treated by both contact aspiration and a combination technique of AC and SR. Background factors and outcomes, including modified treatment in cerebral infarction (mTICI) 2c-3 recanalization, were compared between the groups.
Results: AC and SR groups consisted of 47 and 27 patients respectively. Among them, the rate of mTICI 2b-3 was 93.6% vs 92.6%, and that of mTICI 2c-3 was 72.3% vs 48.2% (P = 0.004). The perioperative symptomatic subarachnoid hemorrhage (SAH) rate was 0% vs 7.4%, and modified Rankin scale scores of 0–2 were 78.6% vs 50% (P = 0.03). In the AC group, the mTICI 2c-3 rate was higher in patients in whom the AC was adequately advanced to the thrombus compared to those with inadequate AC advancement (83.3% vs 36.3%, P = 0.002).
Conclusion: The rate of mTICI 2c-3 was higher in the AC than SR group, with no cases of symptomatic SAH. MT using AC for M2O might achieve safe and effective thrombectomy.

Keywords ▶ mechanical thrombectomy, middle cerebral artery M2 occlusion, aspiration catheter, stent retriever, mTICI2c-3

Introduction

Several randomized controlled trials (RCTs) published after 2015 proved the efficacy of mechanical thrombectomy (MT) in acute ischemic stroke (AIS) due to large vessel occlusion (LVO).[1)] Although the clinical evidence related to MT for middle cerebral artery M2 occlusion (M2O) is not yet established, several case series and a meta-analysis have indicated its efficacy compared with intravenous tissue plasminogen activator (iv-tPA).[2–4)] Initial National Institutes of Health Stroke Scale (NIHSS) scores >7 points[5)] and a long susceptibility vessel sign (SVS) (7–10 mm)[6)] are reportedly related to a poor prognosis after iv-tPA. In such cases, MT for M2O could potentially lead to good clinical outcomes.

However, it is difficult to achieve recanalization with MT for M2O, and the procedure is associated with the risk of procedure-related intracranial hemorrhage compared with LVO because of the tortuosity and narrowness of the M2 lumen. Therefore, the selection of devices and techniques should be considered carefully. In recent studies, MT for M2O with an aspiration catheter (AC),[7)] stent retriever (SR) alone,[8,9)] and with the combination of both devices[10)] was reported, and these studies were further assessed in a meta-analysis.[11)] Although the modified

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treatment in cerebral infarction (mTICI) 2b-3 recanalization rate was equivalent between these techniques in the meta-analysis, the more favorable method for achieving mTICI 2c-3, which is associated with better clinical outcomes than mTICI 2b,[12] has not yet been definitively determined.

The aim of this study was to clarify the efficacy of use of an AC compared with an SR alone in MT for M2O. This study was approved by the local ethics committee (approval number: R-2-13).

Materials and Methods

Patient selection

The subjects were 74 consecutive patients who underwent MT for M2O at our institution between April 2016 and April 2020. Intervention therapy was indicated in patients who satisfied all the following criteria: 1) within 24 hours from onset, 2) NIHSS ≥6 points or NIHSS <6 points with aphasia, 3) diagnosis of M2O by MRA and angiography, and 4) diffusion-weighted imaging (DWI) FLAIR mismatch in MRI. M2 segment was defined as the arteries from the main middle cerebral artery bifurcation or trifurcation to the circular sulcus of the insula.

Device selection and technical tips in this study

From April 2016 to March 2018, M2O was treated by SR alone in our institution because of the favorable results with SR alone in RCTs for LVO.[1] From April 2018 to April 2020, an AC was used for M2O to reduce the risk of procedure-related intracranial hemorrhage. Penumbra 4MAX reperfusion catheters (Penumbra, Alameda, CA, USA) were mainly selected in this period. On the other hand, the AC and SR combined technique was selected for cases in which the tip of the AC could not be inserted up to the proximal edge of the thrombus, a long thrombus was suspected, or if the contact aspiration technique failed. The choice of devices and techniques was determined by the three main operators who have experienced more than 100 MT procedures with AC and SR, and are licensed as specialists by the Japanese Society for Neuroendovascular therapy. The SRs used in this study were mainly Trevo XP ProVue Retriever 3/20 mm (Stryker, Freemont, CA, USA) and Tron FX SR 2/15 mm (Biomedical Solution, Tokyo, Japan). A velocity delivery microcatheter (Penumbra) was selected to navigate ACs and SRs. Technical strategies followed during the procedure were injection of contrast media via the microcatheter just proximal to the site of occlusion to accurately detect the location of the thrombus (**Fig. 1B**, arrow) and appropriate advance of the AC so that it adequately covered the thrombus. To prevent distal migration of the thrombus by injection, the backflow of blood was checked with use of a 2.5 cc syringe and injection should be performed very slowly. Finally, thrombectomy devices were retrieved through an 8-Fr balloon guiding catheter.

