Online September 1, 2020
Journal of Neuroendovascular Therapy 2021; 15: 8–13
DOI: 10.5797/jnet.oa.2020-0103

Original Article

Mechanical Thrombectomy for Acute Cerebral Large Vessel Occlusions Involving a Cerebral Aneurysm in the Target Vessel

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Objective: Mechanical thrombectomy (MT) for acute cerebral large vessel occlusion (LVO), which involves a cerebral aneurysm in the target vessel, indicates a risk of rupture of the aneurysm. Safety of the MT for LVO involving cerebral aneurysm was examined.

Methods: In all, 240 consecutive patients with LVO were treated with MT between January 2018 and December 2019. Angiographic images and clinical records of patients with LVO involving cerebral aneurysm in the target vessel were retrospectively analyzed.

Results: Cerebral aneurysms were involved in seven patients (2.9%) in the target vessels. Aspiration thrombectomy was first considered; however, five of seven lesions were difficult to manage with aspiration thrombectomy alone. The stent retriever (SR) was combined with aspiration catheter for elongated vessel lesions and distal lesions. In all lesions, good recanalization was achieved without aneurysmal rupture.

Conclusion: Aneurysms were identified in 2.9% of LVO in this study. Good recanalization was performed in all cases, and no cerebral aneurysmal rupture was observed during the perioperative period, and the procedure was relatively safe. Further case accumulation is needed for MT device selection and procedures for LVO involving cerebral aneurysm.

Keywords ▶ mechanical thrombectomy, cerebral aneurysm, cerebral large vessel occlusion

Introduction

Mechanical thrombectomy (MT) using a stent retriever (SR) for acute cerebral large vessel occlusion (LVO) is superior to intravenous thrombolysis.[1)] Both aspiration thrombectomy and SR thrombectomy are relatively safe interventions, with a low rate of procedure-related complications, and have recently become standard treatments for ischemic strokes involving LVO.[2)]

Unruptured, potentially unrecognized cerebral aneurysms are associated with a 3%–6.6% incidence of ischemic stroke.[3–8)] MT for LVO involving cerebral aneurysms in the target vessel is also associated with aneurysm rupture risk. Thus, MT using SR is theoretically associated with a higher risk of aneurysmal rupture than MT via aspiration thrombectomy. However, there are few reports of SR for LVO involving a cerebral aneurysm in the target vessel.[9,10)] We retrospectively examined the safety of MT for LVO involving an aneurysm in the target vessel.

Materials and Methods

All consecutive patients with acute cerebral LVO who underwent MT at our institute and associated institutes between January 2018 and December 2019 were included.

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Table 1 Clinical and mechanical thrombectomy data of large vessel occlusion involving cerebral aneurysm in the target vessel

Case	Age (years)	iv tPA	LVO location	Aneurysm			MT		Number to SR pass across aneurysm	P to R (min.)	TICI	mRS
				Location	Size (mm)	Known	First	Second				
1	80s	No	M1	MCA bifurcation	6	No	ADAPT*		0	35	2b	3
2	70s	No	BA	VA-PICA	4	Yes	ADAPT		0	27	3	2
3	80s	No	P2	BA	9	Yes	ADAPT	CAPTIVE	1	76	2b	3
4	80s	No	BA	BA, fusiform	8	Yes	ADAPT	CAPTIVE	1	78	3	5
5	50s	No	Distal BA	mid BA, fusiform	25	Yes	ADAPT	CAPTIVE	2	256	3	6
6	80s	No	BA	VA-PICA	4	Yes	Combined		0	30	3	0
7	60s	Yes	ICA	ICA top	5	No	ASAP		0	35	3	0

ADAPT: a direct aspiration first pass technique; ASAP: A Stent-Retrieving into an Aspiration Catheter with Proximal Balloon (ASAP) Technique; BA: basilar artery; CAPTIVE: continuous aspiration prior to intracranial vascular embolectomy; Combined: combined use of aspiration catheter and SR; ICA: internal cerebral artery; iv tPA: intravenous tissue plasminogen activator; Known: known prior to the intervention; LVO: large vessel occlusion; M1: M1 segment of middle cerebral artery; MCA: middle cerebral artery; mRS: modified Rankin Scale at 3 months after the onset; MT: mechanical thrombectomy; P2: P2 segment of posterior cerebral artery; P to R: time to puncture to recanalization; SR: stent retriever; TICI: Thrombolysis In Cerebral Infarction; VA-PICA: vertebral artery-posterior inferior cerebellar artery
*SR was used to navigate aspiration catheter for ADAPT.

