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Case Report

Acute Proximal Anterior Circulation Occlusion after Pulmonary Lobectomy Treated by Endovascular Therapy: Two Case Reports

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Objective: We report two cases of acute proximal anterior circulation occlusion after pulmonary lobectomy.
Case Presentation: Case 1 was a 64-year-old male who presented with occlusion of the right middle cerebral artery (MCA) one day after left lower lobectomy. Case 2 was a 68-year-old male who presented with occlusion of the right internal carotid artery (ICA). In both cases, mechanical thrombectomy was performed for complete recanalization and symptoms were improved.
Conclusion: Prompt mechanical thrombectomy in the acute phase after pulmonary lobectomy improved the prognosis of patients with acute proximal anterior circulation occlusion. It is important to share information about ischemic complications with medical staff engaged in thoracic surgery.

Keywords ▶ anterior circulation large vessel occlusion, embolism, mechanical thrombectomy, pulmonary lobectomy, perioperative period

Introduction

Thrombus formation in the pulmonary vein stump after lobectomy can cause cerebral embolism. However, there have been only a few reports on this type of embolism, and its treatment methods have yet to be established. As embolism frequently develops during the perioperative period, intravenous thrombolysis with recombinant tissue plasminogen activator (rt-PA) administration is contraindicated, and the use of antithrombotic agents is also limited. In particular, in the case of intracranial large artery occlusion, immediate recanalization by mechanical thrombectomy is necessary; however, the effects and safety of this method in the acute phase after major surgery are unclear. We report two patients in whom proximal anterior circulation occlusion developed in the acute phase after pulmonary lobectomy, but favorable functional outcomes were obtained after mechanical thrombectomy.

Case Presentation

Case 1

Patient: A 64-year-old male
Chief complaints: Disturbance of consciousness, right conjugate deviation, and left hemiplegia.
Past medical history: Dyslipidemia, hypertension, and hyperuricemia
Present illness: Thoracoscopic left lower lobectomy was performed for a chest abnormality detected during screening. He was confirmed normal at 11:50 the following day, but was found collapsed at 12:30.
Neurological findings: He had a Japan Coma Scale (JCS) score of 20, the Glasgow Coma Scale (GCS) E4V5M6, right conjugate deviation, and flaccid paralysis of the left

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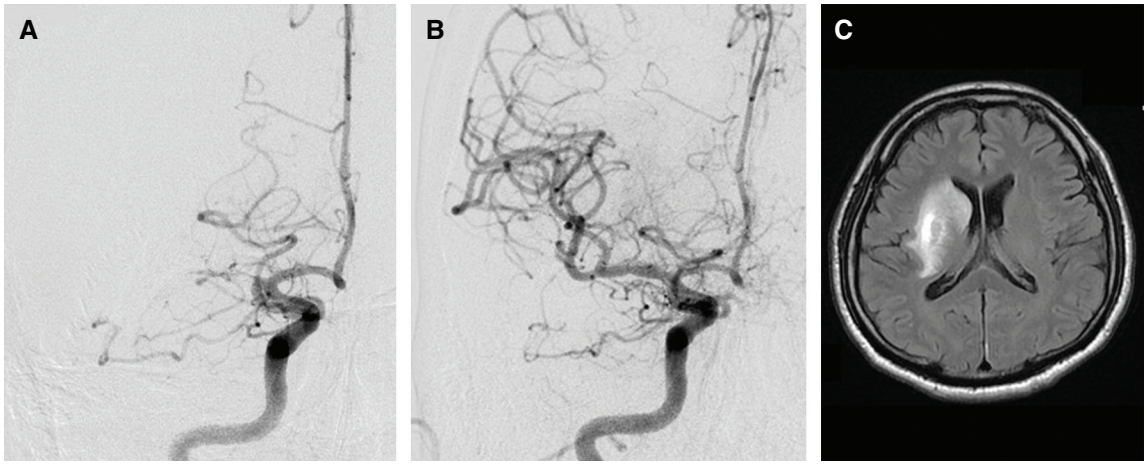

Fig. 1 Case 1: (**A** and **B**) Frontal images of right internal carotid angiography (**A**: before thrombectomy and **B**: after thrombectomy) and (**C**) FLAIR image of head MRI on the day after thrombectomy. FLAIR: fluid-attenuated inversion recovery; MRI: magnetic resonance imaging

upper and lower limbs. The National Institutes of Health Stroke Scale (NIHSS) score was 22.

