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Efficacy of medical thoracoscopy combined with fibrinolytic therapy in the treatment of complicated parapneumonic effusions and empyema

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Abstract

Objective This study aimed to evaluate the clinical efficacy, safety, and feasibility of medical thoracoscopy combined with fibrinolytic therapy for the treatment of complicated parapneumonic effusions and empyema, with a focus on therapeutic outcomes and recovery duration.

Methods A retrospective cohort study was conducted involving 108 patients treated at Zhongshan Hospital, Xiamen University, between January 2015 and May 2024. Patients were categorized into two groups: the medical thoracoscopy group ($n=33$) and the traditional treatment group ($n=75$). The thoracoscopy group underwent thoracoscopic adhesiolysis and loculation breakdown, followed by intrapleural urokinase administration. The traditional treatment group received pleural catheter drainage combined with urokinase therapy. Primary outcomes included changes in inflammatory markers (white blood cell count, C-reactive protein, and procalcitonin), imaging outcomes (resolution of pleural effusion, pulmonary inflammation, and the incidence of pleural thickening at three months), pulmonary function assessed by forced vital capacity (FVC), and in-hospital mortality. Secondary outcomes encompassed the duration of postoperative fever, drainage time, intravenous antibiotic use, complication rates, initial treatment failure, length of hospital stay, and hospitalization costs.

Results Both groups demonstrated significant reductions in inflammatory markers post-treatment ($P<0.05$). Pleural effusion resolution, pulmonary inflammation reduction, and the incidence of pleural thickening at three months were comparable between the groups ($P>0.05$). Improvements in FVC were observed in both groups, with significantly greater gains in the thoracoscopy group ($P<0.05$). No in-hospital mortality was reported. Compared to the traditional treatment group, the thoracoscopy group exhibited significantly lower postoperative inflammatory marker levels ($P<0.05$), alongside shorter durations of postoperative fever, pleural drainage, intravenous antibiotic use, and

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hospital stay (all $P < 0.05$). The thoracoscopy group also had a significantly lower initial treatment failure rate ($P < 0.05$). Complication rates and hospitalization costs were comparable between the groups ($P > 0.05$).

Conclusions Medical thoracoscopy combined with fibrinolytic therapy offers significant advantages in the management of complicated parapneumonic effusions and empyema. This approach effectively enhances inflammation control, improves pulmonary function, and accelerates recovery time without compromising safety or increasing costs, underscoring its potential for broader clinical application.

Keywords Complicated parapneumonic effusions, Empyema, Medical thoracoscopy, Fibrinolytic therapy, Efficacy

Introduction

Pleural diseases constitute a significant subset of respiratory disorders, with pleural effusion being the most frequently encountered pathological manifestation. In recent years, the rising incidence of pleural infections has emerged as a leading cause of pleural effusion [1, 2]. A multicenter real-world study conducted in China in 2021 reported that parapneumonic effusions and empyema accounted for 29% of all cases, underscoring the considerable prevalence and clinical burden of these conditions [3].

Pleural infections result from the invasion and proliferation of pathogens within the pleural cavity [4], progressing through three distinct clinical stages: simple parapneumonic effusion (stage I), complicated parapneumonic effusion (stage II), and empyema (stage III) [5]. Stages II and III represent advanced infections, commonly manifesting with symptoms such as fever, cough, chest pain, and dyspnea. While stage I infections typically respond well to antibiotic therapy, stages II and III often require additional invasive interventions.

The primary therapeutic objectives in managing these advanced stages include effective drainage of purulent fluid, eradication of infection, promotion of lung re-expansion, and prevention of irreversible complications, such as pleural fibrosis and organization [6]. Without timely and appropriate intervention, these infections may progress to severe, life-threatening conditions [7].

Current management strategies for pleural infections include systemic antibiotic therapy complemented by localized pleural interventions [5, 8], with fibrinolytic therapy serving a critical role in enhancing pleural drainage and improving clinical outcomes [9].

In recent years, fibrinolytic therapy has undergone significant advancements. The 2011 MIST-2 study, published in the *New England Journal of Medicine*, demonstrated that the combination of tissue plasminogen activator (tPA) and deoxyribonuclease (DNase) markedly improved pleural effusion drainage efficiency and clinical outcomes [10]. This dual-agent therapy has since been widely endorsed by international guidelines as a standard treatment for complicated pleural infections [11].

Although the tPA-DNase combination is commonly utilized, emerging research suggests that urokinase, another fibrinolytic agent, may offer comparable efficacy in specific clinical settings [12]. Moreover, urokinase has demonstrated a potentially superior safety profile, rendering it an attractive alternative in certain scenarios. However, its therapeutic effectiveness warrants further validation through large-scale, prospective multicenter cohort studies.

