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Medical thoracoscopy combined with argon plasma coagulation as an alternative treatment for intractable pneumothorax: a retrospective study

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Abstract

Background A significant proportion of patients with pneumothorax who do not tolerate surgery develop intractable pneumothorax after prolonged failure of conservative treatment. This significantly lengthens the duration of hospitalization and patients' quality of life. As the application of medical thoracoscopy (MT) in the management of pleural diseases is explored, MT combined with argon plasma coagulation (APC) may be an alternative option for the treatment of intractable pneumothorax.

Methods A retrospective analysis was conducted on thirteen patients with intractable pneumothorax whose duration of the air leak exceeded seven days and subsequently treated with MT combined with APC at West China Hospital of Sichuan University. Under MT, we first dissected the pleural adhesions with an electrocautery knife, probed for the rupture located in the pulmonary bullae or pleural and cauterised it with APC. Subsequently, all pulmonary bullae were cauterised and human fibrin sealant was sprayed locally on the cauterised surface. Preoperative, intraoperative, and more than one year of postoperative follow-up information was collected from these patients. We divided the patients into two groups with and without detected ruptures treated under MT to compare the overall efficacy and safety of this treatment.

Results All patients had pulmonary comorbidities and the median duration of the current pneumothorax episode before MT treatment was 30 days. Nine patients had a history of recurrent pneumothorax episodes, two of whom had been treated with video-assisted thoracoscopic surgery (VATS). Regarding efficacy, the overall median time of time to air leak cessation was 2.5 days, with 2 days in the group with detected ruptures treated and 5 days in the group without detected ruptures treated, and the overall median time of time to chest tube removal was 6 days, with 4 days

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in the group with detected ruptures treated and 7 days in the group without detected ruptures treated. Regarding safety, only 2 patients experienced postoperative adverse events of fever and chest pain.

Conclusions For intractable pneumothorax patients with pleural adhesions that may limit lung re-expansion, who are not candidates for surgery, MT combined with APC can be an alternative treatment option.

Keywords Medical thoracoscopy, Argon plasma coagulation, Treatment, Intractable pneumothorax

Introduction

The British Thoracic Society (BTS) guidelines on pleural disease recommends that in cases of persistent air leak or failure of lung re-expansion, an early thoracic surgical consultation should be sought within 3–5 days [1]. Similarly, the American College of Chest Physicians guidelines (ACCP) on spontaneous pneumothorax suggested treatment with a chest tube for up to 4 days to allow for spontaneous closure of the fistula. If the persistent air leak persists beyond 4 days, patients should be evaluated for surgical intervention to close the air leak [2]. In China, we define various types of pneumothorax as intractable pneumothorax when air leak persists after 7 days of chest tube drainage [3]. Pleural adhesions are an independent risk factor for intractable pneumothorax [4, 5, 6]. Limited lung re-expansion and continuous traction of the rupture in visceral pleura due to pleural adhesions are important causes of intractable pneumothorax. For intractable pneumothorax patients who are not candidates for surgery and unresponsive to chest tube drainage, there remains a lack of alternative treatment options or expert consensus on best practices.

Medical thoracoscopy (MT) is well known as a diagnostic operation with applications in unexplained pleural effusion, diffuse malignant pleural mesothelioma and lung cancer staging. In the therapeutic field, however, it has not been exploited nearly enough. MT allows for the direct visualization of the entire pleural cavity, enabling the biopsy of abnormal tissues. It also facilitates the dissection of pleural adhesions and the management of ruptures and pulmonary bullae. Argon plasma coagulation (APC) is a well-established technology that already exists in several disciplines. It does not involve contact with the wound during the procedure and can control large areas of blood leakage in a short period. Therefore, for this subset of patients for whom conservative treatment is ineffective but cannot tolerate surgery, the combination of APC and MT is a potentially beneficial treatment modality.

