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Original Article

Mechanical Thrombectomy for Patients with Occlusions in Both the Anterior Cerebral Artery and Middle Cerebral Artery: Case Series and Review of the Literature

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Objective: Most large-vessel occlusions (LVOs) amenable to acute recanalization occur in the internal carotid or middle cerebral artery. However, few LVOs with a multivessel disease can be difficult to treat. This study aimed to determine the outcomes of mechanical thrombectomy in patients with both anterior and middle cerebral artery occlusions.
Methods: We retrospectively collected data for patients who had undergone mechanical thrombectomy since January 2016 at Fukushima Medical University and its affiliated institutions (10 institutions). Patients with occluded vessels in the anterior and middle cerebral arteries were selected, and patient background, treatment course, and outcomes were reviewed.
Results: A total of 341 mechanical thrombectomies were performed during the study period. Seven patients had occlusions involving both anterior and middle cerebral arteries. In these seven patients, the median time from onset to imaging, imaging to puncture, and puncture to recanalization was 106, 60, and 74 min, respectively. Only one patient (14%) had a modified Rankin Scale of 0–2 at 90 days.
Conclusion: Comorbid anterior cerebral artery occlusion may worsen the outcome of patients with middle cerebral artery occlusion.

Keywords mechanical thrombectomy, multivessel occlusions, acute stroke

Introduction

Mechanical thrombectomy for acute cerebral large-vessel occlusions (LVOs) in the internal carotid artery (ICA) and middle cerebral artery (MCA) has been reported to be effective with good efficacy in randomized controlled trials. Only a few published case series have reported mechanical thrombectomy for anterior cerebral artery (ACA) occlusion.[1–3)] In our clinical experience, we have encountered cases with occluded vessels in both the ACA and MCA, which can be challenging to treat.[1,4,5)] The present study aimed to clarify the results of mechanical thrombectomy in patients with occluded vessels in both the ACA and MCA.

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Materials and Methods

This study was conducted in 10 stroke centers in Fukushima prefecture that are well-equipped to perform mechanical thrombectomy. We retrospectively enrolled patients who had undergone mechanical thrombectomy between January 2016 and December 2019. Patients who could independently perform daily activities before they were afflicted with stroke (modified Rankin Scale [mRS] score: 0–2) were included in this study. Patients with occluded vessels in both the ACA and MCA were selected by preoperative

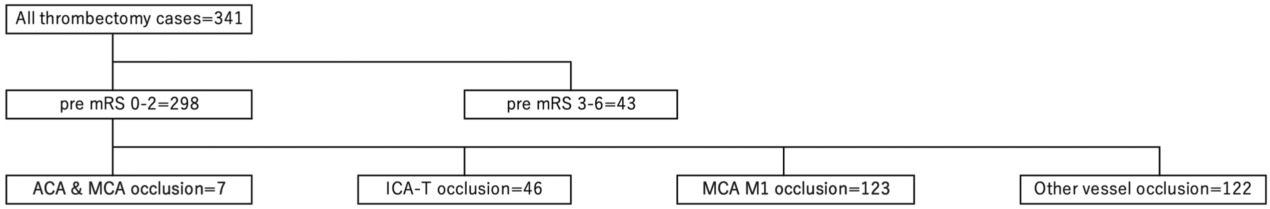

Fig. 1 Patient selection flowchart. During the study period, 341 patients underwent thrombectomy. Of these, 298 patients with a pre-event mRS of 0–2 were analyzed. Seven of these patients had occlusions in the anterior and middle cerebral arteries. Forty-six patients had ICA-T occlusion, and 123 had MCA M1 occlusion. ACA: anterior cerebral artery; ICA-T: internal carotid artery T; MCA: middle cerebral artery; mRS: modified Rankin Scale