For patients with complicated parapneumonic effusions and empyema, closed thoracic drainage and fibrinolysis are sometimes insufficient to fully clear purulent material from the pleural cavity, necessitating additional procedural interventions [8]. Medical thoracoscopy, a minimally invasive technique, offers several distinct advantages in managing complicated pleural infections. By providing direct visualization of the pleural cavity, it facilitates the effective separation of pleural adhesions and the removal of loculations, thereby significantly improving pleural drainage.

Studies have shown that medical thoracoscopy can reduce hospital stays and minimize the use of antibiotics [13, 14]. However, in particularly complex cases, the technique may have limitations, potentially resulting in incomplete drainage and an increased risk of recurrence [15, 16].

This study investigates the efficacy of medical thoracoscopy combined with intrapleural urokinase administration as a treatment strategy for complicated parapneumonic effusions and empyema. This dual-modality approach aims to address the limitations of single-modality therapies by enhancing pleural drainage, reducing inflammatory responses, and providing more comprehensive therapeutic support [16, 17].

In this retrospective cohort analysis, 108 patients with complicated parapneumonic effusions or empyema, treated at Zhongshan Hospital, Xiamen University, were included. The study evaluated the effectiveness of medical thoracoscopy combined with urokinase therapy in comparison to traditional pleural drainage with urokinase therapy, with the goal of generating robust scientific evidence to refine treatment strategies for these complex conditions.

Materials and methods

Study design and population

This retrospective cohort study evaluated the efficacy and safety of medical thoracoscopy combined with intrapleural urokinase administration for the treatment of complicated parapneumonic effusions and empyema. All treatments were completed prior to the initiation of the study, and patient data were reviewed retrospectively. Clinical outcomes were compared between patients who received medical thoracoscopy with intrapleural urokinase therapy (intervention group) and those treated with traditional pleural drainage and urokinase therapy (control group).

As the treatments had already been performed, randomization was not feasible. Consequently, a retrospective cohort design was employed to assess the relative efficacy of these two therapeutic approaches.

The study included patients diagnosed with complicated parapneumonic effusions or empyema who were admitted to the Department of Pulmonary and Critical Care Medicine at Zhongshan Hospital, Xiamen University, between January 2015 and May 2024. All procedures were conducted in accordance with ethical standards and approved by the hospital's ethics committee (Approval Number: 2015-003).

To ensure the accuracy and reliability of the results, stringent inclusion and exclusion criteria were established for both groups. Patient enrollment strictly adhered to these predefined criteria, with four researchers collaboratively overseeing case selection and data recording. To minimize potential bias, all data were independently reviewed by two additional researchers. The patient enrollment process is depicted in Fig. 1.

Inclusion criteria

Patients were eligible for inclusion if they met the following criteria:

1. Age ≥ 18 years.
2. Disease duration ≤ 1 month.
3. Fever (body temperature ≥ 38 °C).
4. Elevated inflammatory markers, including white blood cell count (WBC), C-reactive protein (CRP), and procalcitonin (PCT).
5. Diagnostic thoracentesis performed upon admission, with pleural effusion meeting at least one of the following conditions [17, 18]:

- Grossly purulent appearance.
- Positive Gram stain or microbial culture.
- Pleural fluid pH < 7.2.
- Pleural fluid glucose < 2.2 mmol/L with lactate dehydrogenase (LDH) > 1000 IU/L.

Additionally, patients were required to meet at least one of the following criteria:

- Multiloculated effusion or fibrous septa identified on chest computed tomography (CT) or ultrasound.

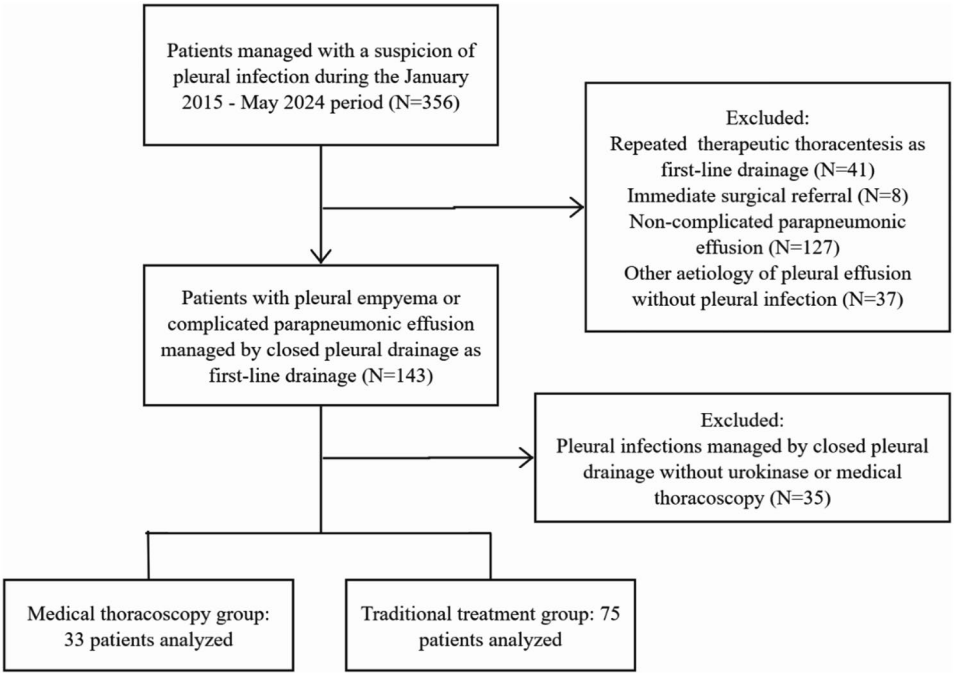

Fig. 1 Flowchart of the study

- Clinical and radiological diagnosis of complicated parapneumonic effusion.
- Significant respiratory distress.