Methods

Study design

This is a retrospective analysis of thirteen intractable pneumothorax patients treated with MT in West China Hospital of Sichuan University from 1 March, 2022 to 31 January, 2024. The study was approved by the Ethics Committee of West China Hospital, Sichuan University and the requirement for informed consent was waived due to the retrospective nature of the study. Inclusion criteria were patients: (1) older than 18 years; and (2) who suffered from pneumothorax diagnosed on chest computed tomography (CT); and (3) who had a chest CT scan within 7 days before MT procedure showing suspected pleural adhesions that may limit lung re-expansion; and (4) who had been treated with MT; and (5) who had been treated with chest tube drainage (>26 F in size) for more than 7 days before receiving MT treatment; and (6) who had treated with high-volume low-pressure suction for more than 48 h before received MT treatment. Exclusion criteria included: (1) Air leak duration uncertain; and (2) Diagnosis of underlying lung condition uncertain; and (3) who had pyopneumothorax.

Device

Semi-flexible Medical Thoracoscope (LTF 240, OLYMPUS), electrocautery knife (KD-31 C-1, OLYMPUS), electrosurgical unit (VIO 200D, ERBE), argon plasma coagulator (APC2, ERBE), APC probe (20132-221, ERBE) and human fibrin sealant kit (Shanghai RAAS Blood Products Co., Ltd.)

Procedure

Preoperative preparation

Preoperative assessments included a complete blood count, blood biochemistry, arterial blood gas analysis, disseminated intravascular coagulation screening, coagulation function tests, and liver and renal function tests (**Supplemental Table**). Preoperative CT scans (Figs. 1A and B and 2A and B) were performed to determine the location of the pneumothorax, assess pleural adhesions, and identify the optimal puncture site.

Medical thoracoscopy operation

Patients were positioned either in the lateral decubitus (healthy side down) or supine position. Intravenous dexmedetomidine and sufentanil were used for sedation and analgesia. 5–10 ml of 2% lidocaine was administered for local anesthesia. Based on CT landmarks, the surgical site was selected over the suspected area of rupture or bullae. A 1.0 cm incision was made at the second intercostal space along the midclavicular line for upper ruptures, and at the 5th to 8th intercostal spaces along the anterior, middle, or posterior axillary line for middle and lower ruptures following disinfection and draping. The subcutaneous and muscle layers were bluntly dissected with vascular forceps to access the pleural cavity, after which the trocar was inserted. A medical thoracoscope was then introduced through the trocar cannula into the pleural cavity.

First, a routine examination of the pleural cavity was performed, including the visceral, parietal, and diaphragmatic pleura. We then dissected any pleural adhesions using an electrocautery knife (power 55 W) (Fig. 2C and D). The chest cavity was inspected for lung bullae, noting their location and number if present. Suspected ruptures in the lung bullae or pleura were carefully probed, and any identified rupture was cauterized using APC (power 40 W). In cases where bullae were found, APC cauterization was performed on the bullae as well (Fig. 1C and D). Finally, the cauterized surface was sprayed locally with human fibrin sealant.

Postoperative monitoring

The chest tube was clamped shut for 24–48 h after stopping air leak. The chest tube was removed if chest CT (Figs. 1E and F and 2E and F) confirmed air absorption of pneumothorax. The time to air leak cessation and the time to chest tube removal were recorded for each person. Postoperative adverse events including haemorrhage, fever, cough, chest pain, shortness of breath, or lung infection were documented.

Follow-up

Postoperative patients were followed up via telephone at one-month intervals to assess survival status and to determine whether they had been readmitted due to recurrent pneumothorax.

