Respiratory Research

REVIEW Open Access

Beyond diagnosis: maximizing the role of medical thoracoscopy in pleural disease treatment

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Abstract
Medical thoracoscopy has been extensively utilized in the diagnosis of pleural disease, yet its potential therapeutic applications remain underutilized. This article presents a comprehensive overview of the various uses of medical thoracoscopy in managing pleural diseases. It has been employed to facilitate thoracic drainage and reduce hospitalization duration of patients with complicated parapneumonic effusions and empyema. Additionally, medical thoracoscopic occlusion therapy can be used for bronchoscopic closure and refractory pneumothorax. However, there is currently a lack of standardized protocols for utilizing medical thoracoscopy to reduce the volume of giant emphysematous bullae. Furthermore, medical thoracoscopy allows for pleurodesis or photodynamic therapy in patients with malignant pleural effusion. Nevertheless, further high-quality clinical research is needed to validate these findings.

Keywords Medical thoracoscopy, Treatment, Pleural disease

Introduction
Medical thoracoscopy has emerged as a crucial tool for diagnosing pleural diseases and has been extensively utilized in clinical settings [1]. Recent advancements in optical imaging techniques and biopsy methods have further advanced the diagnostic capabilities of medical thoracoscopy in identifying pleural diseases. Nevertheless, the current clinical utilization of medical thoracoscopy predominantly centers on diagnostic purposes, with its potential role in the treatment of pleural diseases remaining underutilized. The complexity of the etiology of pleural diseases poses challenges in treatment, particularly in cases of pleural infection, bronchopleural fistula, refractory pneumothorax, and giant emphysematous bullae [2–4]. The application of medical thoracoscopy technology in managing these conditions continues to be a critical concern in clinical practice, extending beyond the conventional indications for its use. This article provides a review of the recent advancements and applications

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of medical thoracoscopy in the management of pleural diseases.

Pleural infection

Based on the characteristics of pleural effusion, pleural infection can be categorized into three distinct types: uncomplicated parapneumonic effusions, complicated parapneumonic effusions and empyema. A multicenter, cross-sectional study carried out in China revealed that parapneumonic effusions and empyema were the predominant etiologies of pleural effusion (25.1%), indicating that pleural infection is the primary underlying cause of pleural effusion in China [5]. Managing patients with pleural infection, particularly those presenting with complicated parapneumonic effusions and empyema, poses significant challenges. The presence of multiple compartments complicates the drainage of pleural effusion and infection control. Furthermore, inflammation of the pleural cavity results in thickening and adhesion of the pleura, ultimately leading to restrictive ventilation dysfunction.

The management of pleural infection necessitates systemic antimicrobial therapy in conjunction with thoracic drainage and other local interventions to facilitate fluid drainage. Patients presenting with complicated parapneumonic effusions and empyema, as well as those exhibiting inadequate response to medical therapy, may require surgical intervention such as video-assisted thoracoscopic surgery (VATS) or open thoracotomy for the removal of infected tissue and debris. In comparison to VATS and open thoracotomy, medical thoracoscopy offers the advantages of reduced trauma and cost-effectiveness. For patients in the organizing stage (Stage III) of empyema, the success rate of medical thoracoscopic treatment is limited. This limitation arises from the inability of medical thoracoscopy to fully excise the organized pleura.

Medical thoracoscopy has been found to be more effective in improving local drainage than traditional thoracic tube drainage or intrathoracic injection of fibrinolytic drugs, leading to favorable clinical outcomes. A randomized controlled study conducted by Kheir et al. in 2020, involving 32 patients, demonstrated that medical thoracoscopy has been shown to decrease the duration of hospitalization following the procedure, reducing the average length of stay from four days to two days [2]. It is considered a safe and dependable option for patients with complicated parapneumonic effusions and empyema. According to the guidelines established by the European Respiratory Society in 2023, medical thoracoscopy is recommended for early intervention in patients with multilocular septal thoracic infections or for those who cannot undergo traditional surgical procedures. However, its superiority and inferiority compared to intrathoracic fibrinolysis therapy still need to be confirmed through large-scale studies [6].

The presence of severe pleural adhesions in patients with pleural infection poses challenges for complete lesion removal via medical thoracoscopy. Consequently, post-thoracoscopy injection of urokinase into the chest cavity can improve fibrin and necrotic tissue dissolution, optimize thoracic drainage, and enhance therapeutic outcomes for patients with pleural infections. In 2022, a retrospective study conducted by Ravaglia et al. at a single center indicated that the combined use of medical thoracoscopy and intrapleural injection of urokinase demonstrates a success rate of 75.6%. The remaining 24.4% of patients require additional local treatment [7].