LVO patterns were determined by MRA in most cases. Intravenous tissue plasminogen activator (tPA) was injected in cases within 4.5 hours from stroke onset. When cerebral aneurysm was diagnosed by pre-MT images, intravenous tPA was not used, which was determined by stroke specialist of the Japan Stroke Society. MT had been performed according to standard techniques using aspiration catheter and SR. In case of LVO involving a cerebral aneurysm in the target vessels, a direct aspiration first pass technique (ADAPT) using aspiration catheter was performed first.[11] If aspiration catheter was not safely reached to the occluded lesion, or sufficient recanalization was not obtained by ADAPT, SR was combined. In combined use of both devices, SR was withdrawn into the aspiration catheter to decrease shearing stress on the vessel wall (e.g., via the ASAP technique [A Stent-Retrieving into an Aspiration Catheter with Proximal Balloon Technique].[12]) Recanalization success was graded according to the Thrombolysis in Cerebral Infarction (TICI) scale. TICI grade of 2b and 3 were determined to good recanalization.

Results

MT was performed for 240 cases with LVO, and in seven cases (2.9%), cerebral aneurysms were involved in the target vessels. The clinical data of the cases with LVO involving cerebral aneurysm are shown in **Table 1**. Five aneurysms were saccular type and two were fusiform type. In all patients, cerebral aneurysm was not diagnosed at the onset of stroke. In two patients (Cases 1 and 7) of these cases, the aneurysm was located distal to the occluded segment, undetectable in pre-MT images and initial angiography prior to MT. The remaining five patients had cerebral aneurysms located proximal to the occlusion, and these aneurysms were recognized by pre-MT images.

ADAPT was first selected in five patients. In two of five patients (Cases 1 and 2), good recanalization was achieved in the first pass. In Case 1, occlusion of left M1 segment of middle carotid artery (MCA; **Fig. 1A**), the microguidewire, while crossing the occluded lesion, advanced in a circle-like coil movement during aneurysmal embolization, which suggested the existence of a saccular aneurysm at the MCA (**Fig. 1B**). Therefore, ADAPT was selected. In one patient who could not achieve good recanalization by APDAT, combined use of aspiration catheter and SR was performed (Case 5, **Fig. 2**). In two patients who were intended to be treated by ADAPT, aspiration catheter was not reached to the occluded lesion; therefore, SR was combined