Results

Baseline characteristic

The main symptoms reported by the patients were cough, chest pain, and shortness of breath. The median age of the population was 56.9 years, and the median body mass index was 19.5 kg/m^2. Among the 13 patients, 12 were male, and 7 had a history of smoking. All patients had comorbidities at the time of the pneumothorax episode. Specifically, 3 patients had chronic obstructive pulmonary disease (COPD), 3 patients had pneumoconiosis, 3 patients had hypertension, 3 patients had diabetes, and 3 patients had coronary artery disease. On chest CT scan within seven days prior to MT procedure, 4 patients (No.1, No.4, No.5, No.12) did not have pleural effusion or pleural thickening, while all other patients had both pleural effusion and pleural thickening. 9 patients had a history of recurrent pneumothorax, two of whom had previously undergone video-assisted thoracoscopic surgery (VATS). The median duration of the current pneumothorax episode before MT treatment was 30 days (Table 1).

Procedure finding

Under MT, pleural adhesions were observed in all patients. Ruptures were observed in 6 patients (2 patients on the visceral pleura and 4 patients on the pulmonary bullae) and pulmonary bullae were observed in 8 patients.

Efficacy and safety

During the follow-up period, patient No.5 died at the twenty-ninth month of follow-up due to COVID-19 and patient No.7 died at the third month of follow-up due to lung cancer. For Patient No. 7, the chest tube had not been removed at the time of discharge, and his time to air leak cessation and time to chest tube removal was missing during his follow-up. The remaining patients survived. Although one patient experienced a recurrence of pneumothorax in the fifth month after treatment, the rest of the patients remained free of recurrence during at least one year of follow-up. The overall survival rate was 84.6% and the recurrence rate was 7.7%. As the management of patients varied based on the findings observed under MT, we divided the patients into two groups: those in whom no rupture was detected and those in whom a rupture was detected. The survival rates of the rupture detected and no rupture detected groups were 83.3% and 85.7%, respectively. The recurrence rates of the rupture detected and no rupture detected groups were 0 and 14.3%, respectively.

The overall median time of time to air leak cessation was 2.5 days and the overall median time of time to chest tube removal was 6 days. The median time to air leak cessation was 2 days in the group with detected ruptures treated and 5 days in the group without detected ruptures treated. The median time to chest tube removal was 4 days in the group with detected ruptures treated and 7 days in the group without detected ruptures treated (Table 2). The Mann-Whitney U test was performed to compare the time to air leak cessation and the time to chest tube removal between the two groups, using SPSS software (version 25.0, IBM Corp., Armonk, NY, USA). There was a statistical difference in the time to air leak cessation ($p = 0.03$) and no statistical difference in the time to chest tube removal between the two groups ($p = 0.106$).

Regarding safety, 2 patients developed fever and chest pain after treatment. No other patients experienced postoperative adverse events including fever, chest pain, dyspnoea, or pulmonary infection.