DSA. Cases in which multiple vessels were occluded due to movement or dislodgement of thrombus during the procedure were excluded. Patients with internal carotid artery T (ICA-T) occlusion with similar blood flow disruption to ACA and MCA occlusion and patients with MCA M1 segment occlusion only were selected as the control group. The medical records of each patient were reviewed to collect information related to patient characteristics, imaging and procedural results, and clinical outcomes. Treatment efficacy was assessed by posttreatment modified thrombolysis in cerebral infarction (mTICI) grading and mRS score 90 days after treatment; mTICI 2b or 3 recanalization was defined as effective recanalization and mRS score 0–2 was defined as a good functional outcome. Treatment safety was assessed by symptomatic intracranial hemorrhages and death within 90 days after treatment. Symptomatic intracranial hemorrhage was defined as an increase of at least four points in the National Institutes of Health Stroke Scale (NIHSS) score compared to the score immediately before thrombectomy for patients in whom brain hemorrhage was considered the cause of the neurological deterioration. CT and CTA were used for diagnostic imaging, and the Alberta stroke program early CT score (ASPECTS) was calculated to assess the extent of ischemia in the MCA territory. The infarct size in the ACA territory was determined according to the following criteria: none, the infarct cannot be identified on imaging; moderate, the infarct is confined to an area anterior to the precentral gyrus; and large, the infarct extends posteriorly to the precentral gyrus. MRI, including diffusion-weighted imaging (DWI), was performed at some centers. Intravenous recombinant tissue plasminogen activator (IV rt-PA) was administered to all patients at approved dose (0.6 mg/kg) for whom this therapy was indicated. There were no restrictions on the choice of procedures and devices, and it was at the treating physician's discretion.

SPSS Statistics version 26 software (IBM, Armonk, NY, USA) was used for statistical analyses. Mann–Whitney U and chi-square tests were used to compare categorical variables. A p value less than 0.05 was considered statistically significant.

The research protocol was approved by the Ethics Committee of Fukushima Medical university (IRB approval number: 2019-314) and the ethics committee of each participating institution. The requirement for written informed consent was waived owing to the retrospective nature of the study.

Results

Between January 2016 and December 2019, 341 patients underwent mechanical thrombectomy. Of these, 298 patients had a preoperative mRS of 0–2 and independently performed their daily activities; 7 patients had simultaneous ACA and MCA occlusion, 46 patients had ICA-T occlusion, and 123 had MCA M1 segment occlusion (**Fig. 1**).

The patient characteristics for each group are listed in **Table 1**. There were no significant differences in patient backgrounds between the ACA and MCA occlusion and ICA-T occlusion groups. However, when comparing the simultaneous occlusion and MCA groups, the preoperative NIHSS scores were significantly lower in the MCA occlusion group (20 vs. 16, $p = 0.03$).

The clinical results are presented in **Table 2**. When the ICA-T occlusion group was compared with the ACA and MCA occlusion groups, we did not observe any significant difference in any of the variables; however, the percentages of patients achieving complete recanalization (mTICI 3) and those with good outcomes at 90 days were both lower in the ACA and MCA occlusion groups. The procedure time (puncture-to-reperfusion time) tended to be longer in the ACA and MCA occlusion groups.

Moreover, comparing MCA occlusion groups, ACA and MCA occlusion groups showed significantly lower ASPECTS on the day after thrombectomy. However, the effective recanalization rates were comparable. The proportion of patients with good outcomes at 90 days tended

Table 1 Patient characteristics

	ACA and MCA	ICA-T	p value	MCA	p value
N	7	46		123	
Age, median (IQR)	81 (71–85)	80 (72.75–87)	0.85*	77 (69–84)	0.41*
NIHSS, median (IQR)	20 (19–21)	20 (16.5–25.25)	0.94*	16 (12–20)	0.03*
ASPECTS, median (IQR)	7 (7–10)	9 (6–10)	0.94*	9 (8–10)	0.21*
Cardiac embolism (%)	7 (100)	44 (95.7)	0.09†	91 (74)	0.19†

