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# Severe acute ischaemic stroke early after wedge resection in middle-aged patients: analysis and endovascular treatment

Chong Zhang, Di Meng, Jinming Xu, Jinlin Cao and Jian Hu,

Department of Thoracic Surgery, The First Affiliated Hospital, Zhejiang University School of Medicine, Hangzhou, China

\* Corresponding author. Department of Thoracic Surgery, The First Affiliated Hospital, Zhejiang University School of Medicine, 79 Qingchun Road, Hangzhou 310003, China. Tel: 86-0571-87236847; e-mail: haiyanzhangchong@163.com (J. Hu).

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## Abstract

Severe acute ischaemic stroke early after wedge resection is very rare in healthy middle-aged patients. Here, we reviewed the data and characteristics of 9 cases. The infarction resulted from embolism in intracranial arteries, severely impacting the quality of life. In the first 2 patients, the onset symptom was confused with residual anaesthetic effects early after surgery. Drawing from the initial 2 cases, the following 7 patients received accurate diagnosis and emergent endovascular thrombus aspiration with good outcome due to immediate reperfusion. Furthermore, we discuss the principal causes of severe acute stroke in healthy middle-aged patients and the efficacy of endovascular thrombus aspiration.

**Keywords:** Stroke • Wedge resection • Endovascular thrombus aspiration

## INTRODUCTION

Perioperative acute ischaemic stroke after lobectomy or pneumonectomy is sometimes encountered, mostly in older patients with atrial fibrillation. The most common mechanisms are thrombus detachment from the stump of pulmonary vein or left atrium, paradoxical embolism from deep venous thrombosis and hypercoagulability-induced thrombosis in high-risk older patients [1]. Severe acute stroke caused by cerebral artery occlusion early after simple wedge resection is very rare in healthy middle-aged patients, which unfortunately results in permanent neurological disability or death. The clinical records of these patients in our centre were reviewed. We explored the possible mechanism and proposed an effective team approach for promptly diagnosis and treatment with this clinical entity.

## PATIENTS AND METHODS

We retrospectively reviewed 9 cases of middle-aged patients with cerebral artery occlusion after wedge resection. Wedge resection was performed in early sequence on the operation day. Severe stroke occurred within 24 h after surgery, sometimes only several hours. The clinical characteristics of these patients were analysed (Table 1).

Nine patients developed severe acute cerebral artery occlusion after wedge resection between September 2016 and December 2020. The total number of wedges made in our medical centre was 7917. Nine patients had severe acute ischaemic stroke early

after wedge surgery. In our series, the percentage corresponds to the total number of wedges made in the same period is about 0.11. Nine patients (8 females, 1 male) were all healthy middle-aged (mean age: 51.2 years; range: 41–61 years). They received standard wedge resection and lymph node sampling with triple ports in 3 patients and uniport in 6 patients. The operation time ranged from 29 to 75 min, and blood loss ranged from ~10 to 50 ml. Three patients underwent right upper wedge resection, all were double wedge resections. Two patients underwent right lower wedge resection, 1 patient underwent left upper wedge resection and 3 patients underwent left lower wedge resection. No patients had perioperative atrial fibrillation. Preoperative electrocardiography, echocardiography, ultrasonography of limb veins, ultrasonography of carotid and cerebral arteries and cerebral magnetic resonance imaging were normal.

The onset of cerebral infarction occurred between 5 and 25 h postoperatively. Six patients had middle cerebral artery occlusion, 2 had posterior cerebral artery occlusion and 1 had C7 segment occlusion of the internal carotid artery. The occlusion location was M1 segment of right middle cerebral artery (4 patients), M1 segment of left middle cerebral artery (2 patients), P1 segment of right posterior cerebral artery (1 patient), P1 segment of left posterior cerebral artery (1 patient) and C7 segment of right internal carotid artery (1 patient). The first patient did not receive interventional treatment, other 8 patients received endovascular thrombus aspiration.