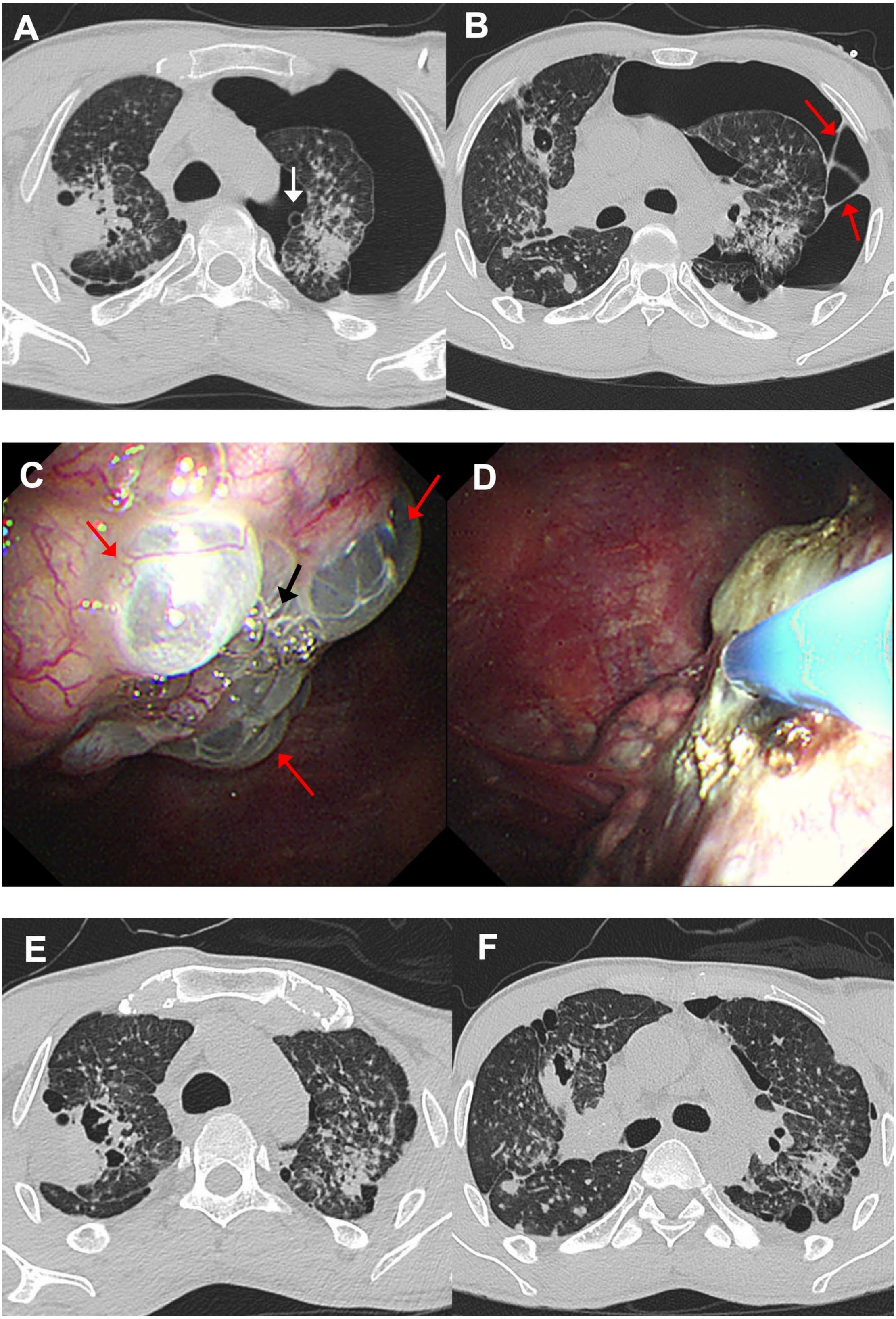

Fig. 1 Patient No.2's MT procedure and preoperative/postoperative CT. **A**, **B** Preoperative CT, the white arrow indicates the pulmonary bulla and red arrows indicate pleural adhesions. **C** MT procedure, red arrows indicate pulmonary bullae and the black arrow indicates bubbles spilling out of the rupture. **D** MT procedure, cauterisation of the rupture and peripheral pulmonary bullae with APC. **E**, **F** Postoperative CT confirmed lung re-expansion. APC, argon plasma coagulation. CT, computed tomography. MT, medical thoracoscopy

