Mechanical Thrombectomy for Acute Ischemic Stroke Arising from Thrombus of the Left Superior Pulmonary Vein Stump after Left Pneumonectomy: A Case Report

Shinya Sonobe,1 Masahiro Yoshida,1 Kuniyasu Niizuma,2 and Teiji Tominaga2

Pulmonary vein thrombosis is a rare disease but can cause severe complications. However, pathophysiology of this entity is not fully understood. We report a case of mechanical thrombectomy for acute ischemic stroke arising from thrombus of the left superior pulmonary vein stump after left pneumonectomy. A 67-year-old male without atrial fibrillation presented with middle cerebral artery occlusion 11 days after left pneumonectomy. Contrast-enhanced computed tomography showed thrombus in the left superior pulmonary vein stump. He received mechanical thrombectomy and had a good postoperative course. The retrieved embolus was macroscopically red thrombus and histological examination revealed that the embolus consisted of fibrin and erythrocyte-rich thrombus. Thrombus formation in a pulmonary vein stump after lung resection may be an embolic source of AIS. Mechanical thrombectomy and anticoagulation is effective for the treatment of this pathology.

Keywords: mechanical thrombectomy, acute ischemic stroke, left pneumonectomy, left superior pulmonary vein stump, histological features

Introduction

Pulmonary vein thrombosis is a rare disease but can cause severe complications. Thrombus can be formed in a pulmonary vein stump after lung resection. It is commonly asymptomatic, but sometimes causes peripheral embolism including acute ischemic stroke (AIS), and this entity is getting known to respiratory surgeons.1) However, macroscopic and histological features of the embolus is poorly documented.

We report a case of mechanical thrombectomy for AIS with an embolus from the pulmonary vein stump after left pneumonectomy and present the features of the retrieved thrombus.

Case Report

A 67-year-old man without atrial fibrillation was admitted with sudden onset of severe left hemiparesis. He underwent a left pneumonectomy for asymptomatic lung cancer 11 days before the onset of hemiparesis with an uneventful postoperative course. He had a history of right occipital lobe infarction of undetermined etiology, but he recovered from it without any sequela, and clopidogrel was chosen for the secondary prevention. He also had a history of hypertension, dyslipidemia and hyperuricemia. For the past 30 years he had been smoking 20 cigarettes per day. Physical examination revealed that the blood pressure and heart were normal. His consciousness level was Japan Coma Scale 1 and he was presented with severe left hemiparesis and sensory disturbance involving face and left unilateral spatial neglect with the National Institute of Health Stroke Scale (NIHSS) score of 16. Laboratory studies showed no evidence of a Trousseau’s syndrome: normal platelet count and activated partial thromboplastin time, and slightly elevated PT-INR (1.23), D-dimer (3.6 μg/ml), FDP (6.7 μg/ml). Computed tomography (CT) showed an old infarction in the right occipital lobe and early ischemic changes in the right middle frontal gyrus with Alberta stroke program early CT score (ASPECTS) of 9 (Figs. 1A and 1B). Contrast-enhanced CT indicated the right middle cerebral artery (MCA) occlusion and demonstrated no evidence of aortic dissection (Fig. 1C). A contrast defect in the left superior pulmonary vein stump was also presented, which were not recognized as a significant finding at that time. He was diagnosed as right MCA occlusion with clinical-imaging mismatch and received mechanical thrombectomy. Intravenous alteplase was contraindication because he underwent thoracotomy 11 days before.

Digital subtraction angiography (DSA) revealed that the right MCA was occluded at the proximal site of the superior trunk (Fig. 1D). A Trevo XP ProVue Retriever (Stryker, Kalamazoo, MI, USA), 4 × 20 mm2, was deployed across the occluding lesion from the superior trunk to the M1 segment and the embolus was retrieved with standard techniques. The thrombolysis in cerebral infarction score was 3 and there were no stenotic lesions indicating atherosclerosis (Fig. 1E). The retrieved embolus was macroscopically red thrombus (Figs. 2A and 2B). His symptoms including hemiparesis, sensory disturbance and unilateral spatial neglect improved.
immediately after recanalization post-operative CT showed no hemorrhagic change and NIHSS score improved to 0. Histological examination with hematoxylin–eosin staining and Elastica-Masson staining revealed that the retrieved embolus consisted of both fibrin and erythrocyte-rich thrombus (Figs. 2C–2F). No tumor cells were observed in the thrombus.

To further analyze the embolic source, transesophageal echocardiography was performed 6 days after thrombectomy, and a thrombus in the left superior pulmonary vein stump was detected (Fig. 3A). Contrast-enhanced CT at hospital arrival was assessed retrospectively and the thrombus was detected in the same location as a contrast defect (Fig. 1C). Anticoagulation therapy with heparin and warfarin was started. Follow-up transesophageal echocardiography 18 days after thrombectomy and contrast-enhanced CT 19 days after thrombectomy demonstrated that the thrombus completely disappeared (Figs. 3B and 3C). He was discharged.
to home 49 days after thrombectomy with NIHSS score of 0 and modified Rankin Scale of 1 due to a little weakness of left hand movement.

**Discussion**

We reported a rare case of AIS arising from the pulmonary venous thrombosis after left pneumonectomy. The embolus was removed by mechanical thrombectomy. It was a red thrombus confirmed by histologically analyses. After anticoagulation, the pulmonary venous thrombus disappeared, and post-operative course was uneventful.