Hence, medical thoracoscopy may be employed in the management of individuals with complicated parapneumonic effusion and empyema, facilitating thoracic drainage and reducing the duration of hospitalization. In cases where complete clearance of purulent cavities is not achieved through medical thoracoscopy alone, the additional use of urokinase injection via thoracic catheterization may result in improved therapeutic outcomes. However, for patients with empyema in the organizing stage or those who have not responded to medical thoracoscopic treatment, it is imperative to assess the necessity of surgical intervention.

Bronchopleural fistula

A bronchopleural fistula (BPF) is defined as a communication pathway that forms between the alveoli, bronchi, and pleural cavity. This condition can arise due to various factors, including pulmonary resection, interventional surgery, lung abscess, empyema, tuberculosis, and lung tumors. BPF is considered a significant complication following thoracic surgery and can be categorized into central and peripheral types based on the specific location of the fistula. Patients with BPF often experience accompanying symptoms such as thoracic infections, pneumothorax, pulmonary infections, and respiratory failure, leading to a notably high mortality rate [8]. Surgical intervention for BPF is associated with considerable financial expenses, substantial physical trauma, and a notable rate of treatment failure. Although bronchoscopic closure is a frequently employed interventional approach, its efficacy may be suboptimal in certain cases. The emergence of medical thoracoscopy has introduced novel therapeutic possibilities for individuals with BPF. In a recent case study conducted by Ren et al. [9], a patient with BPF following lobectomy underwent an unsuccessful bronchoscopic closure surgery. After receiving treatment with argon plasma coagulation burning combined with medical glue local spraying and sealing, the air leakage ceased, enabling the successful removal of the thoracic drainage tube. This case highlights the potential efficacy of medical thoracoscopy in situations where bronchoscopic closure or surgical operation is unsuccessful or not suitable, indicating a potential role for medical thoracoscopy in the management of peripheral bronchopleural fistula.

Refractory pneumothorax

In clinical setting, pneumothorax that continues to exhibit air leakage after 7 days of continuous intercostal drainage is commonly classified as refractory pneumothorax, colloquially known as “stubborn pneumothorax“ [10]. The primary etiology of refractory pneumothorax is persistent air leakage resulting from pulmonary bullae or visceral pleural rupture. Pulmonary bullae are categorized into three types according to their size: Type I, which are minuscule and can only be detected with light microscopy, often appearing normal under thoracoscopy and naked eye examination; Type II, slightly larger blisters measuring less than 2 cm in diameter that are fixed and connected to the lung parenchyma; and Type III, giant pulmonary bullae with a diameter of 2 cm or larger. The treatment approach for pulmonary bullae varies depending on their classification.

Bronchial occlusion is a frequently employed technique for managing refractory pneumothorax, although challenges may arise, such as difficulty in identifying the affected bronchus and the potential for the sealing material to dislodge. Recent studies suggest that medical thoracoscopy has emerged as a viable alternative for the treatment of refractory pneumothorax.

Pleurodesis by medical thoracoscopy

Pleurodesis is a treatment method used for refractory pneumothorax. It involves stimulating the visceral pleura through physical or chemical methods to induce inflammation and adhesion, ultimately aiding in the closure of the pleura. Talcum powder can be administered through direct medical thoracoscopy or applied to the parietal pleura using gauze. In a study conducted by Tschopp et al., a success rate of 97% was reported in 93 patients with pneumothorax treated with medical thoracoscopic talcum powder spraying. However, the risk of failure is increased for patients with pulmonary bullae larger than 2 cm in diameter (odds ratio 7) [11]. Pleurodesis requires a thorough evaluation of lung re-expansion preoperatively, as well as ongoing negative pressure suction postoperatively, to ensure proper adhesion of the visceral pleura and facilitate pleural adhesion and fixation. Nevertheless, caution should be exercised when considering pleural fixation surgery for patients undergoing VATS or open thoracotomy procedures due to the potential for pleural cavity adhesion and occlusion.