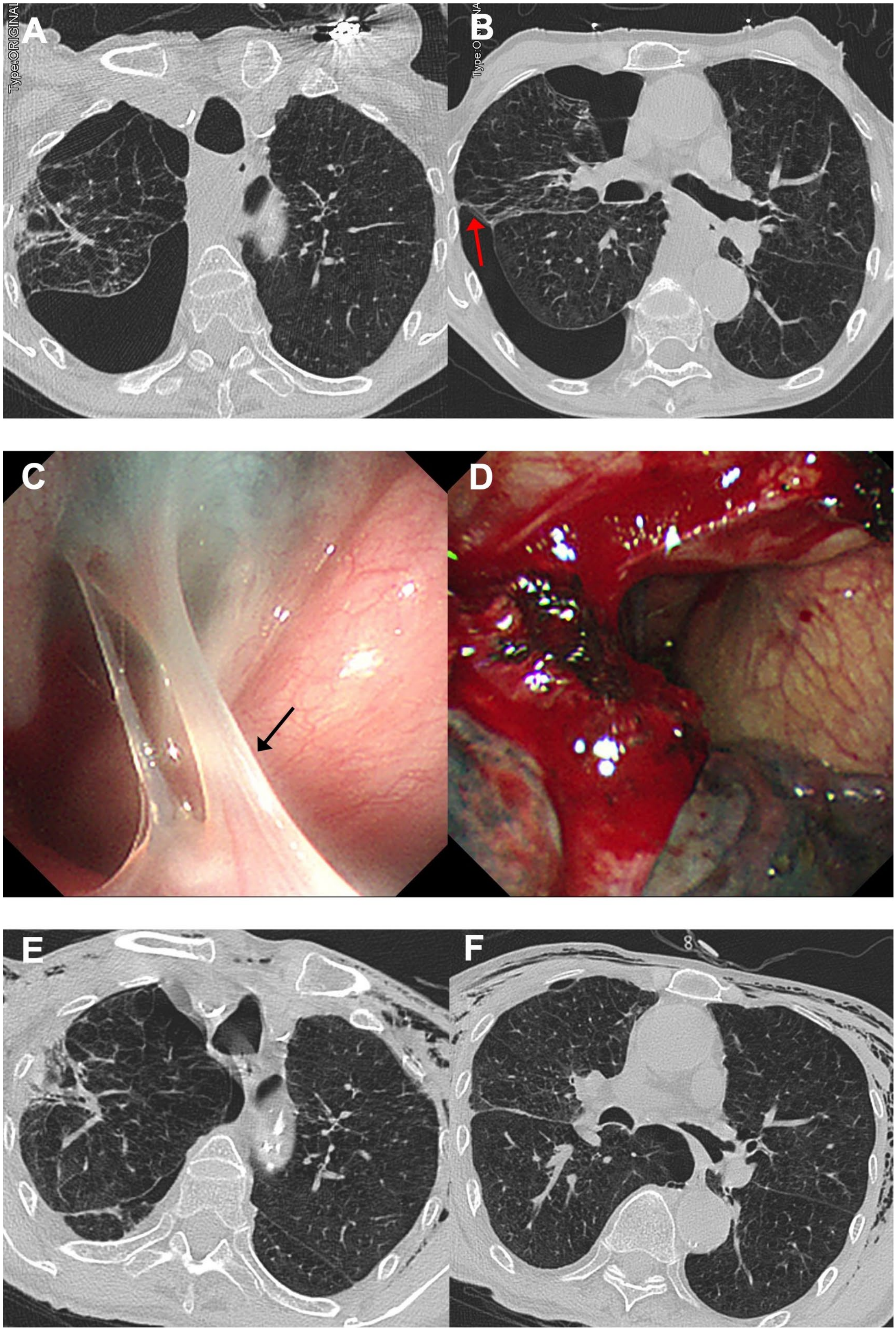

Fig. 2 Patient No.5's MT procedure and preoperative/postoperative CT. **A**, **B** Preoperative CT, the red arrow indicates pleural adhesions. **C** MT procedure, the black arrow indicates pleural adhesions. **D** MT procedure, dissection of pleural adhesions with electrocautery knife. **E**, **F** Postoperative CT confirmed lung re-expansion. CT, computed tomography. MT, medical thoracoscopy