These inclusion criteria were designed to capture a broad spectrum of clinical presentations and disease severities, ensuring the findings are applicable to diverse patient populations. Complete medical records were mandatory for inclusion, encompassing data from blood tests, CRP, PCT, chest CT, chest ultrasound, and pulmonary function assessments.

Exclusion criteria

Patients were excluded from the study if they met any of the following conditions:

1. Prior pleural drainage performed before admission.
2. Known allergy to urokinase.
3. Stage III empyema, characterized by pleural fibrothorax or significant organization.
4. Coexisting major bleeding disorder or severe bleeding tendency.
5. Unstable vital signs.
6. Inability to tolerate medical thoracoscopy.
7. Pregnancy or lactation.
8. Pleural fluid depth < 3 cm.
9. Severe cardiopulmonary dysfunction.
10. Expected survival time of less than 3 months.

As this was a retrospective cohort study, treatment selection was primarily guided by the attending physician's recommendation and the patient's preference. Patients were allocated to either the medical thoracoscopy group (33 cases) or the traditional treatment group (75 cases) based on their chosen treatment modality. All enrolled patients met the diagnostic criteria for complicated parapneumonic effusions or empyema.

To ensure comparability between the two groups, matching was performed based on key pathological characteristics, including age, disease duration, comorbidities, symptoms, and the severity of pleural infection.

Interventions

Medical thoracoscopy group

Before undergoing medical thoracoscopy, patients underwent comprehensive preoperative evaluations. These included blood tests, biochemical analyses, coagulation profiles, CRP and PCT measurements, chest CT, chest ultrasound, and pulmonary function tests. These assessments were conducted to confirm patient eligibility and to provide essential data for individualized treatment planning.

The puncture sheath insertion site was identified using chest ultrasound. Sedation was achieved with midazolam (2 mg) and sufentanil (50 μg), combined with local subcutaneous anesthesia using lidocaine (10~15 ml).

A semi-rigid medical thoracoscope, which integrates the flexibility of a bronchoscope with the stability of a rigid thoracoscope, was utilized to enhance maneuverability and allow comprehensive exploration of the pleural cavity. A single 1.5 cm incision was made to insert the semi-rigid thoracoscope (LTF-240, Olympus, Tokyo, Japan).

Biopsy forceps and a suction device were employed to effectively remove fibrin clots, fibrin membranes, and pleural effusions. Upon completing the inspection, an 8Fr pleural drainage tube was inserted through the puncture sheath.

Starting the next day, urokinase (100,000 units in 50 ml of normal saline) was administered once daily through the drainage tube for three consecutive days. After each administration, the tube was clamped for two hours to allow adequate exposure before being reopened for continuous drainage.

Currently, no standardized protocol exists for the dosage or administration of urokinase. The dosage used in this study was determined based on published literature [19–21] and the clinical experience of our hospital, aiming to ensure therapeutic efficacy while minimizing adverse effects. The drainage tube was removed when the drainage volume remained consistently below 50 ml/day for two consecutive days, and no significant effusion was detected on chest ultrasound.

Traditional treatment group

In the traditional treatment group, an 8Fr pleural drainage tube was inserted under ultrasound guidance. Starting the next day, patients received urokinase fibrinolytic therapy once daily for three consecutive days. The administration protocol and criteria for tube removal were consistent with those used in the medical thoracoscopy group.

For cases of complicated pleural effusion, such as loculated effusions, the decision to insert an intercostal drainage tube was guided by the following considerations:

1. **Volume of Effusion**: Drainage was recommended if the effusion occupied 50% or more of one hemithorax and was accompanied by clinical symptoms such as dyspnea [5, 22].
2. **Pleural Loculations**: Significant loculations observed on imaging studies (e.g., chest CT or ultrasound) that could not be adequately addressed by traditional thoracentesis necessitated tube insertion.
3. **Effusion Characteristics**: Indicators included grossly purulent fluid, a positive Gram stain or microbial culture, pleural fluid pH < 7.2, or pleural

fluid glucose < 2.2 mmol/L combined with lactate dehydrogenase (LDH) > 1000 IU/L [17, 18].

4. **Drainage Tube Selection**: An 8Fr or larger tube was selected based on the characteristics of the effusion and the patient's clinical condition, with adjustments made as necessary during observation.