The limited experience and lack of awareness of cerebral infarction after wedge resection resulted in severe complications and sequelae in the first 2 patients. The onset symptom of the

**Table 1:** Characteristics of patients with severe acute ischaemic stroke early after lung wedge resection

| Characteristics/patients             | 1                   | 2   | 3                      | 4                      | 5                                 | 6                            | 7             | 8                      | 9                                 |
|--------------------------------------|---------------------|---|------------------------|------------------------|-----------------------------------|------------------------------|---------------|------------------------|-----------------------------------|
| Age (years)                          | 52                  | 48  | 61                     | 48                     | 48                                | 53                           | 59            | 41                     | 51                                |
| Gender                               | F                   | F   | F                      | F                      | F                                 | M                            | F             | F                      | F                                 |
| Nodule location                      | RUL                 | RLL   | LLL                    | RUL                    | RLL                               | LLL                          | LLL           | LUL                    | RUL                               |
| Wedge                                | 2                   | 1   | 1                      | 2                      | 1                                 | 1                            | 1             | 1                      | 2                                 |
| Operation time (min)                 | 72                  | 64  | 52                     | 51                     | 75                                | 57                           | 29            | 74                     | 51                                |
| Blood loss (ml)                      | 20                  | 20  | 10                     | 10                     | 20                                | 50                           | 10            | 50                     | 20                                |
| Ports                                | Triple              | Triple  | Uniport                | Uniport                | Uniport                           | Uniport                      | Uniport       | Uniport                | Triple                            |
| Pathology                            | AIS                 | IAC   | IAC                    | IAC/MIA                | MIA                               | MIA                          | IAC           | IAC                    | IAC                               |
| AF                                   | No                  | No  | No                     | No                     | No                                | No                           | No            | No                     | No                                |
| Medical examination                  | Normal              | Normal  | Normal                 | Normal                 | Normal                            | Normal                       | Normal        | Normal                 | Normal                            |
| Sign time from surgery (h)           | 5                   | 8   | 12                     | 5                      | 8                                 | 20                           | 4             | 25                     | 24                                |
| Initial symptom                      | Somnolence          | Somnolence, dysarthria, dysphoria, hemiplegia | Dysarthria, hemiplegia | Dysarthria, hemiplegia | Hemiplegia                        | Somnolence, hemiplegia       | Somnolence    | Hemiplegia, somnolence | Dizziness, dysarthria, hemiplegia |
| Location of embolism                 | RMCA, M1            | LMCA, M1                                      | RMCA, M1               | RMCA, M1               | LMCA, M1                          | RMCA, M1                     | RPCA, P1      | RICA, C7               | LPCA, P1                          |
| Endovascular thrombus aspiration     | No                  | Yes   | Yes                    | Yes                    | Yes                               | Yes                          | Yes           | Yes                    | Yes                               |
| Aspiration time from initial symptom | -                   | 14 h  | 1 h 40 min             | 1 h                    | 2 h                               | 3 h 20 min                   | 3 h           | 4 h                    | 5 h                               |
| Interventional time                  | -                   | 1 h 17 min                                    | 42 min                 | 1 h                    | 47 min                            | 1 h 10 min                   | 38 min        | 1 h                    | 1 h 10 min                        |
| Secondary cerebral surgery           | Yes/cerebral hernia | Yes/cerebral hernia                           | -                      | -                      | -                                 | -                            | -             | -                      | -                                 |
| Foaming test                         | No                  | No  | Yes/positive           | No                     | Yes/positive                      | No                           | No            | Yes/positive           | No                                |
| Neurological outcome at discharge    | No recovery         | No recovery                                   | Full recovery          | Full recovery          | Partial recovery, mild hemiplegia | Full recovery, mild headache | Full recovery | Full recovery          | Full recovery                     |
| Hospital day                         | 33                  | 37  | 10                     | 12                     | 22                                | 13                           | 10            | 9                      | 12                                |

AIS: adenocarcinoma in situ; F: female; IAC: invasive adenocarcinoma; LLL: left lower lobe; LMCA: left middle cerebral artery; LPCA: left posterior cerebral artery; LUL: left upper lobe; M: male; MIA: minimally invasive adenocarcinoma; RICA: right internal carotid artery; RLL: right lower lobe; RMCA: right middle cerebral artery; RPCA: right posterior cerebral artery; RUL: right upper lobe; AF: atrial fibrillation.