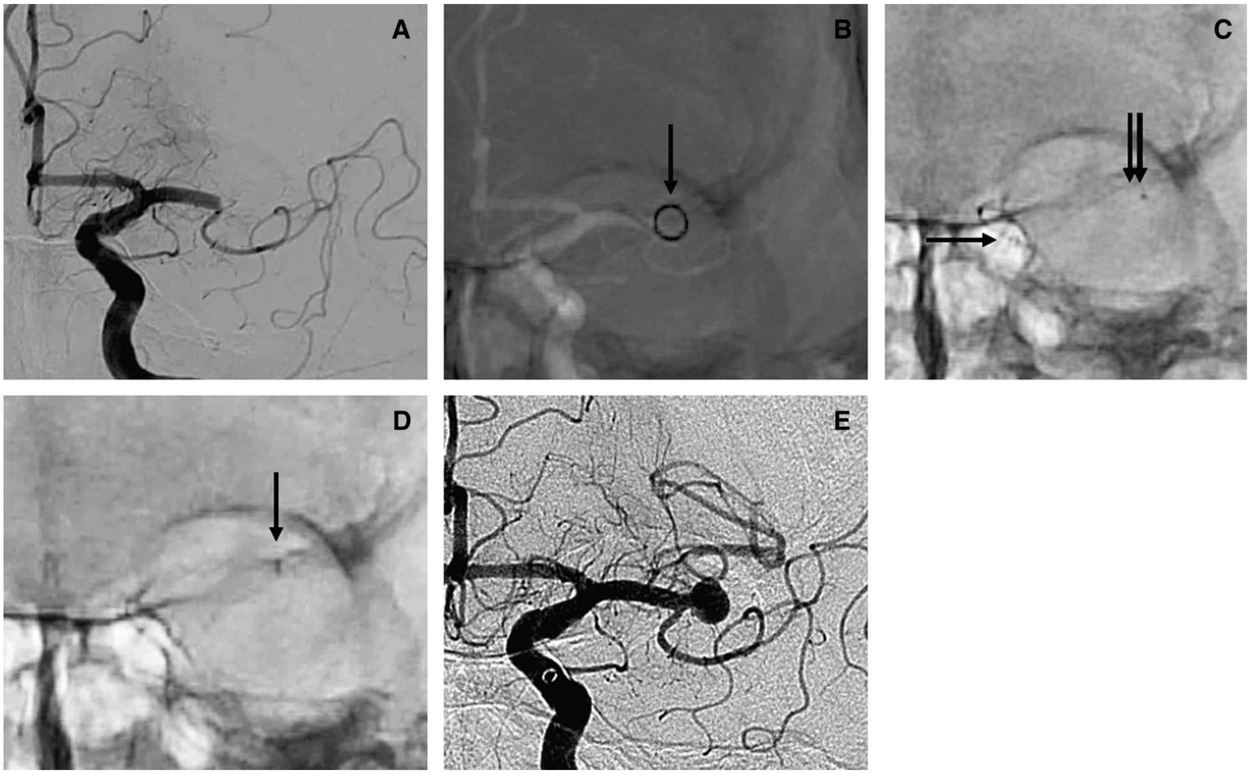

Fig. 1 Case 1. (**A**) Left internal carotid angiography showed occlusion of M1 segment of left MCA. (**B**) A microguidewire advanced in a circle-like coil movement during aneurysmal embolization and distal to the occluded lesion, suggesting the presence of an aneurysm. The arrow indicates the microguidewire. (**C**) As an anchor, we deployed SR to the M1 segment of the MCA. Double arrows indicate the tip of the SR. The arrow points to the tip of aspiration catheter. (**D**) Aspiration catheter was navigated to the M1 segment of the MCA for a direct aspiration first pass technique. The arrow indicates the tip of the aspiration catheter. (E) After aspiration thrombectomy, the saccular aneurysm at the bifurcation of the MCA was contrasted. MCA: middle cerebral artery; SR: stent retriever

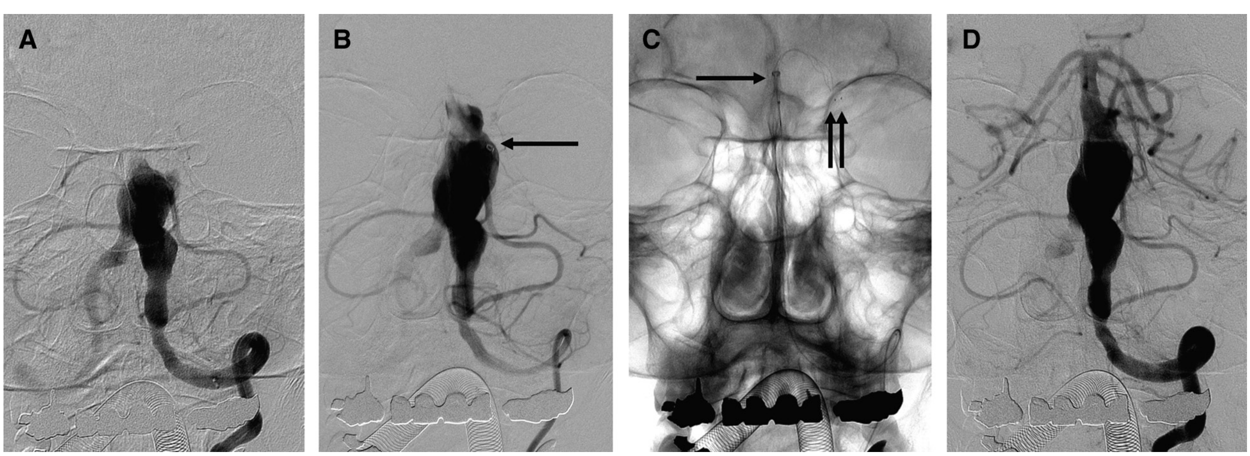

Fig. 2 Case 5. (**A**) Left vertebral angiography revealed occlusion of the basilar artery. (**B**) After attempting aspiration thrombectomy, recanalization failed. The arrow indicates the tip of the aspiration catheter. The aspiration catheter advanced to only one direction. (**C**) SR was deployed at the posterior cerebral artery to basilar artery. The arrow indicates the tip of the aspiration catheter and double arrows indicate SR. (**D**) After combined thrombectomy, excellent recanalization was achieved. SR: stent retriever