Primary and secondary outcome measures

Primary outcomes

- **Inflammatory Markers**: White blood cell count (WBC), CRP and PCT.
- **Imaging Outcomes**: Resolution of pleural effusion, absorption of pulmonary inflammation, and incidence of pleural thickening three months postoperatively.
- **Pulmonary Function**: Forced vital capacity (FVC).
- **In-Hospital Mortality**: All-cause mortality during hospitalization.

Secondary outcomes

- **Duration of Postoperative Fever**: Time required for fever resolution after the intervention.
- **Pleural Drainage Time**: Duration of chest tube placement for effective drainage.
- **Duration of Intravenous Antibiotic Use**: Length of time patients required intravenous antibiotics postoperatively.
- **Incidence of Postoperative Complications**: Frequency of complications such as subcutaneous emphysema or pleural bleeding.
- **Rate of Initial Treatment Failure**: Proportion of patients requiring additional interventions due to unsuccessful initial treatment.
- **Length of Hospital Stay**: Total duration of inpatient care.
- **Hospitalization Costs**: Total costs incurred during the hospital stay.

Principles for selecting secondary outcomes

1. **Duration of Postoperative Fever**: Fever is a common symptom following pleural infections, and its prolonged presence may indicate suboptimal treatment or underlying complications. Therefore, the duration of postoperative fever serves as a critical marker for evaluating the effectiveness of the treatment.
2. **Pleural Drainage Time**: The duration of pleural drainage is directly associated with patient recovery. Extended drainage times may indicate inadequate fluid clearance or the presence of postoperative complications.
3. **Duration of Intravenous Antibiotic Use**: This metric reflects the success of infection control during treatment. It is crucial for assessing clinical outcomes while minimizing the risk of developing antibiotic resistance.
4. **Incidence of Postoperative Complications**: Complications arising after surgery can significantly impact recovery and prolong hospital stays. Their incidence is, therefore, a vital factor in evaluating treatment efficacy.
5. **Rate of Initial Treatment Failure**: This metric measures the initial effectiveness of the treatment strategy. The need for additional interventions or surgeries may suggest inadequate success of the initial approach.
6. **Length of Hospital Stay**: The total duration of hospital stay serves as a key indicator of treatment efficacy and recovery rate. It also has important implications for hospital resource management and operational efficiency.
7. **Hospitalization Costs**: As an economic evaluation metric, hospitalization costs provide insights into the cost-effectiveness of the treatment strategy, particularly in resource-limited healthcare settings.

The selection of these secondary outcomes enables a comprehensive evaluation of the therapeutic approach, addressing its efficacy, safety, patient recovery, and economic implications. This holistic assessment ensures a thorough understanding of the overall effectiveness of the treatment strategy.

During the case selection process, careful consideration was given to factors such as concomitant pneumonia, lung collapse, age, comorbidities, and disease severity. These potential confounding variables were rigorously controlled during statistical analysis to minimize bias. Recognizing that such clinical variables could significantly influence the primary outcomes, their impact was systematically assessed to ensure the reliability and robustness of the results.

Statistical analysis

Data were analyzed using SPSS software, version 26.0. Continuous variables with a normal distribution were expressed as mean ± standard deviation ($\bar{x} \pm s$) and compared between groups using an independent sample t-test. For non-normally distributed continuous variables, data were presented as median (interquartile range) [M (P25, P75)] and analyzed using the Mann-Whitney U test. Categorical variables were reported as frequencies (%) and evaluated using the chi-square test.

A *P*-value of < 0.05 was considered statistically significant.

Table 1 Comparison of general data between the two groups

Group	Sample size (*n*)	Gender composition m (%)	Age (y, $\bar{x}\pm s$)	Body mass index ($\bar{x}\pm s$)	Disease duration (d, $\bar{x}\pm s$)
Medical thoracoscopy group	33	81.8	60.7 ± 11.8	22.3 ± 3.2	8.2 ± 4.5
Traditional treatment group	75	80.0	62.0 ± 10.4	22.5 ± 2.7	8.7 ± 4.2
Statistical value		0.048	*t* = -0.571	*t* = -0.349	*t* = -0.588
P Value		0.826[a]	0.569	0.728	0.557

Note: [a]Chi-square test was used for the gender composition comparison

Table 2 Comparison of underlying diseases and preoperative symptoms between the two groups

Group	Sample size (*n*)	History of tumors (%)	Chronic kidney disease (%)	Chronic airway disease (%)	Diabetes (%)
Medical thoracoscopy group	33	24.2	15.2	24.2	18.2
Traditional treatment group	75	14.7	8.0	16.0	12.0
Statistical value		1.449	1.281	1.032	0.732
P value		0.229	0.258	0.310	0.392
Group	**Sample size (*n*)**	**Fever (%)**	**Cough (%)**	**Dyspnea (%)**	**Chest pain (%)**
Medical thoracoscopy group	33	100	72.7	54.5	39.4
Traditional treatment group	75	100	78.7	73.3	30.7
Statistical value		0.000	0.454	3.693	0.785
P value		1.000	0.500	0.055	0.375

Results

General patient information

A total of 108 patients with complicated parapneumonic effusions or empyema were included in this study. Of these, 33 patients were allocated to the medical thoracoscopy group (27 males and 6 females; mean age 60.7 ± 11.8 years), while 75 patients were assigned to the traditional treatment group (60 males and 15 females; mean age 62.0 ± 10.4 years).