Evaluation

The subjects were retrospectively classified into those who were treated by AC (AC group) or SR alone (SR group). The AC group included patients who were treated by both contact aspiration technique or by a combination technique. Background factors, types of procedures, and outcomes were retrospectively compared between the two groups.

As background factors, patient age, sex, NIHSS score, and DWI-Alberta stroke program early CT score (ASPECTS) at arrival, length of thrombus suspected by the SVS on T2*-weighted images, onset-to-door time and door-to-puncture time, and the use of iv-tPA were evaluated.

To assess procedure details and outcomes, the number of passes, mTICI 2b-3 recanalization, mTICI 2c-3 recanalization, puncture to reperfusion time (time from puncture to the end of the procedure with mTICI 2b or better recanalization [P2R]), onset-to-reperfusion time (O2R), procedure-related complications (symptomatic subarachnoid hemorrhage [SAH] accompanied by exacerbation of NIHSS score to ≥4, vasospasm and dissection), favorable outcomes at 3 months (modified Rankin Scale [mRS] scores of 0–2 in premorbid independent patients or recovery to premorbid activities of daily living [ADLs] in premorbid mRS score 3–4 patients), and mortality at 3 months were investigated.

In the AC group, a sub-analysis of the relationship between appropriate advancement of the AC at the site of the thrombus and mTICI 2c-3 was performed.

Appropriate advancement is defined as follows: the stump finding of thrombus was confirmed via angiography (**Figs. 1B** and **2C**, arrowheads), and then AC could be advanced over the stump point under the roadmap (**Fig. 1C**, arrowhead).

Statistical analysis

Continuous variables were reported as median (interquartile range [IQR]), and categorical variables were reported as numbers and percentages. Statistical analysis was performed using JMP ver. 13.2.0 (SAS Institute, Cary, NC, USA). Continuous and categorical variables were examined using