*Mann–Whitney test. †Chi-square test. ACA: anterior cerebral artery; ASPECTS: Alberta Stroke Program Early CT Score; ICA-T: internal carotid artery-T; IQR: interquartile range; MCA: middle cerebral artery; NIHSS: National Institutes of Health Stroke Scale

Table 2 Clinical results

	ACA and MCA	ICA-T	p value	MCA	p value
N	7	46		123	
IV rt-PA (%)	6 (85.7)	25 (54.3)	0.22†	59 (48)	0.12†
mTICI (%)					
2b≤	6 (85.7)	38 (82.6)	>0.99†	100 (81.3)	>0.99†
3	2 (28.6)	31 (67.4)	0.09†	59 (48)	0.45†
mRS 0–2 at 90 days (%)	1 (14.3)	13 (28.3)	0.66†	62 (50.4)	0.12†
Cerebrovascular complications					
Intracranial hemorrhage (%)	3 (42.9)	19 (41.3)	>0.99†	26 (21.1)	0.19†
Symptomatic intracranial hemorrhage (%)	0 (0)	2 (4.3)	>0.99†	11 (8.9)	>0.99†
ASPECTS on the next day	4 (3–6)	3.5 (2–7)	0.98*	7 (5–8)	0.016*
Death at 90 days (%)	2 (28.6)	10 (21.7)	0.66†	15 (12.2)	0.23
Time course					
Onset to picture (min, median) (IQR)	106 (70–124)	127 (80–170)	0.32*	119 (73–225)	0.45*
Onset to needle (min, median) (IQR)	134 (118–166)	140 (104–182)	0.71*	130 (103–181)	0.97*
Picture to puncture (min, median) (IQR)	60 (55–123)	50 (30–81.75)	0.10*	45 (29–72)	0.047*
Puncture to reperfusion (min, median) (IQR)	74 (51–90)	52 (28.75–74.25)	0.18*	57 (37–88)	0.36*
Onset to reperfusion (min, median) (IQR)	238 (196–238)	234 (182.5–234)	0.60*	245 (186–387)	0.87*

*Mann-Whitney test. †Chi-square test. ACA: anterior cerebral artery; ASPECTS: Alberta stroke program early CT score; ICA-T: internal carotid artery-T; IQR: interquartile range; IV rt-PA: intravenous recombinant tissue plasminogen activator; MCA: middle cerebral artery; mRS: modified Rankin Scale; mTICI: modified thrombolysis in cerebral infarction

to be lower in the ACA and MCA occlusion groups, although the difference was insignificant.

Among the seven cases of ACA and MCA occlusion, one patient (case 6) demonstrated ICA-T occlusion by preoperative CTA, which was converted to ACA and MCA occlusions by preoperative DSA. In the other six patients, preoperative CTA or MRA showed occlusion of the entire ACA and MCA. These seven cases are summarized in **Table 3**.

Six patients received IV rt-PA and had received prior MCA treatment; four patients had not taken any treatment for ACA occlusion. We reviewed the medical records to understand why mechanical thrombectomy was not performed in the ACA region, with results such as "the surgeon considered the effective recanalization of the MCA to be sufficient and terminated treatment (cases 1 and 5)" and "the surgeon refrained from intervention because of the peripheral (A2) occlusions (cases 3 and 4)."

Effective recanalization was achieved in six of seven patients in the MCA region and two of seven patients in the ACA region; due to the broader perfusion of the MCA compared to the ACA, we inferred that six patients had effective recanalization and two patients had complete recanalization. Intracranial hemorrhage occurred in three patients, but no symptomatic intracranial hemorrhage was noted. After 90 days of treatment, only one patient had a good outcome (mRS: 0–2). Two patients died: case 4 due to pneumonia in the chronic phase and case 5 with extensive cerebral infarction the day after thrombectomy; he underwent external decompression but died shortly after.