Baseline characteristics, including sex, age, body mass index, disease duration, underlying conditions, presence of pneumonia, degree of lung collapse, preoperative symptoms, and pleural effusion volume, showed no significant differences between the two groups ($P > 0.05$). Detailed data are presented in Tables 1 and 2, and 3.

Changes in inflammatory markers, imaging findings, and pulmonary function

Preoperatively, there were no significant differences between the two groups in terms of RAPID scores, WBC, CRP, PCT, presence of pneumonia, degree of lung collapse, or FVC ($P > 0.05$).

Postoperatively, both groups showed significant reductions in inflammatory markers, including WBC, CRP, and PCT, alongside substantial resolution of pneumonia and pleural effusion, full lung re-expansion, and notable improvements in FVC ($P < 0.05$). However, the medical thoracoscopy group exhibited significantly lower postoperative levels of WBC, CRP, and PCT, as well as higher FVC values compared to the traditional treatment group (all $P < 0.05$).

At three months postoperatively, no significant differences in the incidence of pleural thickening were observed between the two groups ($P > 0.05$). Detailed findings are presented in Tables 3 and 5.

Clinical efficacy

Symptom improvement

The median duration of postoperative fever in the medical thoracoscopy group was 3.0 [1.0–3.0] days, significantly shorter than the 3.0 [2.0–4.0] days observed in the traditional treatment group ($P < 0.05$, Table 4).

Treatment efficiency

The medical thoracoscopy group demonstrated significantly shorter durations for pleural drainage (6.0 [5.0–7.0] days), intravenous antibiotic use (16.0 [13.0–20.0] days), and hospital stay (19.0 [15.5–23.0] days) compared to the traditional treatment group. The corresponding durations in the traditional treatment group were 7.0 [6.0–9.0] days, 21.0 [19.0–24.5] days, and 24.0 [22.0–27.0] days, respectively ($P < 0.05$, Table 4).

Rate of initial treatment failure

All patients in the medical thoracoscopy group achieved treatment success without requiring reoperation or referral for surgical intervention. Conversely, 10 patients in the traditional treatment group experienced treatment failure, necessitating additional medical thoracoscopy. The initial treatment failure rate was significantly lower in the medical thoracoscopy group than in the traditional treatment group ($P < 0.05$, Table 5).

Table 3 Comparison of RAPID score, pneumonia incidence, atelectasis, inflammatory markers, and lung function between groups

Group	Sample size (n)	RAPID score	Pneumonia	Pulmonary atelectasis
		Preoperative	(%)	G (%)
Medical thoracoscopy group	33	4 [3, 5] *	45.5	G1(27.3) G2(36.4) G3 (36.3)
Traditional treatment group	75	4 [3, 4] *	57.3	G1(22.7) G2(36.0) G3 (41.3)
Statistical value		*Z* = -0.401	1.301	*Z*=-0.577
P value		0.688	0.254	0.564

Group	Sample size (n)	White blood cell count (×10^9/L, $\bar{x}\pm s$)		C-reactive protein (mg/L, $\bar{x}\pm s$)	
		Preoperative	Discharge	Preoperative	Discharge
Medical thoracoscopy group	33	15.8 ± 4.9	6.8 ± 1.4	181.1 ± 43.6	22.4 ± 11.6
Traditional treatment group	75	16.5 [12.2, 18.6] *	7.8 ± 1.7	176.5 [165.5, 195.4] *	29.3 [21.2, 38.0] *
Statistical value		*Z* = -0.560	*t*=-3.056	*Z*=-0.640	*Z*=-3.331
P value		0.575	0.003	0.522	0.001

Group	Sample size (n)	Procalcitonin (ng/mL, $\bar{x}\pm s$)		Forced vital capacity(L, $\bar{x}\pm s$)			
		Preoperative	Discharge	Preoperative	Discharge	3 months after operation	6 months after operation
Medical thoracoscopy group	33	0.98 [0.72, 1.89] *	0.07 [0.05, 0.13] *	2.13 [1.98, 2.68] *	3.47 ± 0.34	3.68 ± 0.30	4.03 ± 0.20
Traditional treatment group	75	1.48 [1.17, 1.84] *	0.21 ± 0.14	2.10 ± 0.24	3.15 ± 0.19	3.29 ± 0.19	3.75 ± 0.17
Statistical value		*Z*=-1.591	*Z*=-4.753	*Z*=-1.912	*t* = 5.024	*t* = 6.750	*t* = 7.370
P value		0.112	0.000	0.056	<0.001	<0.001	<0.001