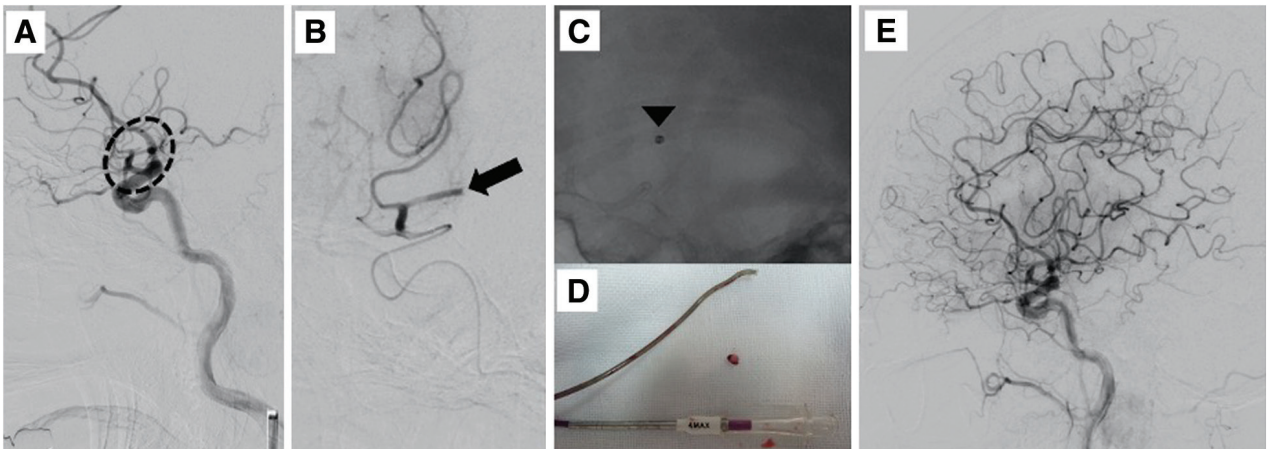

Fig. 1 The occluded site was not detected clearly by angiography using a guide catheter (**A**, circle). On the other hand, angiography via the microcatheter accurately demonstrated the site of occlusion (**B**, arrow). The Penumbra 4MAX was advanced adequately to the thrombus beyond the length of the distal marker (**C**, arrowhead). A solid thrombus was retrieved using the contact aspiration technique (**D**) and mTICI 3 recanalization was achieved (**E**). mTICI: modified treatment in cerebral infarction

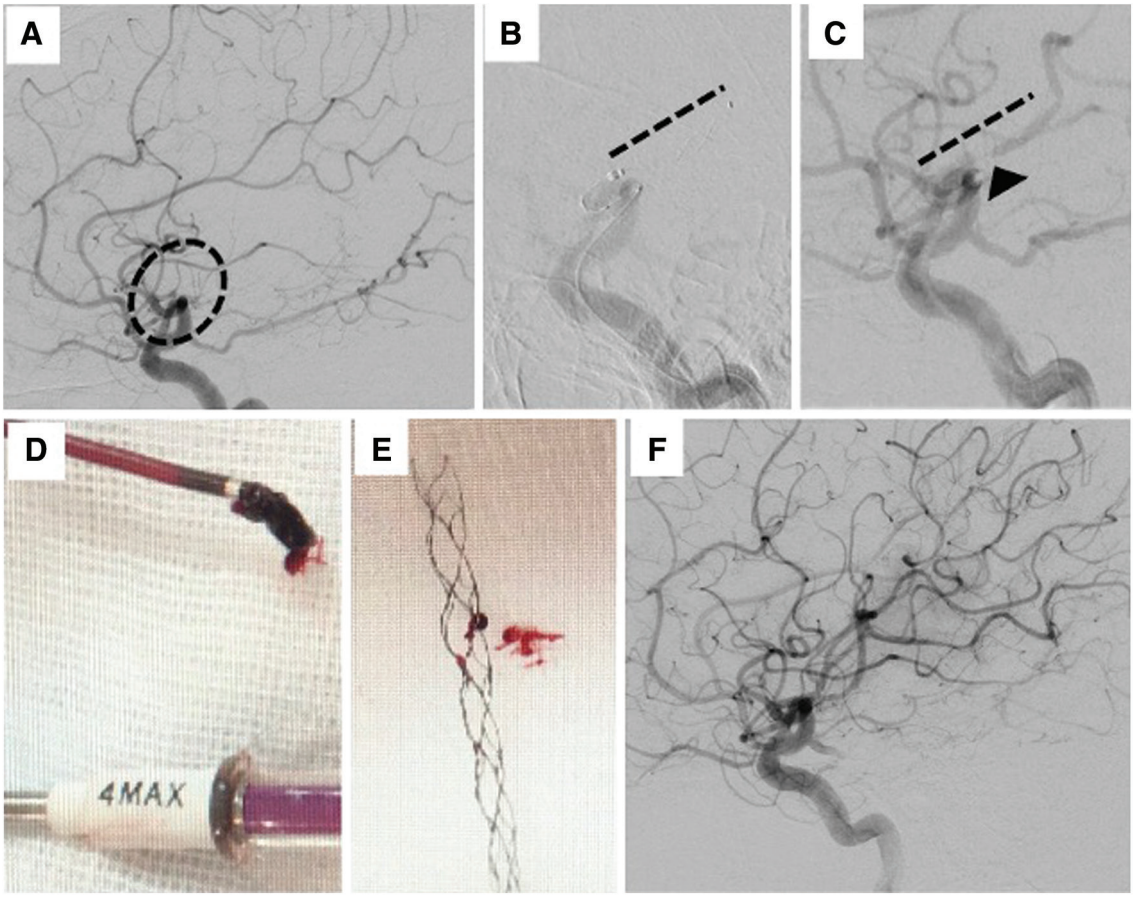

Fig. 2 Preprocedural angiography showed right M2O (**A**, circle). A Trevo XP3 SR was deployed from the distal M2 (**B** and **C**, dotted line) and immediate flow restoration was visualized at the site of the thrombus (**C**, arrowhead). The Penumbra 4MAX reperfusion catheter was adequately advanced up to the thrombus. Moderate amount of thrombus was retrieved by the combination of Trevo XP3 and Penumbra 4MAX (**D** and **E**), resulting in mTICI 2c recanalization (**F**). M2O: M2 occlusion; mTICI: modified treatment in cerebral infarction; SR: stent retriever