Imaging findings: On plain computed tomography (CT) images of the head (12:47), there were no early CT signs (ASPECTS, 10), but a right hyper-dense middle cerebral artery (MCA) sign was observed. Magnetic resonance imaging (MRI) was performed (13:10), and diffusion-weighted imaging (DWI) demonstrated faint high-intensity signals from the right putamen and caudate nucleus to the insular gyrus and corona radiata (DWI-ASPECTS, 6). Magnetic resonance angiography (MRA) revealed occlusion of the right M1 segment of the MCA.

Endovascular therapy: Although the ASPECTS was 6, only markedly faint changes were observed on DWI. Therefore, functional recovery by recanalization was considered to be highly probable, and mechanical thrombectomy was performed. At 14:09, the right femoral artery was punctured, and a 9Fr Optimo (Tokai Medical, Aichi, Japan) was placed in the right internal carotid artery (ICA). Occlusion of the proximal M1 segment was confirmed by angiography (**Fig. 1A**), and a Penumbra Reperfusion Catheter 5MAX ACE (Penumbra, Alameda, CA, USA) was advanced to the site of occlusion over a Penumbra Reperfusion Catheter 3MAX and a CHIKAI (0.014 inches, Asahi Intecc, Aichi, Japan) microwire. Aspiration was performed twice with the 5MAX ACE using a direct aspiration first pass technique (ADAPT). However, as clots were unable to be retrieved, ADAPT was changed to stent retriever thrombectomy. After an XT-27 (Stryker Neurovascular, Fremont, CA, USA), microcatheter was navigated distal to the thrombus, a Trevo (4 × 30 mm: Stryker Neurovascular, Fremont, CA, USA) was depolyed and the clots were retrieved. Clots were also observed from inside of the Optimo. Angiography revealed complete right MCA recanalization, and the Thrombolysis in Cerebral Infarction (TICI) score was 3 (15:15) (**Fig. 1B**). The time from symptom onset to recanalization (OTR) was 205 minutes.

Postoperative course: Regarding the consciousness level after the treatment, the JCS score improved to 10 and the GCS improved to E3V4M6. His hemispatial neglect disappeared and the left hemiplegia improved (NIHSS score, 9). MRI on the day after thrombectomy demonstrated an ischemic lesion extending from the right putamen to the head of the caudate nucleus, with a reduction in size compared with the preoperative DWI high-intensity area (**Fig. 1C**). No abnormality was found while searching for the source of the embolism. His paralysis nearly disappeared, and he was able to walk without assistance. He was transferred with the modified Rankin scale (mRS) score of 1 to another hospital 13 days after the onset of cerebral embolism.

Case 2

Patient: A 68-year-old male

Chief complaints: Right conjugate deviation and left hemiplegia

Past medical history: Diabetes mellitus, cerebral infarction, and oral clopidogrel (75 mg/day)

Present illness: Thoracoscopic right lower lobectomy was performed for a right hilar mass detected during screening. The operation was completed at 12:00, and he woke up from anesthesia without problems. He was confirmed to be