Table 1 Patient pre-treatment, treatment and post-treatment information

No.	Sex	Age (years)	Complaints	BMI (kg/m^2)	Smoking (pack-year)	Course (days)	Chest tube size	Comorbidities	Recurrence before MT	Presentations under MT	Location of the rupture	Diameter of rupture (mm)	Time to air leak cessation (days)	Time to chest tube removal (days)	Follow-up time (months)
1	F	27	No symptom	16.4	0	45	26 F	Pulmonary tuberculosis	None	Pleural adhesions, rupture	Left upper lobe	2	3	4	31
2	M	34	Cough, chest pain, shortness of breath	17.5	18	30	26 F	NTM	None	Pleural adhesions, rupture, bullae	Left upper lobe	1	2	5	37
3	M	65	Cough, chest pain, shortness of breath	NA	50	70	26 F	Coronary artery disease, COPD	Pneumothorax 10 years ago, treated with chest drainage	Pleural adhesions, rupture	Left upper lobe	3	1	3	29
4	M	68	Cough, shortness of breath	22.3	0	40	28 F	COPD, Parkinson's disease	Five relapses, the latest 4 months ago, treated with chest drainage	Pleural adhesions, bullae	-	-	39	41	18
5	M	80	Cough, shortness of breath	NA	0	30	28 F	Coronary artery disease, COPD, hypertension	Pneumothorax 3 years ago, treated with chest drainage	Pleural adhesions	-	-	7	8	29
6	M	36	Cough, shortness of breath	22.5	0	130	28 F	Pneumoconiosis, coronary artery disease	None	Peural adhesions	-	-	5	7	30
7	M	73	Cough, chest pain, shortness of breath	23.4	NA	45	28 F	Hypertension, COPD, lung cancer, asthma	None	Pleural adhesions, rupture, bullae	Left lower lobe	3	NA	NA	3
8	M	47	Shortness of breath	17.1	0.5	9	26 F	Hypertension	Four relapses, the latest 20 days ago, treated with chest drainage	Pleural adhesions, bullae	Right upper lobe	-	5	7	18
9	M	62	Shortness of breath, haemoptysis	24.2	38	7	28 F	Diabetes, hypertension, hyperlipidemia	Two relapses, the latest 4 years ago, treated with VATS	Pleural adhesions, bullae	Left lower lobe	-	12	14	16
10	M	66	Cough, shortness of breath	19.5	7.5	7	28 F	COPD, tuberculosis	Three relapses, the latest 6 months ago, treated with chest drainage	Pleural adhesions, bullae	Right upper lobe	-	2	4	10
11	M	59	Cough, chest pain	17.3	0	8	28 F	Pneumoconiosis	Four relapses, the latest 2 months ago, treated with chest drainage	Pleural adhesions, rupture, bullae	Left upper lobe	1	2	8	19

Table 1 (continued)

No.	Sex	Age (years)	Complaints	BMI (kg/m^2)	Smoking (pack-year)	Course (days)	Chest tube size	Comorbidities	Recurrence before MT	Presentations under MT	Location of the rupture	Diameter of rupture (mm)	Time to air leak cessation (days)	Time to chest tube removal (days)	Follow-up time (months)
12	M	60	Cough, shortness of breath	17.6	30	16	28 F	COPD	Nine relapses, the latest 4 years ago, treated with VATS 2 months ago	Pleural adhesions, rupture, bullae	Left upper lobe	1	1	3	10
13	M	60	Cough, chest pain, shortness of breath	19.7	0	31	28 F	Hypertension, pneumoconiosis	Pneumothorax 1 months ago, treated with chest drainage	Pleural adhesions	Left upper lobe	-	2	4	10

BMI, body mass index. COPD, chronic obstructive pulmonary disease. MT, medical thoracoscopy. NTM, non-tuberculous Mycobacteria

Discussion

For intractable pneumothorax, the best management strategy is controversial and there is a lack of effective interventions [7]. While MT is mainly used for diagnosing pleural diseases, its therapeutic potential is being increasingly recognised. Emerging studies are exploring MT for managing pleural infections, bronchopleural fistulae, vanishing lung syndrome, and malignant pleural effusions [8]. In this study, we further investigate the application of MT in treating intractable pneumothorax.