first patient was somnolence 5 h after wedge resection, which was ascribed to the residual anaesthetic effect. Delayed diagnosis was confirmed with exacerbating symptoms. Rapid cerebral hernia emerged 15 h postoperatively and emergent bone flap craniectomy decompression was performed. After severe ventricular arrhythmia, heart arrest and cranial inflammation, the patient was rescued. One month later, the patient was discharged and transferred to other rehabilitation medical centre with no recovery from coma and hemiplegia. The symptom in the second patient occurred 8 h after wedge resection. The manifestation was mild dysarthria and dysphoria, which was ascribed to the residual anaesthetic effect. The diagnosis of cerebral ischaemic stroke was confirmed when the patient developed hemiplegia. Fourteen hours later, she underwent endovascular thrombus aspiration for M1 segment occlusion of left middle cerebral artery. Secondary cerebral hernia unfortunately developed and bone flap craniectomy decompression was performed on the next day. Twenty-seven days later, the patient was discharged with no recovery from dysarthria and hemiplegia.

Drawing from these 2 cases, other 7 patients were successfully managed. In these cases, the onset time of initial symptom ranged from 4 to 25 h after wedge surgery. We suspected stroke and immediately diagnosed cerebral artery occlusion with cerebral computed tomography angiography (Fig. 1A). One to five hours later, interventional cerebral thrombus aspiration was performed, which ranged from 38 min to 1 h 10 min. The thrombus was fresh red thrombus (Fig. 1B). No cerebral hernia developed and no bone flap craniectomy decompression was needed. Six patients were discharged with full recovery and 1 patient with only mild hemiplegia. The hospital stays from intervention to discharge ranged from 5 to 11 days for 6 patients and 1 was 20 days.

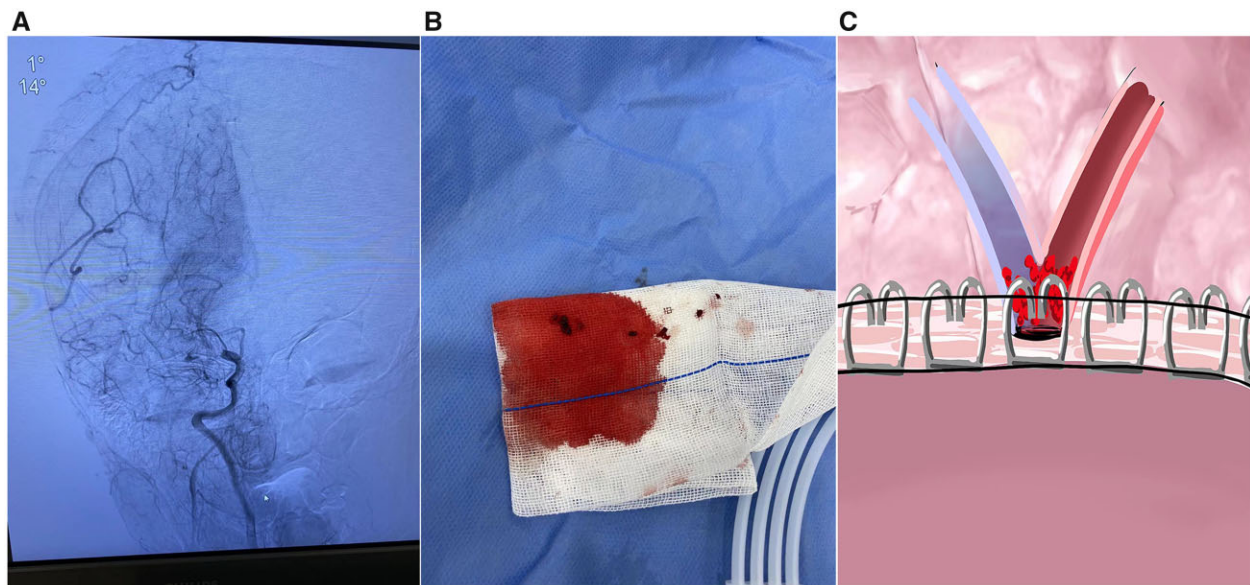
Nine patients had no perioperative atrial fibrillation and congenital cardiac deformities. Three patients received foaming tests with transoesophageal echocardiography and used hand vibrated

saline, which demonstrated left atrial bubbles originating from the pulmonary vein flowed into the left ventricle.