Table 1 Backgrounds, procedure details, and outcomes

	AC group (n = 47)	SR group (n = 27)	P value
Backgrounds			
Age (years), median (IQR)	81 (68–87)	82 (68–86)	0.60
Female patients, n (%)	21 (44.7)	13 (48.2)	0.77
Onset-to-door time (min), median (IQR)	173 (84–421)	69 (47–247)	0.20
NIHSS at baseline, median (IQR)	14 (6–22)	17 (11–22)	0.22
Baseline DWI ASPECTS, median (IQR)	8 (7–9)	9 (8–9)	0.89
Length of susceptibility vessel sign on T2* (mm), median (IQR)	7.8 (6.6–10.4)	7.8 (6.7–9.6)	0.80
Intravenous alteplase admissioned, n (%)	22 (47.8)	14 (56.0)	0.51
Door to puncture time (min), median (IQR)	38 (32–52)	52 (44–69)	0.02
Procedure details and outcomes			
Number of passes, median (IQR)	1 (1–2)	2 (1–2)	0.70
Angiographic outcome, mTICI, n (%)			
2c-3	34 (72.3)	13 (48.2)	0.04
2b-3	44 (93.6)	25 (92.6)	0.85
Puncture to recanalization time (min), median (IQR)	49 (32–66)	52 (37–67)	0.61
Onset to recanalization time (min), median (IQR)	248 (173–490)	187 (130–356)	0.34
Procedure-related complication, n (%)			
Dissection	1 (2.1)	0 (0)	0.45
Vasospasm	0 (0)	3 (11.1)	0.02
Symptomatic SAH	0 (0)	2 (7.4)	0.06
Symptomatic ICH, n (%)	0 (0)	2 (7.4)	0.06
Favorable outcome	36 (76.6)	14 (51.9)	0.04
mRS 0–2 at 3 months in premorbid independent patients, n (%)	33/42 (78.6)	11/22 (50.0)	0.03
Recovery to premorbid ADLs at 3 months in premorbid mRS 3–4 patients, n (%)	3/5 (60.0)	3/5 (60.0)	1.00
Mortality at 3 months	4 (8.5)	2 (7.4)	0.87

AC: aspiration catheter; ADLs: activities of daily living; ASPECTS: Alberta stroke program early CT score; DWI: diffusion-weighted imaging; ICH: intracranial hemorrhage; IQR: interquartile range; mRS: modified Rankin Scale; mTICI: modified treatment in cerebral infarction; NIHSS: National Institutes of Health Stroke Scale; SAH: subarachnoid hemorrhage; SR: stent retriever

the t-test and chi-square test, respectively, and P <0.05 was regarded as significant.

Results

Overall results

The AC and SR groups consisted of 47 and 27 patients, respectively. In the AC group, 23 patients were treated using the contact aspiration technique and 24 patients were treated by a combination technique using an AC and an SR. In terms of the AC used, the Penumbra 4MAX was used in 78.7% (37 cases), Penumbra ACE 60 in 14.9% (7 cases), Penumbra 3MAX in 4.3% (2 cases), and Penumbra ACE 68 in 2.1% (1 case) of patients.