(Cases 3 and 4). Then, continuous aspiration prior to intracranial vascular embolectomy (CAPTIVE) technique was used in the cases because SR was not withdrawn into the aspiration catheter.[13)]

In two patients, aspiration catheter was navigated to distal to the aneurysm, and SR was withdrawn into aspiration catheter (Case 6 [**Fig. 3**], Case 7). In Case 6, the aspiration catheter was advanced just proximal to the aneurysm.

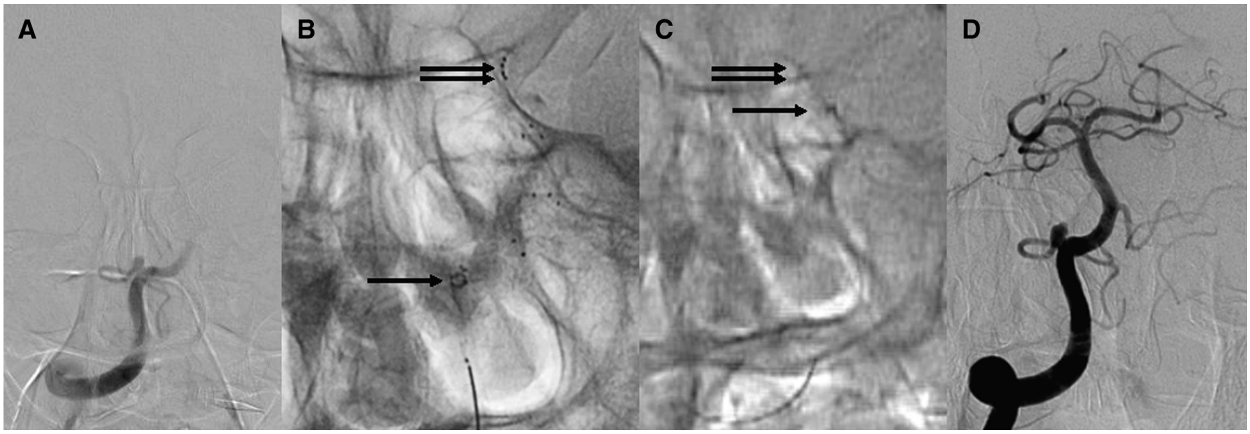

Fig. 3 Case 6. (**A**) Right vertebral angiography revealed occluded basilar artery distal to the aneurysm. (**B**) SR was deployed at the occluded lesion distal to the aneurysm, and the aspiration catheter was navigated just proximal to the aneurysm. The arrow indicates the tip of the aspiration catheter, and double arrows indicate the tip of SR. (**C**) The SR anchored to shift vascular travel and reduce stress affected by the ledge to the aneurysm when raising the aspiration catheter. The arrow indicates the tip of the aspiration catheter, and double arrows indicate the tip of SR. (**D**) Final angiography revealed complete recanalization. SR: stent retriever

Given the concern about aneurysm stress during induction of the aspiration catheter, SR was first deployed. The stent was then anchored to guide the aspiration catheter to the occlusion without interfering with the aneurysm. The SR was withdrawn into the aspiration catheter to minimize device interference with the aneurysm (combined use). In Case 7, aspiration catheter was not smoothly reached to the occluded lesion due to steep vessel curve; therefore, we deployed the SR at the occluded portion and SR was withdrawn into the aspiration catheter (ASAP technique[12]).

The time of puncture to recanalization was 27–256 minutes (median, 35 minutes). In Case 5, the massive thrombi were aspirated by repeat ADAPT resulting in partial recanalization; therefore, a long time was taken. Good recanalization was achieved in all lesions. Aneurysmal rupture and any intracranial hemorrhage were not occurred in all patients. About the etiology of the LVO, atrial fibrillation was confirmed in five of the seven cases and judged to be cardiogenic infarction, but in the remaining two cases (Cases 4 and 5), the embolus source was not detected and the fusiform aneurysm itself seemed to be the embolus source.