In our study, the median duration of the current pneumothorax episode before MT treatment was 30 days. 9 patients (69%) had recurrent episodes of ipsilateral pneumothorax. As chest tube drainage is standard management for pneumothorax, a high-volume low-pressure suction was attempted in all of our patients before MT treatment but was ineffective. Since all patients had secondary spontaneous pneumothorax (combined with underlying lung disease), they were directly drained with a large-bore chest tube (26–28 F) on admission. Chest tube drainage, including Heimlich valve, water seal device and high-volume low-pressure suction, is associated with an increased risk of infection in patients if it is ineffective in the long term [9]. When standard management does not sufficiently resolve the air leak, surgical referral is recommended in BTS and ACCP guidelines [2, 10]. Nevertheless, the overall general condition of the patients in this study was poor. Advanced age, pulmonary comorbidities, or recurrence after VATS rendered them unable to tolerate surgery. Non-surgical options include endobronchial valve placement, chemical pleurodesis, and autologous blood patch pleurodesis [11]. However, current guidelines do not favour any single non-surgical approach [10]. In our study, pleural adhesions were observed both on pre-procedure CT scans and during the MT procedure, further limiting interventional options. Therefore, after a comprehensive assessment, the patient underwent MT treatment. The overall median time to air leak cessation was 2.5 days and the overall median time to chest tube removal was 6 days in the study population. The overall survival rate was 84.6% and the recurrence rate was 7.7%. Notably, patients with a history of multiple pneumothorax recurrences did not relapse during the follow-up period after treatment with MT.

A previous study has explored the possibility of treating pneumothorax with APC under MT. Zhang Lei et al. treated three COPD patients with pneumothorax by using APC to coagulate the pulmonary bullae under MT [12]. We expanded upon them by enrolling additional patients with intractable pneumothorax whose cause of pneumothorax was not limited to COPD. In our study, for patients in whom ruptures were found in the pleura or pulmonary bullae, we first dissected the adhesions, cauterised the ruptures with APC and then sprayed

Table 2 Efficacy comparisons between the two groups

	The median time to air leak cessation (days)	The median time to chest tube removal (days)	1-year Survival Rate (%)	1-year Recurrence Rate (%)
Rupture detected (6)	2	4	83.3	0
No rupture detected (7)	5	7	85.7	14.3
Overall (13)	2.5	6	84.6	7.7

human fibrin sealant, and this treatment method proved to be effective. In patients where no rupture was found, simply dissecting the adhesions with an electrocautery knife could also promote lung re-expansion and achieve a good therapeutic effect.

There are also limitations to our study. First, the sample size was relatively small. Second, as a retrospective study, it lacked comprehensive patient data. Despite these limitations, our findings demonstrate the feasibility of MT combined with APC for treating intractable pneumothorax. To validate these results, we are currently conducting a prospective study with a larger sample size to provide more robust evidence.

Conclusion

With the advantage of direct view of the thoracic cavity, MT can observe and deal with rupture and pleural adhesions under MT. For intractable pneumothorax patients with pleural adhesions that may limit lung re-expansion, who are not candidates for surgery, MT combined with APC can be an alternative treatment.

Abbreviations

APC	Argon plasma coagulation
ACCP	The American College of Chest Physicians
BTS	The British Thoracic Society
COPD	Chronic obstructive pulmonary disease
CT	Computed tomography
MT	Medical thoracoscopy
VATS	Video-assisted thoracoscopic surgery

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12931-025-03255-0.

Supplementary Material 1

Acknowledgements

Not applicable.

Author contributions

Dan Liu, Panwen Tian and Kaige Wang designed the study. Rui Xu and Kaige Wang collected clinical data, created the figure, and wrote the manuscript. Kaige Wang and Jingyu Shi performed medical thoracoscopy treatment on patients. All authors read and approved the final manuscript.

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Data availability

All data generated or analysed during this study are included in this published article [and its supplementary information files].

Declarations

Ethics approval and consent to participate

The study was performed in accordance with the declaration of Helsinki and was approved by the ethic committee of the West China Hospital of Sichuan University (No. 2023 – 1636). Written informed consent was waived approved by the ethic committee of the West China Hospital of Sichuan University due to the retrospective noninterventional design.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Clinical trial number

Not applicable.

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