Note: *Non-normally distributed continuous data are presented as M [P25, P75]. G1: Mild pulmonary atelectasis (with a degree of atelectasis less than 30%). G2: Moderate pulmonary atelectasis (with a degree of atelectasis ranging from 30–50%). G3: Severe pulmonary atelectasis (with a degree of atelectasis exceeding 50%)

Table 4 Comparison of postoperative drainage, antibiotics, hospitalization, and costs between two groups

Group	Sample size (*n*)	Preoperative pleural effusion volume	Postoperative chest drainage time	Postoperative duration of fever
		G (%)	d, M [P25, P75]	d, M [P25, P75]
Medical thoracoscopy group	33	G1(27.3) G2(36.4) G3 (36.3)	6.0 [5.0, 7.0]	3.0 [1.0, 3.0]
Traditional treatment group	75	G1(22.7) G2(36.0) G3 (41.3)	7.0 [6.0, 9.0]	3.0 [2.0, 4.0]
Statistical value		*Z*=-0.577	*Z*=-3.607	*Z*=-2.220
P value		0.564	<0.001	0.026

Group	Sample size (*n*)	Intravenous antibiotic use duration	Hospitalization duration	Medical costs
		d, M [P25, P75]	d, M [P25, P75]	¥, M [P25, P75]
Medical thoracoscopy group	33	16.0 [13.0, 20.0]	19.0 [15.5, 23.0]	20257.2 [18530.0, 22479.5]
Traditional treatment group	75	21.0 [19.0, 24.5]	24.0 [22.0, 27.0]	19672.0 [17845.0, 21644.5]
Statistical value		*Z*=-4.322	*Z*=-4.463	*Z*=-1.060
P value		<0.001	<0.001	0.289

Note: Preoperative pleural effusion volume grading (G): G1: <500 ml, G2: 500–1500 ml, G3: >1500 ml. Postoperative chest drainage time, fever duration, intravenous antibiotic use duration, hospitalization duration and medical costs in the medical thoracoscopy group are presented as M [P25, P75] due to non-normal distribution

Table 5 Comparison of treatment failure, complications, and pleural thickening at 3 months between groups

Group	Sample size (*n*)	Initial treatment failure rate	Postoperative complications	Pleural thickening at 3 months post-operation
		(%)	(%)	(%)
Medical thoracoscopy group	33	0.0	18.2	15.2
Traditional treatment group	75	13.3	12.0	24.0
Statistical value		4.849	0.732	1.071
P value		0.028	0.392	0.301

Incidence of complications

Postoperative complications, including subcutaneous emphysema and pleural bleeding, occurred at similar rates in both groups, with no statistically significant differences ($P > 0.05$, Table 5).

Economic indicators

Hospitalization costs were comparable between the two groups ($P > 0.05$, Table 4).

In-hospital mortality

No deaths were reported in either group during the hospital stay.

Summary of treatment outcomes

The medical thoracoscopy group demonstrated superior outcomes compared to the traditional treatment group in terms of reducing inflammatory markers, improving pulmonary function, shortening postoperative recovery time, and decreasing antibiotic use. Postoperative complication rates and hospitalization costs were comparable between the two groups, highlighting the good safety profile and similar economic efficiency of both approaches.

Typical case

Case presentation

A 46-year-old male patient diagnosed with empyema was treated using medical thoracoscopy combined with intrapleural urokinase administration. The treatment process and clinical outcomes are detailed in Fig. 2.

Discussion

This retrospective cohort analysis of treatment strategies for complicated parapneumonic effusions and empyema demonstrated that medical thoracoscopy combined with urokinase administration significantly outperformed traditional pleural drainage with urokinase across multiple clinical parameters. The combined approach resulted in substantial improvements in inflammatory markers and pulmonary function, reduced postoperative recovery time, shortened pleural drainage duration and intravenous antibiotic use, decreased hospital stay, and a lower rate of initial treatment failure.

Moreover, no significant differences were observed between the two groups in terms of complication rates or hospitalization costs. Importantly, no in-hospital deaths were reported in either group, and the incidence of pleural thickening three months postoperatively remained low, underscoring the excellent safety profile and cost-effectiveness of both treatment modalities.

While urokinase has been used clinically for decades, it remains a widely utilized fibrinolytic agent, particularly in resource-limited healthcare settings. Although newer fibrinolytic agents such as tPA and DNase have gained broader endorsement, urokinase continues to offer substantial clinical value in the treatment of complicated parapneumonic effusions and empyema due to its lower cost and favorable safety profile [23, 24].

However, some patients may not respond adequately to intrapleural fibrinolytic therapy, necessitating the use of more invasive procedures [25].

Medical thoracoscopy provides several distinct advantages over pleural drainage alone. It enables the opening of multiple loculations, aspiration of purulent material, and removal of fibrin adhesions, thereby creating a larger intrapleural space for urokinase to exert its therapeutic effects more effectively [15, 16].