Management of ruptures by medical thoracoscopy

Medical thoracoscopy enables direct visualization of the lung surface to identify leaking pulmonary bullae and suspicious ruptures. The utilization of various imaging modalities aids in the identification of pulmonary bullae and fistulas. In cases where ruptures are challenging to detect, physiological saline can be applied to suspicious areas of the lung surface. The appearance of bubbles indicates a rupture, and some patients may need to change their position for better observation. In 2009, Peng et al. [12] conducted medical thoracoscopic treatment on 36 cases of refractory recurrent pneumothorax with bullae measuring less than 4 cm. The bullae were injected with medical bioprotein glue, resulting in rapid atrophy and adhesion during the procedure. The outcomes were deemed satisfactory with no notable adverse events, and there were no instances of recurrence within a 2-year follow-up period. Furthermore, the team uesd high-frequency electrocoagulation to induce coagulation in pulmonary bullae that were less than 2 cm in diameter. For pulmonary bullae larger than 2 cm in diameter, the treatment involved puncture and gel injection. Ultimately, all 32 patients with pneumothorax achieved favorable treatment outcomes.

Zhang et al. [13, 14] utilized argon plasma coagulation (APC) for the localized treatment of pulmonary bullae measuring less than 4 cm in diameter, in conjunction with the application of biological glue. In cases where the pulmonary bullae exceed 4 cm in diameter, injection of glue into pulmonary bulla is employed for treatment. Research findings indicate that the use of biological glue in conjunction with APC, combined with giant bullous lung volume reduction surgery via medical thoracoscopy, is a safe and effective approach for managing spontaneous pneumothorax resulting from subpleural bullae measuring 4 cm or larger in diameter.

For patients with refractory pneumothorax who cannot tolerate surgical operation or surgical operation failure, medical thoracoscopy has the potential not only to identify and manage pulmonary bullae and suspicious fistulas but also to alleviate thoracic adhesions. This facilitates the restoration of natural lung expansion and enhances lung re-expansion capacity. Consequently, in cases of refractory pneumothorax without a definitive rupture, endoscopic adhesion release not only helps with lung recruitment but also speeds up pneumothorax resolution.

Vanishing lung syndrome

Vanishing pulmonary syndrome, also referred to as giant emphysematous bulla, is a progressive lung disorder characterized by the presence of pulmonary bullae, frequently in conjunction with chronic obstructive pulmonary disease [15, 16]. The radiological diagnostic criteria involve the identification of one or two sizable pulmonary bullae occupying a minimum of one-third of one side of the thoracic cavity and exerting pressure on the adjacent lung tissue. This condition results in compromised ventilation function in functional lung tissue and, in severe instances, mediastinal displacement. Some individuals may also experience pneumothorax episodes, which can lead to life-threatening consequences.

Thoracic surgery is the primary approach for volume reduction in patients with vanishing lung syndrome, but it is associated with challenges including prolonged postoperative air leakage, significant trauma, and high hospitalization expenses. While some researchers have explored alternative methods such as silicone plugs or autologous blood occlusion via bronchoscopy for volume reduction in patients with giant pulmonary bullae, the efficacy of endobronchial occlusion treatment is constrained by the presence of collateral ventilation in these cases [17]. In recent years, with the advancement of intervention technology, some scholars have used medical thoracoscopy to reduce the volume of giant emphysematous bullae [4, 18], indicating that this approach is highly safe and effective. The operational procedure can be outlined as follows: (1) Administration of general anesthesia, preferably utilizing double-lumen tracheal intubation for single lung ventilation, identification of predetermined incision site for endoscopic intervention, dissection of adhesions, and adequate release of pulmonary bullae; (2) Utilization of percutaneous puncture with a puncture needle under direct visualization of medicine thoracoscopy to aspirate the target pulmonary bulla to a semi-collapsed state; (3) Uniform injection of medical adhesive into the bulla through the puncture needle; (4) Prompt evacuation of the residual gas from the large bubble, followed by the withdrawal of the puncture needle and the compression of the bubble wall using oval forceps.

Following the surgical procedure, routine thoracic closed drainage was initiated. After 24 h of cessation of air leakage, the drainage tube was clamped, and a chest CT scan was repeated to assess the suitability for extenuation.

Currently, there is a lack of standardized operating procedures for the use of medical thoracoscopy in reducing the volume of giant emphysematous bulla, leading to potential risks of postoperative pulmonary bullous re-expansion and prolonged air leakage in some patients. Therefore, it is imperative to optimize the operational process and standardize postoperative management methods to enhance treatment outcomes for patients. However, surgical operation remains the preferred treatment modality for patients, except in cases where they are unable to tolerate the procedure.