## DISCUSSION

The incidence of acute ischaemic stroke after pulmonary surgery is low. Atrial fibrillation and ageing are regarded as the risk factors [2]. Cerebral infarction often occurs during lobectomies or pneumonectomies, especially left upper lobectomy with longer stump [3–5]. Blood flow stagnation and turbulence accelerate thrombus formation [6]. However, severe acute stroke in middle-aged patients early after wedge resection is very rare.

Nine healthy middle-aged patients in our centre developed severe acute cerebral artery occlusion after wedge resection, which led us to explore the possible reasons. The common characteristics were almost middle-aged female, early surgery sequence and wedge procedure. Hypercoagulability and pulmonary artery–vein terminal circuit were the possible factors. Compared with men and older women, middle-aged women tend to menopause in stage of rapid oestrogen depletion, which leads to higher coagulability [7]. Patients with earlier surgery sequence have hypercoagulability due to fasting 1 night before surgery [8]. The patterns of lung tissue cutting and closing in wedge procedure might develop fistula circuit between terminal pulmonary artery and vein. In wedge resection, we considered the risk of severe acute ischaemic stroke early after surgery is rather higher in deep nodule than in shallow nodule according to our retrospective clinical cases and analytical hypothesis. When inappropriate cartridge moulding causes bleeding and fresh hypercoagulated thrombus is coincidentally formed in the fistula circuit (Fig. 1C). Unfortunately, the thrombus drops and flows from the pulmonary vein into the cerebral artery. The positive result of foaming test showed the possible existence of fistula circuit between the terminal pulmonary artery and vein suspected by inappropriate moulding tightness during wedge resection. To prevent the possibility of hypercoagulability and microthrombosis, we now



**Figure 1:** (A) Main cerebral artery occlusion with cerebral computed tomography angiography; (B) fresh red thrombus was aspirated by emergent interventional endovascular treatment; and (C) the patterns of lung tissue cutting and closing in wedge procedure might develop fistula circuit between terminal pulmonary artery and vein. When inappropriate cartridge moulding cause bleeding and fresh hypercoagulated thrombus is coincidentally formed in the fistula circuit.

intravenously inject at least 500 ml fluid early in the surgery morning. The most appropriate thick cartridge was selected to avoid local bleeding and fistula circuit formation. Since new practice, acute ischaemic stroke has not developed after wedge resection in our centre.

Except 2 patients, other 7 patients received endovascular thrombus aspiration promptly and had good neurological prognosis. The advent of strategy has resulted in drastic success in stroke management [9]. The recanalization rate is high as 81.6% with better neurological improvement and lower adverse effects compared with traditional treatment [10]. Nowadays, if sudden dysarthria, somnolence or hemiplegia suspected after surgery in our centre, onsite consultation with anaesthetist and neurologist must be undertaken. If residual anaesthetic effect is excluded, the next step is one-stop ischaemic stroke and thrombolysis-specific CT examination. When cerebral artery occlusion is diagnosed, emergent endovascular thrombosis aspiration should be performed. The golden time from initial symptom to intervention is no more than 4 h for best neurological prognosis. We consider thrombus aspiration efficacious for treating acute ischaemic stroke and neurological outcomes are also satisfactory.

## CONCLUSIONS

Endovascular thrombus aspiration is a promising strategy for acute ischaemic stroke after thoracic surgery to improve neurological outcomes. Our strategy for avoid hypercoagulation, appropriated cartridge selection, early stroke recognition, diagnostic cerebral imaging and emergent intervention is essential for achieving best neurological prognosis.

**Conflict of interest:** none declared.

## Reviewer information

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