Evaluation of procedure details and outcomes showed that the number of passes was not different between the two groups. Although the rate of mTICI 2b-3 recanalization was not different in the two groups (93.6% vs 92.6%, P = 0.85), the rate of mTICI 2c-3 recanalization was significantly higher in the AC group (72.3% vs 48.2%, P = 0.04). The distribution of each mTICI grade among AC and SR groups, respectively, was as follows: mTICI 3: 51.1% vs 37.0%, mTICI 2c: 21.3% vs 11.1%, mTICI 2b: 23.4% vs 44.4%, mTICI 2a: 2.1% vs 3.7%, and mTICI 0: 2.1% vs 3.7%. In terms of procedure-related complications, vasospasm was seen in 3 cases (11.1%) and symptomatic SAH was seen in 2 cases (7.4%) in the SR group. Asymptomatic dissection was seen in one case (2.1%) in the AC group (**Table 1**). Both vasospasm and dissection did not need additional treatment and did not affect clinical outcomes. P2R was shorter (median: 38 vs 52 min, P = 0.61) and O2R was longer (median: 248 vs 187 min, P = 0.34) in the AC group compared with the SR group. The percentage of patients with mRS scores of 0–2 at 3 months in premorbid independent patients (42 patients in the AC group and 22 patients in the SR group) was significantly higher in the AC group (33/42 cases: 78.6% vs 11/22 cases: 50.0%, P = 0.03) and the percentage of patients with recovery to premorbid ADL among patients with premorbid mRS scores of 3–4 patients (5 patients in the AC group and 5 patients in the

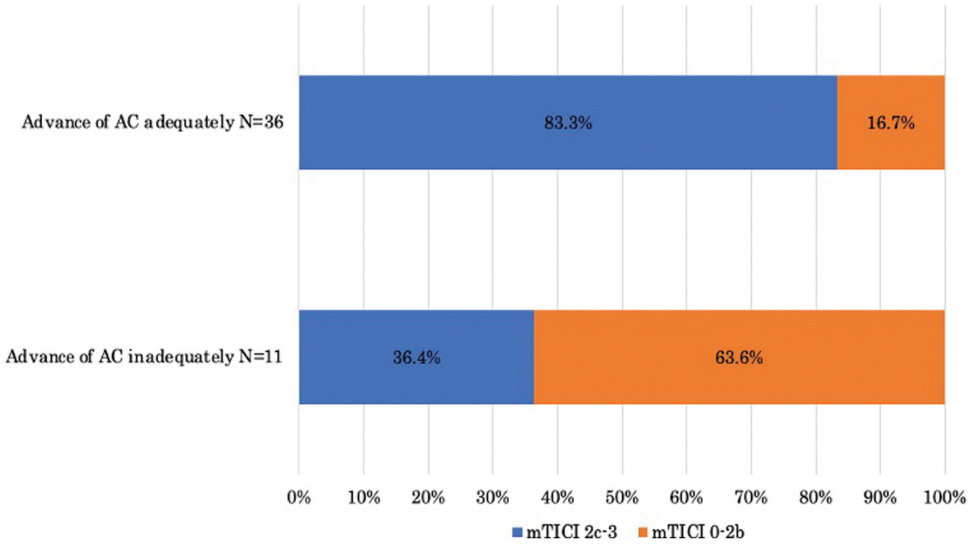

Fig. 3 Relationship between advance of the AC and mTICI 2c-3 recanalization among the AC group (47 cases). AC: aspiration catheter; mTICI: modified treatment in cerebral infarction

SR group) was not different (3/5 cases: 60.0% vs 3/5 cases: 60.0%) between the two groups. Furthermore, favorable outcomes in this study, defined as the total numbers of those two contents (42 + 5 patients in the AC group and 22 + 5 patients in the SR group), was higher in the AC group (36/47: 76.6% vs 14/27: 51.9%, P = 0.04). No difference in mortality rates was observed between the two groups (**Table 1**).

Sub-analysis: Relationship between advance of the AC and outcomes in the AC group

Among the AC group (47 patients), the relationship between advance of the AC to the thrombus and mTICI 2c-3 was analyzed. The rate of mTICI 2c-3 was higher in patients in whom the AC was advanced to the thrombus adequately than in those in whom the procedure was inadequate (**Fig. 3**, 30/36 cases: 83.3% vs 4/11 cases: 36.6%, P = 0.002). Favorable outcomes in this study were slightly higher in those in whom the AC was advanced adequately (80.6% vs 63.3%, P = 0.25).