Thrombus formation in the pulmonary vein stump after pulmonary resection has recently been identified as a cause of systemic thromboembolism including AIS. Blood stasis and disturbed stagnant flow in the pulmonary vein stump have been implicated as the cause of pulmonary vein thrombosis.\(^3\) Ohtaka et al. reported that thrombus formation was observed specifically in the left superior pulmonary vein after lung resection involving the left upper lobe. This could be explained by the fact that the intrapericardial left superior pulmonary vein is anatomically longer than the other pulmonary veins and the length of its stump after left upper lobectomy was significantly longer than the other pulmonary vein stumps.\(^3,4\)

So far, 13 cases of embolic stroke with thrombus in the pulmonary vein stump (Table 1) were reported previously.\(^5–15\)

Two cases were transient ischemic attack and 11 were cerebral infarction. In all cases, lung resection involving the left upper

![Fig. 3](image)

**Fig. 3** Post-operative findings of the imaging studies. Transesophageal echocardiography 6 days after thrombectomy (A) shows thrombus (arrow) in the left superior pulmonary vein stump. Transesophageal echocardiography 18 days after thrombectomy (B) and contrast axial computed tomography 19 days after thrombectomy (C) reveal complete disappearance of the thrombus.

| Author (year) | Age | Sex | Diagnosis | Primary lung disease | Operative procedure | Interval | Location of the thrombus | Atrial fibrillation | Treatment for cerebral ischemia | Reference |
|---------------|-----|-----|-----------|----------------------|---------------------|---------|--------------------------|-------------------|-----------------------------|-----------|
| Schwalm (2004) | 73  | M   | TIA       | LC                   | LUL                 | 20 days | LSPV                    | None              | Medication                  | [5]       |
| Ohtaka (2012)  | 66  | M   | CI        | LC                   | LUL                 | 18 months | LSPV                  | None              | Medication                  | [6]       |
| Gual-Caplonch (2013) | 70  | M   | CI        | LC                   | LUL                 | 7 years  | LSPV                   | None              | Medication                  | [7]       |
| Ohira (2013)   | 46  | F   | CI        | LC                   | LUL                 | 6 months  | LSPV                   | None              | Medication                  | [8]       |
| Asai (2014)    | 76  | F   | TIA       | Mets                 | LUDS                | 2 days    | LSPV                   | None              | Medication                  | [9]       |
| Ikeda (2014)   | 58  | M   | CI        | LC                   | LUL                 | 2 days    | LSPV                   | None              | Thrombectomy                | [10]      |
| Umeda (2015)   | 69  | M   | CI        | LC                   | LUL                 | 15 months | LSPV                  | None              | Medication                  | [11]      |
| Yamamoto (2016)| 70  | M   | CI        | LC                   | LUL                 | 1 day     | LSPV                   | None              | Medication                  | [12]      |
| Yamamoto (2016)| 68  | M   | CI        | LC                   | LUL                 | 9 days    | LSPV                   | None              | Medication                  | [12]      |
| Yamamoto (2016)| 55  | M   | CI        | LC                   | LUL                 | 3 days    | LSPV                   | None              | Medication                  | [12]      |
| Haga (2017)    | 73  | F   | CI        | LC                   | LUL                 | 3 days    | LSPV                   | None              | Medication                  | [13]      |
| Kobayashi (2017)| 66  | M   | CI        | LC                   | LUL                 | 1 day     | LSPV                   | None              | Medication                  | [14]      |
| Nakano (2017)  | 77  | F   | CI        | LC                   | LUL                 | 8 days    | LSPV                   | None              | Medication                  | [15]      |
| Present case   | 67  | M   | CI        | LC                   | LP                  | 11 days   | LSPV                   | None              | Thrombectomy                | –         |

CI: cerebral infarction; F: female; LC: lung cancer; LP: left pneumonectomy; LUL: left upper lobectomy; LUDS: left upper division segmentectomy; LSPV: left superior pulmonary vein; M: male; Mets: metastatic tumor; TIA: transient ischemic attack.
lobe were performed for malignant lung tumor. Nine cases had embolism in the early post-operative period and remaining had embolism after more than 6 months. Thrombus was detected in the left superior pulmonary vein stump by contrast-enhanced CT in all cases. All patients did not have a history of atrial fibrillation. Ikeda et al.\cite{10} reported a case treated by aspiration of the thrombus with Penumbra System, and the others were treated by medication. Our case is the first case treated by mechanical thrombectomy with a stent retriever.

Although thrombus in this pathology has been suspected as red thrombus because of its formation mechanism, no previous report documented the characteristics of the embolus. This is the first report to illustrate macroscopic and histological features of the embolus in this pathology to our knowledge. Our histological analyses revealed that the embolus arising from the left superior pulmonary vein was fibrin and erythrocyte-rich (red) thrombus. In this regard, anticoagulation with heparin and warfarin should be effective as a thrombolytic therapy. Moreover, our case developed thromboembolism even under clopidogrel treatment, suggesting this etiology should be treated by not antplatelets but anticoagulants. Direct thrombin inhibitors and direct factor Xa inhibitors are also expected to be effective. The optimal duration of anticoagulation therapy for this pathology remains unknown. However, a case of cerebral embolism 7 years after pulmonary resection was reported,\cite{71} which may suggest the necessity of indefinite anticoagulation therapy. Further studies are required to discuss detailed pathology and optimal treatments, because the duration of anticoagulation depends on the anticipated risk of recurrent thrombosis and hemorrhagic complications.

**Conclusion**

Thrombus formation in a pulmonary vein stump after lung resection can be an embolic source of AIS. The embolus is macroscopically red thrombus and histologically consisted of fibrin and erythrocyte-rich thrombus. Mechanical thrombectomy and anticoagulation is effective for the treatment of this pathology.

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**Conflicts of Interest Disclosure**

All authors have no conflict of interest.

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