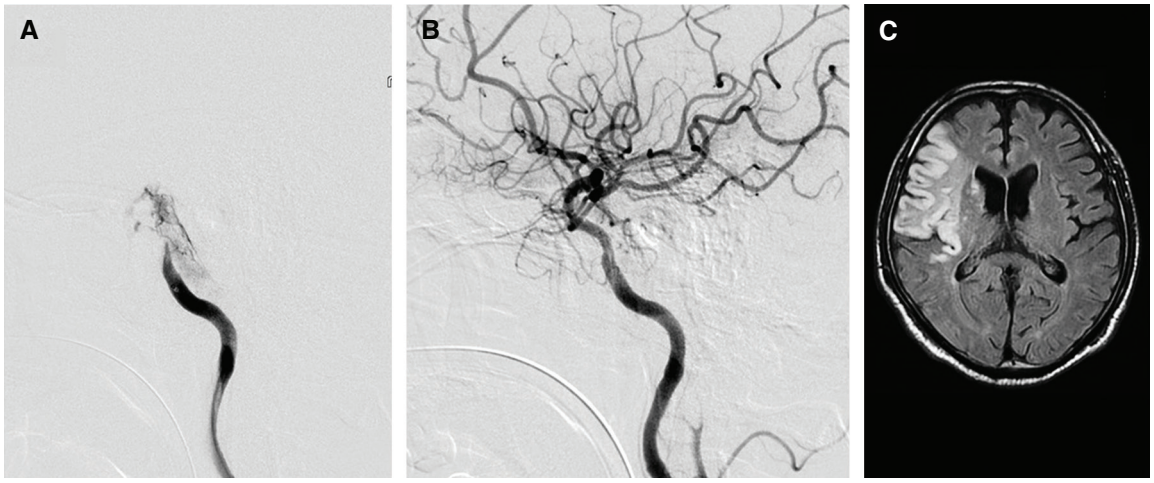

Fig. 2 Case 2: (**A** and **B**) Lateral images of right internal carotid angiography (**A**: before thrombectomy and **B:** after thrombectomy) and (**C**) DWI of head MRI on the day after thrombectomy. DWI: diffusion-weighted imaging, MRI: magnetic resonance imaging

normal at 14:15, but was found in a state of left hemiplegia at 15:00.

Neurological findings: The JCS score was 10 and the GCS was E3V4M6. Somnolence, right conjugate deviation, and flaccid paralysis of the left upper and lower limbs were observed. The NIHSS score was 16.

Imaging findings: MRI of the head was performed (15:27), and DWI revealed faint high-intensity signals from the right basal ganglia to the insular gyrus and frontal and parietal lobes (DWI-ASPECT, 6), whereas T2-weighted imaging and fluid-attenuated inversion recovery (FLAIR) exhibited negligible signal changes. MRA revealed right ICA occlusion, and occlusion of M1 of the right MCA was visualized via the anterior communicating artery.

Endovascular therapy: As signal changes on DWI were negligible, suggesting ischemic penumbra, mechanical thrombectomy was performed. The right femoral artery was punctured (16:11), and a 9Fr Optimo was placed in the right common carotid artery. Angiography revealed occlusion of the right ICA siphon (C3) (**Fig. 2A**). A Penumbra Reperfusion Catheter 68ACE was wedged at the occlusion site over a Penumbra Reperfusion Catheter 3MAX and a CHIKAI microwire, and clots were removed using ADAPT. A control angiography demonstrated complete recanalization of the ICA (16:26) (**Fig. 2B**). The OTR time was 131 minutes.

Postoperative course: After the treatment, his consciousness level improved and conjugate deviation disappeared. The NIHSS score improved to 14. MRI on the day after thrombectomy revealed ischemic changes from the right frontal lobe to the insular gyrus and parietal lobe on FLAIR images (**Fig. 2C**). Although the embolic source was searched for, no abnormality was observed. He became awake and alert. Although paralysis of the left upper limb remained, he was able to walk. He was transferred with the mRS score of 3 to another hospital 46 days after the onset of cerebral embolism.

Discussion

Cerebral embolism after pulmonary lobectomy, which is a rare complication observed in 0.6%–0.8% of patients,[1–3] is considered to be caused by thrombus formation in the resected pulmonary vein stump. This complication induces serious neurological deficits due to intracranial large artery occlusion. However, as recovery is expected after immediate thrombectomy, this method has recently attracted attention. We performed mechanical thrombectomy on two patients who developed major cerebral artery occlusion in the acute phase after pulmonary lobectomy and whose symptoms were improved without complications related to the surgical procedure.

Attacks of cerebral ischemia in the acute phase after pulmonary lobectomy are a contraindication to rt-PA administration. In particular, for major cerebral artery occlusion, mechanical thrombectomy is the only method for recanalization, but its safety and therapeutic effects are unknown. Among previously reported patients who developed cerebral embolism in the acute phase after pulmonary lobectomy, seven, including the two reported in this study, underwent mechanical thrombectomy (**Table 1**).[4–8] Complete recanalization was achieved in five patients and partial recanalization in the other two patients, and

Table 1 Summary of patients treated with mechanical thrombectomy for cerebral embolism after pulmonary lobectomy