Discussion

The main findings related to MT for M2O in this study were that 1) the rate of mTICI 2c-3 recanalization was significantly higher with use of the AC than with the SR alone, 2) adequate advance to the thrombus by the AC effectively achieved mTICI 2c-3 recanalization, 3) the rate of perioperative SAH was lower when using the AC rather than when using an SR alone, and 4) favorable outcomes were significantly higher when using the AC than the SR alone.

In recent studies, MT for M2O using an AC,[7] SR alone,[8,9] and the combination of the two devices[10] has been reported, and these studies were further investigated in a meta-analysis.[11] In the meta-analysis, the rate of mTICI 2b-3 was not different between using an AC versus using the SR alone (207/268 cases: 77.2% vs 176/226 cases: 77.9%, p = 0.4). In our study, the rate of mTICI 2b-3 was also not different (93.6% vs 92.6%, p = 0.85), although the rate of mTICI 2c-3 recanalization, which is related to better outcomes[12,13] than mTICI 2b-3 was significantly higher in the AC group than in the SR group (72.3% vs 48.2%, p = 0.04). This is the most important finding of our study. Furthermore, sub-analysis in our study indicated that adequate covering of the thrombus by the AC correlated with mTICI 2c-3 recanalization (**Fig. 3**). In some cases of M2O, the contrast medium does not reach the site of occlusion when injected via the guide catheter, which might lead to misdiagnosis of the site of occlusion (**Fig. 1A**). In our institution, the contrast medium is injected via the microcatheter just proximal to the site of occlusion to accurately locate the thrombus (**Fig. 1B**, arrow). In addition, when the combination technique of AC and SR was performed, the location of the thrombus was detected by observation of interruption of blood flow on angiography after deployment of the SR (**Fig. 2C**, arrowhead). With the aid of these procedures, the AC could be advanced to the thrombus and adequately cover it, allowing successful mTICI 2c-3 recanalization.

Performing MT with the SR alone for M2O is technically difficult because the occluded artery is narrow and

tortuous. Therefore, the risk of post-procedure SAH following SR alone is reportedly higher in situations requiring more than two SR passes and when the SR is positioned ≥2 cm along an M2 branch.[14] On the other hand, using an AC might contribute to reducing the risk of bleeding for the following reasons. The first reason is that since the contact aspiration technique does not require navigation of the microcatheter and micro-guidewire beyond the occluded artery, vessel perforation by these devices can be avoided. Second, in cases of MT by a combination of AC and SR, the AC can be adequately advanced to the thrombus using the SR for support (**Fig. 2C**) and the length of SR deployment can be reduced by half or less. Hence, excessive traction on the perforators and cortical arteries by pulling the SR might be avoided, which would reduce the risk of SAH. In our study, procedure-related symptomatic SAH was seen only in the SR group (2 cases: 7.4%), suggesting that using the AC might contribute to safe MT for M2O. In the AC group, asymptomatic dissection in the M2 segment was seen in one case (2.1%) treated using a combination of Penumbra ACE60 and Trevo 3/20 mm. The Penumbra ACE60 might be too large for some cases, suggesting that using a larger AC for M2O might be associated with the risk of dissection. In this study, we estimated only procedure-related symptomatic SAH and excluded asymptomatic SAH from a viewpoint of safety outcome.

In a meta-analysis,[11] the rate of an mRS score of 0–2 at 3 months was higher in those in whom an AC was used than in those in whom an SR alone was used (160/251 cases: 63.7% vs 92/177 cases: 52.0%, p = 0.01). The possible reasons that were reported for this were that the rate of mTICI 2b-3 recanalization at the first pass was slightly higher (60% vs 51%, p = 0.3) and the rate of intracranial hemorrhage was slightly lower (5.5% vs 9.5%, p = 0.1). In our study as well, the rate of favorable outcomes was higher in the AC group compared to the SR group (76.6% vs 51.9%, p = 0.04) because of the following reasons: the rate of mTICI 2c-3 was significantly higher, the number of passes of the devices was slightly lower, and symptomatic intracranial hemorrhage was not seen in the AC group.