Discussion

Mechanical thrombectomy is effective for LVO of the anterior circulation and is strongly recommended by the American Heart Association/American Stroke Association guidelines. However, only a few case series have reported the results of mechanical thrombectomy for ACA

Table 3 Summary of ACA and MCA occlusion cases

Case	Age	NIHSS	ASPECTS	Infarction volume of ACA territory	Dense MCA sign	IV rt-PA	Occlusion site (CTA/MRA)	Occlusion site (DSA)	Strategy	Device (ACA)	Device (MCA)	No of procedures	mTICI (ACA)	mTICI (MCA)	Puncture to reperfusion	ASPECTS (next day)	Infarction volume of ACA territory (next day)	Complications	mRS 90 days	Cause of death
1	67	20	7	Moderate	+	+	A2, M2	A2, M2	MCA only	–	Stent, aspiration	3	0	2b	79	6	Moderate	SAH	2	–
2	71	21	10	None	+	+	A2, M2	A2, M2	MCA first	Combined	Combined	2	0	2b	74	6	Large	–	4	–
3	77	19	7	Moderate	+	–	A2, M1 distal	A2, M1 distal	MCA only	–	Stent	1	0	2b	41	4	Moderate	–	4	–
4	81	19	9	None	–	+	A2, M1 distal	A2, M1 distal	MCA only	–	Combined	2	0	2a	81	3	Large	–	6	Pneumonia
5	82	30	7	None	–	+	A1, M1 distal	A1, M1 distal	MCA first	Aspiration	Combined	2	3	3	90	0	Large	–	6	CI
6	85	16	10	None	–	+	ICA-T	A2, M1 proximal, P2	MCA first	Combined	Combined	2	3	3	52	3	Large	SAH	5	–
7	91	21	7	None	–	+	A2, M2	A2, M2	MCA only	–	Stent	3	0	2b	51	6	Moderate	HI	4	–

ACA: anterior cerebral artery; ASPECTS: Alberta stroke program early CT score; CI: cerebral infarction; HI: hemorrhagic infarction; ICA-T: internal carotid artery-T; IV rt-PA: intravenous recombinant tissue plasminogen activator; MCA: middle cerebral artery; mRS: modified Rankin Scale; mTICI: modified thrombolysis in cerebral infarction; NIHSS: National Institutes of Health Stroke Scale; SAH: subarachnoid hemorrhage

Table 4 Summary of published studies of ACA and MCA occlusions

Study	Origin	No. of cases	NIHSS (median [IQR])	ASPECTS (median [IQR])	mTICI ≥2b, n (%)	mRS 0–2, n (%)	Mortality, n (%)
Grossberg et al.[1]	USA	11	23 (18–26)	8.5 (8–9)	10 (91)	3 (27)	3 (27)
Kim et al.[4]	Korea	12	18 (16–20)	8 (7–9)	8 (66.7)	3 (25)	2 (16.7)
Uno et al.[5]	Japan	4	28 (21.15–28.75)	9 (6–9.75)	4 (100)	0 (0)	0 (0)
Present study	Japan	7	20 (19–21)	7 (7–10)	6 (85.7)	1 (14.3)	2 (28.6)

ACA: anterior cerebral artery; ASPECTS: Alberta stroke program early CT score; MCA: middle cerebral artery; mRS: modified Rankin Scale; mTICI: modified thrombolysis in cerebral infarction; NIHSS: National Institutes of Health Stroke Scale

occlusion,[2,3,5–7] and a few reports have described the outcomes of mechanical thrombectomy in patients with both ACA and MCA occlusions. These studies showed unfavorable outcomes of thrombectomy for these simultaneous arterial occlusions; however, they had small sample sizes.[1,4,5]

Uno et al. reviewed cases of ACA occlusion and reported that all five patients with preprocedural ACA occlusion had poor outcomes despite effective recanalization.[5] Four patients had concomitant MCA occlusions, which is consistent with our findings. Kim et al. reported 12 cases of simultaneous ACA and MCA occlusions.[4] MCA recanalization, ACA recanalization, and effective recanalization were achieved in 10 (83.3%), 10 (83.3%), and 8 (66.7%) patients, respectively. However, only three (25%) patients had a good outcome (90 days mRS: 0–2). Grossberg et al. summarized 69 cases of distal vessel occlusion.[1] Of these, 11 patients had simultaneous ACA and MCA occlusions; effective recanalization of mTICI 2b or greater was achieved in 10 patients (91%), and mRS 0–2 at 90 days was achieved in 3 (27%) patients. **Table 4** summarizes the published studies on ACA and MCA occlusions.