Discussion

The clinical effectiveness of MT for LVO and its superiority over intravenous thrombolysis has been demonstrated in a series of large-scale randomized Trials.[1] However, MT for LVO involving a cerebral aneurysm in the target vessel is associated with an increased risk for aneurysm rupture.[9,10] Zibold et al.[10] reported that 3.7% of MT cases had an aneurysm, and a 9% incidence of aneurysmal rupture during MT for acute cerebral LVO involving a target vessel aneurysm. They also reported that the target vessel-related aneurysmal prevalence was higher in the anterior circulation than in the posterior circulation.[10] In this study, 2.9% of those who underwent MT had an aneurysm, and five of seven cases were posterior circulation. Although the rate of aneurysm complications is considered to be similar, the reason for a large number of cases in the posterior circulatory system is too few cases to give a clear answer.

The aneurysm existing in the target vessel is classified into a distal type of the occlusion, that is, a hidden type (distal type) and a proximal type of the occlusion (proximal type). In the proximal type, an aneurysm is often found by an image examination before MT, while in the distal type, the presence of an aneurysm is not known by a pre-examination. Moreover, the distal type is probably more dangerous than the proximal type. This type of aneurysm is located distal to the occlusion site; therefore, prior to stent deployment, a microguidewire and microcatheter must pass the thrombus into distal unopacified vessel segments where they might inadvertently enter and perforate the aneurysm. It is important to make the tip of the microguidewire J-shaped and to operate the wire carefully. As in Case 1, it is important to pay attention to how the microguidewire advances and to suspect the existence of an aneurysm. On the other hand, the proximal type poses another danger even if it is visualized. Stress to the aneurysm due to the ledge may be concerning, as when a large-diameter aspiration catheter passes through an aneurysm at a bifurcation. In such case, as in Case 6, the SR can be deployed and anchored to shift vascular travel and reduce stress affected by the ledge to the aneurysm when raising the aspiration catheter. A problem common to both types of aneurysms is that shear stress acts on the vessel wall due to the traction force when the SR withdrawal. And this force may be sufficient to tear the fragile wall of the aneurysm. So that, at the time of thrombectomy, interference with the aneurysm by the stent could be avoided by drawing the SR into the aspiration catheter (e.g., ASAP technique[12]).

SR maneuvers carry the risk of rupture of coincidental aneurysms. Therefore, an SR should never be deployed inside or at the neck of an aneurysm. The ADAPT technique may help to decrease shearing forces on the vessel wall compared to an SR, and can achieve recanalization without passing the thrombus and the aneurysm.[11] However, this technique is difficult to perform safely because of less inner-support during catheter navigation. In Case 1, the aspiration catheter could not cross the carotid siphon, though anchoring support provided by the SR, deploying SR on M1 segment of MCA to ICA so that it does not affect the aneurysm, was effective for navigating the aspiration catheter to the target portion. In Case 5, the thrombus could not be aspirated sufficiently to achieve recanalization because of the size of the thrombus and the approach angle, which limited movement of the aspiration catheter. Reshaping the aspiration catheter might be effective for aspirating a thrombus exiting a wide aneurysmal space. To navigate the microcatheter to the distal portion of the thrombus, the microcatheter and microguidewire were manipulated; however, selection of a peripheral artery was difficult because of the wide aneurysmal space.

In combined use of aspiration catheter and SR, SR can be withdrawn into large lumen aspiration catheter (ASAP technique[12]), and the method may prevent withdrawing SR through the neck of the aneurysm. However, it can occur distal migration of thrombus from SR when withdrawing SR into the aspiration catheter, and narrow aspiration catheter such as Penumbra 3MAX reperfusion catheter (Penumbra, Alameda, CA, USA) cannot withdraw the SR with captured thrombus. CAPTIVE technique also has the risk of rupture of coincidental aneurysms; however, traction forces may be less than simple SR.[13]

We thought ADAPT is the first selection for LVO involving cerebral aneurysm in the target vessel; however, the lesion suitable for ADAPT is limited. Combined use of aspiration catheter and SR is useful for elongated vessel and distal lesion to decrease shearing stress on the vessel wall.[11]

Conclusion

MT was performed for 240 cases with LVO, and aneurysms were identified in 2.9%. In all cases, we achieved good recanalization and cerebral aneurysmal rupture was not observed during the perioperative period, and the procedure was relatively safe. Further case accumulation is needed for MT device selection and procedures for LVO involving cerebral aneurysm.

Disclosure Statement

We declare that we have no conflict of interest.

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