The combined application of thoracoscopy and intrapleural urokinase has demonstrated excellent clinical outcomes, consistent with findings from existing literature [16, 26]. These results further confirm the efficacy and feasibility of this combined treatment approach.

Significant improvements in postoperative inflammatory markers represent a critical indicator of treatment efficacy [16, 17]. This study showed that patients in the medical thoracoscopy group experienced significantly greater reductions in WBC, CRP, and PCT levels compared to those in the traditional treatment group.

These findings underscore the pivotal role of medical thoracoscopy in mitigating inflammatory responses. By improving the pleural environment, thoracoscopy enhances the therapeutic efficacy of fibrinolytic therapy. Consistent with previous research [27, 28], this study reinforces the clinical value of medical thoracoscopy in reducing inflammation.

This study demonstrated significant imaging recovery in both treatment groups. Postoperatively, pleural

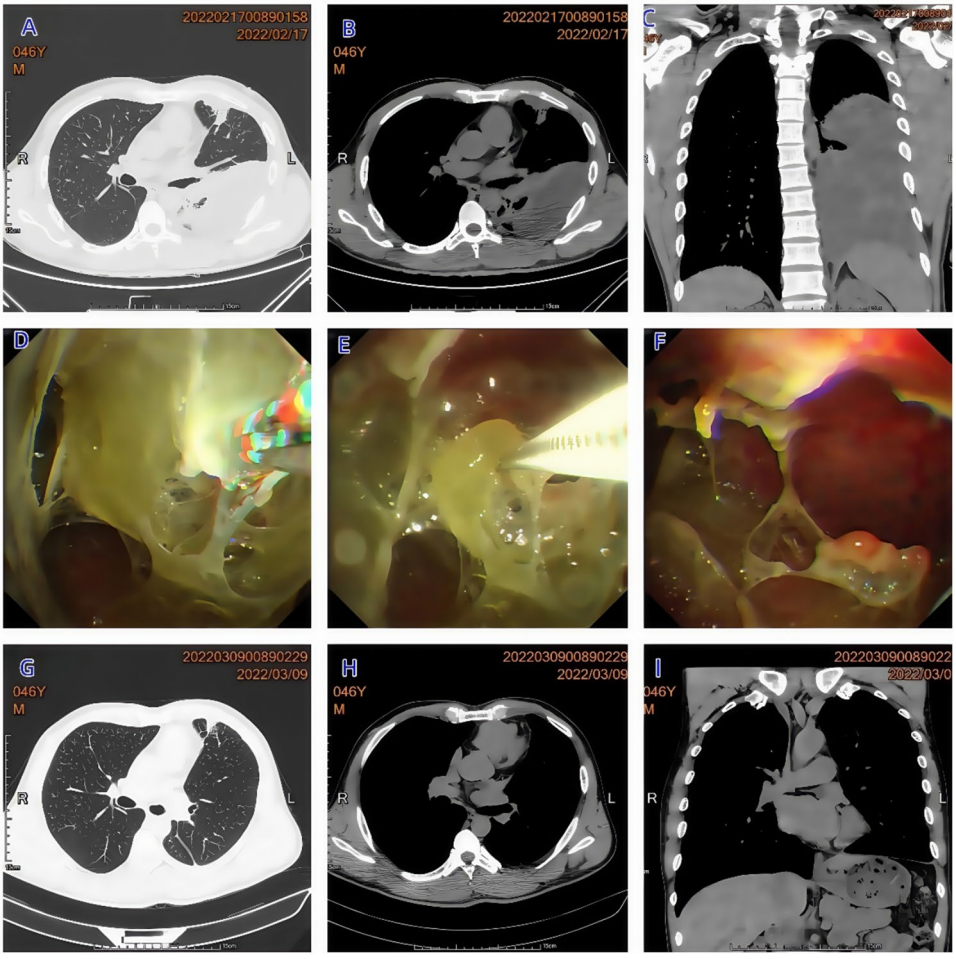

Fig. 2 Medical thoracoscopy combined with urokinase for the treatment of empyema. (**A**-**C**): The preoperative chest CT scan demonstrated a loculated pleural effusion in the left hemithorax. (**D**-**F**): Thoracoscopy revealed a substantial accumulation of purulent pleural effusion in the pleural cavity, with adhesions and fibrinous membranes successfully removed via medical thoracoscopic intervention. (**G**-**I**): Postoperative follow-up chest CT demonstrated complete resolution of the loculated pleural effusion on the left side

effusion and pulmonary inflammation were effectively resolved, accompanied by full re-expansion of collapsed lung tissue. Follow-up chest CT scans at three months revealed a low incidence of pleural thickening in both groups, with no significant differences observed.

These findings indicate that both traditional closed pleural drainage with urokinase and medical thoracoscopy with urokinase are effective in promoting pleural effusion absorption and lung re-expansion, thereby facilitating the resolution of pulmonary inflammation. Early and thorough drainage of pleural effusion is essential for preventing chronic pleural inflammation and reducing the risk of pleural thickening.