Malignant pleural effusion

Malignant pleural effusion (MPE) is characterized by the presence of malignant tumor cells in pleural effusion or pleural tissues, resulting from the metastasis of primary or secondary malignant tumors to the pleura. Common etiologies include lung cancer, breast cancer, and malignant pleural mesothelioma. The primary approach to managing MPE involves palliative interventions aimed at symptom relief. Presently, medical thoracoscopy facilitates the execution of pleural adhesion surgery or photodynamic therapy for individuals afflicted with MPE.

Pleurodesis

Pleurodesis involves the application of sclerosing agents to induce significant adhesion between the parietal and visceral pleura, resulting in the closure of the pleural cavity and regulation of pleural effusion production. This procedure is recommended for patients whose lung expansion can be adequately assessed through imaging following thoracic puncture drainage [19]. Talc powder is the preferred agent for pleural sclerosis, with alternative options including povidone iodine, bleomycin, doxycycline, and autologous blood. The application techniques for talc powder in the treatment of malignant pleural effusion encompass the dispersion of talc powder particles via medical thoracoscopy and the infusion of talc powder homogenate through thoracic tube insertion. The former method carries a heightened risk of thoracic infection in comparison to the latter, which is more susceptible to catheter displacement; however, both methods exhibit similar rates of success. A multicenter study conducted by Bhatnagar et al. in 2019, involving 330 patients with malignant pleural effusion, revealed no significant difference in the efficacy of pleural adhesion formation between the two aforementioned techniques [20]. Hence, in cases where a patient requires thoracoscopic pleural biopsy, it is recommended that priority be given to the application of talcum powder particles via medical thoracoscopy.

Photodynamic therapy

Medical thoracoscopy is characterized by minimal trauma and fewer complications, making it well tolerated by patients. Tumor photodynamic therapy involves the injection of photosensitizers that selectively accumulate in tumor tissue. When exposed to a specific wavelength of laser irradiation and oxygen, a luminescent chemical reaction is induced, resulting in tumor cell death. Thus, combining photodynamic therapy with medical thoracoscopy allows for the complete removal of pleural effusion and minimally invasive treatment of pleural lesions.

Current clinical reports primarily focus on the efficacy of photodynamic therapy for pleural tumors in conjunction with surgical procedures, providing good survival outcomes, especially for patients with malignant pleural mesothelioma [21–23]. However, patients with advanced tumors may not be suitable candidates for surgical intervention due to anesthesia and intubation challenges. Consequently, the development of medical thoracoscopic photodynamic therapy technology is imperative. This innovative approach has been implemented in various Chinese hospitals, with case reports and single-center studies demonstrating the favorable therapeutic effects of photodynamic therapy on pleural malignancies. However, more clinical research is still needed to obtain advanced evidence.

Conclusion

Medical thoracoscopy has the potential to improve local drainage in individuals with pleural infection, leading to a reduction in the duration of hospitalization. Additionally, it can serve as a viable treatment option for challenging conditions such as bronchopleural fistula, refractory pneumothorax, giant pulmonary bullae, and malignant pleural effusion. Nonetheless, further investigation and research are required to determine the appropriate indications and beneficiaries of this procedure. At the same time, some studies are needed to assess the real feasibility and standardization of such techniques. With the continuous advancement of thoracic intervention technology, it is anticipated that medical thoracoscopy will play a more prominent role in the management of pleural diseases.

Abbreviations

MT	Medical thoracoscopy
VATS	Video-assisted thoracoscopic surgery
MPE	Malignant pleural effusion
BPF	Bronchopleural fistula
APC	Argon plasma coagulation

Acknowledgements

The work is also supported by Sichuan University West China Hospital Clinical Incubation 1.3.5 Project (2022HXFH002).

Author contributions

All authors have made substantive contributions to the preparation and writing of the manuscript. Weimin Li and Fen Tan conceptualization, supervision and funding acquisition. Kaige Wang and Ling Zuo drafted the initial manuscript, searched for bibliography, and revised the final manuscript. Panwen Tian were involved in critical revision of the manuscript. All authors approved the final version of the manuscript.

Funding

The work is also supported by Sichuan University West China Hospital Clinical Incubation 1.3.5 Project (2022HXFH002).

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 6 June 2024 / Accepted: 2 October 2024
Published online: 11 November 2024

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