We also compared the outcomes of ACA and MCA occlusions with those of ICA and MCA M1 occlusions in the same cohort. Owing to the small number of patients with ACA and MCA occlusions, there were no significant differences in outcomes between the groups; however, lower good outcomes were noted in the ACA and MCA occlusion groups.

Reduced collateral circulation is one of the possible reasons for the lack of good outcomes despite effective recanalization.[2] The significantly lower next-day ASPECTS in the ACA and MCA occlusion groups compared to the MCA occlusion-alone group, despite similar effective recanalization rates and time from onset to recanalization, suggests that concomitant ACA occlusion may have compromised collateral blood flow to the MCA region.

In addition, the extent of cerebral infarction in the ACA territory before mechanical thrombectomy was not depicted on imaging in five of the seven cases. Postoperatively, all patients had moderate to large infarcts in the ACA region, including two patients in whom ACA recanalization was achieved, which may have contributed to the poor outcome. Overall, the outcome remained poor, irrespective of whether the ACA was recanalized. Our opinion at this time is that we should attempt to recanalize the ACA occlusion after obtaining recanalization of the MCA occlusion. This is because the ACA and MCA complement each other's blood flow, and we believe that obtaining recanalization of both will contribute to improved intracranial perfusion. However, the results of this study do not allow us to judge the merit of this strategy. Further case studies are required to determine whether therapeutic intervention in the ACA should be performed, and if so, whether it should be performed before or after MCA recanalization.

In the present seven cases, two patients underwent mechanical thrombectomy for ACA occlusion. It has been hypothesized that the need for retrieval procedures in multiple vascular territories may increase procedure time.[5] Decreased collateral blood flow due to ACA occlusion in patients treated only with MCA and prolonged procedure time in patients treated with ACA intervention may have contributed to poor outcomes.

In our series, case 6 had an occlusion at the tip of the ICA on preoperative imaging. However, it shifted to a distal artery occlusion at the time of angiography immediately before the procedure, suggesting that rt-PA administration may have caused thrombus fragmentation. However, in the other six cases, the thrombolytic effect of rt-PA was unclear, although rt-PA is relatively effective for treating distal artery occlusions.[8] The thrombolytic effect of rt-PA is reduced in hard thrombi with high fibrin content,[9] and we suspect that the thrombi in the current series may have had high fibrin content.

Spontaneous fragmentation of a thrombus occluding the ICA or proximal MCA before imaging may have resulted in occlusion of the distal arteries by a hard "core" of a high fibrin content thrombus. Mechanical thrombectomy for patients with high fibrin content can increase the number of thrombus retrieval procedures required and prolong the procedure time.[10] In the present study, 3 of 7 patients had a positive dense MCA sign, so there is no consistent trend in assuming the nature of the thrombus, and since only a small number of cases were studied, it is difficult to conclude the efficacy of IV rt-PA therapy for multiple arterial occlusions.

The retrospective design and small number of cases are the limitations of our study. A prospective registry study is desirable because the results must be compared with those of ACA and MCA occlusion cases in which mechanical thrombectomy was not performed.

Conclusion

In our study, patients with simultaneous ACA and MCA occlusions had a high rate of poor outcomes despite a high rate of effective recanalization. In patients with multiple cerebral LVOs, the disruption of collateral blood flow may increase the extent of infarction and lead to poor outcomes.

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Disclosure Statement

All authors have no conflicts of interest.

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