A limitation of this study is that it was the retrospective study conducted with a small number of patients at a single institution, and the difference of background factors in each group might also have affected our results. Our main therapeutic methods were time varying and each method was not always selected at random, which was also a limitation of it. In addition, the patients treated with both contact aspiration and combined technique were included in the AC group to focus on the advantage of use of AC itself for M2O. However, in the future, we would have to analyze the data of more patients and evaluate the difference between contact aspiration and combined technique in the view of efficacy and safety.

Despite these limitations, this study seems to indicate that MT with AC is effective for achieving mTICI 2c-3 recanalization and for reducing the risk of procedure-related hemorrhage for M2O.

Conclusion

In this study, the rate of mTICI 2c-3 recanalization was higher and no cases of symptomatic SAH were seen in the AC group. This suggests that MT using AC for M2O may enable the achievement of effective and safe recanalization. Additional multicenter studies are warranted to confirm the findings of this study.

Disclosure Statement

The authors declare no conflicts of interest.

References

1) Saver JL, Goyal M, van der Lugt A, et al. Time to treatment with endovascular thrombectomy and outcomes from ischemic stroke: a meta-analysis. *JAMA* 2016; 316: 1279–1288.
2) Sarraj A, Sangha N, Hussain MS, et al. Endovascular therapy for acute ischemic stroke with occlusion of the middle cerebral artery M2 segment. *JAMA Neurol* 2016; 73: 1291–1296.
3) Menon BK, Hill MD, Davalos A, et al. Efficacy of endovascular thrombectomy in patients with M2 segment middle cerebral artery occlusions: meta-analysis of data from the HERMES collaboration. *J Neurointerv Surg* 2019; 11: 1065–1069.
4) Miura M, Yoshimura S, Sakai N, et al. Endovascular therapy for middle cerebral artery M2 segment occlusion: subanalyses of RESCUE-Japan Registry 2. *J Neurointerv Surg* 2019; 11: 964–969.
5) DeGraba TJ, Hallenbeck JM, Pettigrew KD, et al. Progression in acute stroke: value of the initial NIH stroke scale score on patient stratification in future trials. *Stroke* 1999; 30: 1208–1212.
6) Seners P, Turc G, Naggara O, et al. Post-thrombolysis recanalization in stroke referrals for thrombectomy: incidence, predictors, and prediction scores. *Stroke* 2018; 49: 2975–2982.
7) Altenbernd J, Kuhnt O, Hennigs S, et al. Frontline ADAPT therapy to treat patients with symptomatic M2 and M3 occlusions in acute ischemic stroke: initial experience with the Penumbra ACE and 3MAX reperfusion system. *J Neurointerv Surg* 2018; 10: 434–439.

8) Kühn AL, Wakhloo AK, Lozano JD, et al. Two-year single-center experience with the 'Baby Trevo' stent retriever for mechanical thrombectomy in acute ischemic stroke. *J Neurointerv Surg* 2017; 9: 541–546.
9) Grieb D, Schlunz-Hendann M, Brinjikji W, et al. Mechanical thrombectomy of M2 occlusions with distal access catheters using ADAPT. *J Neuroradiol* 2019; 46: 231–237.
10) Haussen DC, Al-Bayati AR, Eby B, et al. Blind exchange with mini-pinning technique for distal occlusion thrombectomy. *J Neurointerv Surg* 2020; 12: 392–395.
11) Barchetti G, Cagnazzo F, Raz E, et al. Mechanical thrombectomy of distal occlusions using a direct aspiration first pass technique compared with new generation of mini-0.017 microcatheter compatible-stent retrievers: a meta-analysis. *World Neurosurg* 2020; 134: 111–119.
12) Goyal M, Fargen KM, Turk AS, et al. 2C or not 2C: defining an improved revascularization grading scale and the need for standardization of angiography outcomes in stroke trials. *J Neurointerv Surg* 2014; 6: 83–86.
13) Kaesmacher J, Maegerlein C, Zibold F, et al. Improving mTICI2b reperfusion to mTICI2c/3 reperfusions: a retrospective observational study assessing technical feasibility, safety and clinical efficacy. *Eur Radiol* 2018; 28: 274–282.
14) Ng PP, Larson TC, Nichols CW, et al. Intraprocedural predictors of post-stent retriever thrombectomy subarachnoid hemorrhage in middle cerebral artery stroke. *J Neurointerv Surg* 2019; 11: 127–132.