Authors	Year	Age/Sex	Procedure	Postoperative period	Site of occlusion	Symptom	Used device	Recanalization
Suma T[4]	2013	68M	LUL	1 day	Rt ICA	Hemiparesis	Merci	Complete
Ikeda H[5]	2015	58M	LUL	2 days	Lt ICA	Disturbance of consciousness Aphasia Hemiparesis	Penumbra + Trevo	Complete
Koga N[6]	2016	71M	LLL	1 day	Lt MCA	Aphasia Hemiparesis	No description	Partial
Yamauchi T[7]	2017	76M	LLL	1 day	Rt MCA	Hemiparesis	Trevo	Complete
Binbin Z[8]	2019	55M	LUL	2 days	Lt ICA	Disturbance of consciousness Aphasia Hemiparesis	Aspiration	Partial
Our cases	2019	64M	LLL	1 day	Rt MCA	Disturbance of consciousness Hemiparesis	Trevo	Complete
		68M	RLL	3 hous	Rt ICA	Disturbance of consciousness Hemiparesis	Penumbra	Complete

ICA: internal carotid artery; LLL: left lower lobectomy; LUL: left upper lobectomy; MCA: middle cerebral artery; RLL: right lower lobectomy

improvement in symptoms was observed in six patients. No postoperative complications were reported. In our patients, mechanical thrombectomy was performed on the day of or day after pulmonary lobectomy, and complete recanalization was achieved. The subsequent course was favorable without problems, and the symptoms also improved. The routine surgical procedure was used, including heparinization, and no problems developed during the treatment and subsequent course. In addition, no hemorrhagic complications at the pulmonary lobectomy site developed. Therefore, although the number of evaluated patients was small, immediate mechanical thrombectomy can be considered for patients with suspected major cerebral artery occlusion even in the acute phase after pulmonary lobectomy. All patients developed cerebral embolism early (within 2 days). Ohtaka et al. reported that the median duration from lobectomy until the detection of thrombosis in the pulmonary vein stump is 3 months.[9] To our knowledge, 12 of 17 patients with cerebral embolism after lobectomy developed cerebral embolism within 3 days after surgery.[6,10–13] Therefore, special attention may be necessary within 3 days after surgery.

The past medical history of the two patients in this study did not include carotid artery stenosis or atrial fibrillation. Electrocardiographic monitoring during the peri-lobectomy period also confirmed the absence of arrhythmia. Examination for the embolus source revealed no abnormalities such as atrial fibrillation or patent foramen ovale. As the patients had lung cancer, the possibility of Trousseau syndrome was unable to be excluded. However, as cerebral embolism developed within a day after the operation, lobectomy was the most likely cause.

Embolism after lobectomy was previously considered to be caused by atrial fibrillation present as an underlying disease or to occur after lobectomy. However, a study in 2013 revealed thrombus formation in the pulmonary vein stump as a possible cause, which was of great interest.[9] In this study, the authors observed a significant correlation between embolism after lobectomy and the surgical procedure; thrombus formation in the pulmonary vein stump after lobectomy was present in 3.6% of the patients, all of whom had undergone left upper lobectomy, and its incidence was 13.5% when the patients were limited to those who underwent left upper lobectomy.[9] They suggested that this is because the left upper pulmonary vein stump is significantly longer than other vein stumps anatomically, and blood flow often becomes stagnant or turbulent, causing thrombus formation. Indeed, most previously reported patients who

developed cerebral embolism in the early phase after lobectomy had undergone left upper lobectomy.[14] However, both of our patients developed cerebral embolism after left lower and right lower lobectomy, respectively. In both patients, a general thoracoscopic lobectomy procedure, in which the pulmonary vein is resected using a stapler, was used. The cause of cerebral embolism after lower lobectomy in both patients is unclear, but we hypothesize that lower pulmonary vein stagnation was affected by the postoperative hypercoagulable state, resulting in thrombus formation.

There are no established effective preventive measures against cerebral embolism after pulmonary lobectomy. The initiation of antithrombotic therapy in the early phase after surgery is not practical due to the risk of wound hemorrhage; therefore, early detection efforts are important. For early detection, staff members performing lobectomy in the department of chest surgery and those in the intensive care unit should be fully informed of the diagnostic method for cerebral ischemic attacks, and that recovery can be expected using mechanical thrombectomy if arrangements for prompt treatment are made.

Conclusion

We reported two patients with cerebral embolism after pulmonary lobectomy in whom endovascular therapy was useful.

Disclosure Statement

We declare no conflicts of interest.

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