In clinical practice, chronic pleural infections often result in pleural thickening, leading to ipsilateral chest wall collapse, reduced compliance, and restrictive pulmonary dysfunction. Early intervention for complicated pleural effusion is essential to prevent pleural thickening, enhance patients' long-term quality of life, and restore their work capacity [29].

This study demonstrated improvements in postoperative pulmonary function in both treatment groups, underscoring the importance of early and proactive intervention. Such interventions facilitate pleural effusion drainage, promote lung re-expansion, restore pulmonary function, alleviate dyspnea, and improve overall quality of life. These findings are consistent with previous research [29]. Notably, patients in the medical thoracoscopy group showed significantly greater postoperative improvement in FVC compared to those in the traditional treatment group ($P < 0.05$).

Follow-up assessments further validated the long-term efficacy of medical thoracoscopy combined with urokinase therapy. Pulmonary function recovery at 3 and 6 months was significantly better in the medical thoracoscopy group compared to the traditional treatment group. This improvement is likely due to the thoracoscopic

procedure's ability to remodel pleural structures and promote lung re-expansion.

While prior studies have established the efficacy of surgical pleurectomy in improving pulmonary function in patients with chronic empyema [30, 31], the findings of this study highlight the applicability and advantages of medical thoracoscopy for managing pleural infections at early and intermediate stages [32].

Medical thoracoscopy combined with urokinase therapy significantly reduced postoperative recovery time, including the duration of fever, pleural drainage, intravenous antibiotic use, and hospital stay. These findings are consistent with previous studies showing that medical thoracoscopy shortens hospitalization time [27].

According to the literature, the success rate of medical thoracoscopy ranges from approximately 85–93% [32, 33]. In this study, the medical thoracoscopy group achieved a 100% success rate on the first treatment, significantly outperforming the traditional treatment group.

These results underscore the high efficacy of combining medical thoracoscopy with urokinase in controlling inflammatory responses, accelerating pleural effusion drainage, and consequently reducing recovery time and antibiotic use [16]. This approach aligns with contemporary antibiotic stewardship goals and has important public health implications [34].

Although medical thoracoscopy requires advanced technical expertise and specialized equipment, this study found no significant difference in hospitalization costs between the two groups. Furthermore, the incidence of complications was comparable between the two groups, with no deaths reported during hospitalization. These findings underscore the excellent safety profile and cost-effectiveness of medical thoracoscopy.

The results demonstrate that medical thoracoscopy combined with urokinase therapy offers not only significant clinical benefits but also economic feasibility, particularly in resource-constrained settings [35–37]. Consistent with prior research [16, 38], this study reinforces the combined use of medical thoracoscopy and intrapleural urokinase as a safe and effective treatment option for complicated parapneumonic effusions and empyema.

This study has several limitations as a single-center, retrospective, cohort investigation. First, retrospective data collection may not fully capture complications related to the interventions, particularly minor events that are less likely to be documented in medical records [33, 39]. Second, the relatively small subgroup sample size may limit the reliability and generalizability of the findings. Third, the choice of treatment strategies was influenced by the preferences of attending physicians and patients rather than being guided by standardized clinical criteria.

Future research should focus on large-scale, multicenter, prospective randomized controlled trials to further validate the efficacy of the combined therapy across different stages of empyema. Additionally, long-term follow-up studies are essential to assess the durability of treatment outcomes and evaluate the risk of recurrence.

Conclusion

This study demonstrates that medical thoracoscopy combined with fibrinolytic therapy provides significant clinical advantages for the treatment of complicated parapneumonic effusions and empyema. This combined approach effectively improves inflammatory markers, accelerates pulmonary function recovery, and reduces postoperative recovery time, all without increasing medical costs.

Furthermore, this treatment strategy has been shown to be both highly effective and safe for patients in the early and intermediate stages of disease, offering a promising option for the management of complicated parapneumonic effusions and empyema.

Abbreviations

CRP	C-reactive protein
PCT	Procalcitonin
CT	Computed tomography
WBC	White blood cell count
FVC	Forced vital capacity
tPA	Tissue plasminogen activator
DNase	Deoxyribonuclease
RAPID	Renal, age, fluid purulence, infection source, and dietary factors

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Author contributions

ZFF, and ZXB conceived and designed the analysis. ZFF, HMH, DYP, and CY collected the data. CHH, LYL, CYY, and CL contributed to the analysis. ZFF, ZXB, HMH, and DYP performed the analysis. ZFF and ZXB wrote the paper. All authors read and approved the final manuscript.

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Data availability

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Zhongshan Hospital, Xiamen University (Approval No. 2015-003), and all procedures were performed in accordance with the ethical standards of the Declaration of Helsinki and national ethical guidelines. Due to the retrospective nature of the study using anonymous claims data, the requirement for informed consent was waived.

Clinical trial number

Not applicable.

Consent for publication
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Competing interests
The authors declare no competing interests.

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