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Cryotherapy in Semirigid Thoracoscopy for Debridement of Multiloculated Empyema

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Established Facts

- Surgical intervention (video-assisted thoracic surgery [VATS] or thoracotomy) is indicated for multiloculated empyema.
- Medical thoracoscopy (MT; semirigid or rigid) is less invasive than VATS and can be performed under local anesthesia.
- Cryobiopsy is used in bronchoscopy for diagnostic purposes and increasingly used in MT with encouraging results.
- Cryotherapy is widely used in bronchoscopy for extraction of tissues and substances that are harder to extract by forceps or suction, for example, blood clots.

Novel Insights

- Cryotherapy combined with semirigid thoracoscopy can be used to treat multiloculated pleural empyema under medical thoracoscopy by effective and efficient extraction of pseudomembrane and pus and is superior over flexible forceps or suction.

Keywords
Semirigid thoracoscopy · Pleural empyema · Cryotherapy · Cryoextraction

Abstract
Surgical intervention is occasionally required for the treatment of pleural empyema. Semirigid thoracoscopy is a safe and successful surgical approach utilized by interventional pulmonologists, conventionally utilizing flexible forceps and suction as the main tools, but they can sometimes be inefficient for more complicated cases. In debriding a case of multiloculated empyema with semirigid thoracoscopy, we report the novel use of cryotherapy in clearing adhesions from the pleural cavity. We found using the cryoprobe to be more efficient than using forceps and suggest further investigation into its use in medical thoracoscopy.

Introduction

Pleural empyema is a severe infection in the pleural cavity and progresses through 3 phases: exudative, fibrinopurulent, and organizing. The incidence of pleural empyema is rising in both children and adults [1, 2] with a mortality rate of approximately 15% [3]. Traditionally, empyema is treated with appropriate antimicrobial ther-

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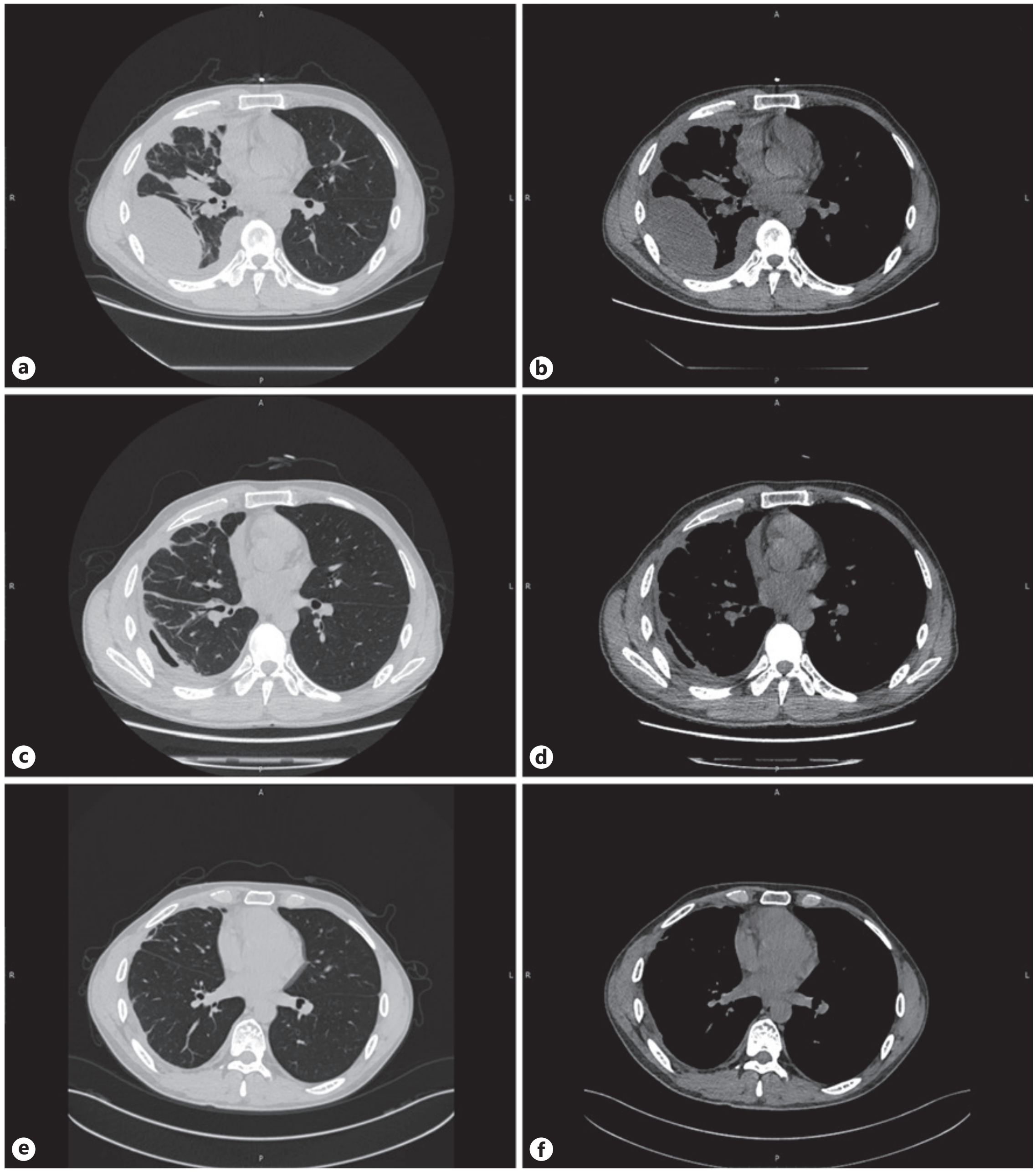

Fig. 1. Chest CT images. **a**, **b** Pre-MT chest CT showing right encapsulated pleural effusion with atelectasis of the right lung. **c**, **d** Chest CT 1 week after MT showing less pleural effusions than before MT and restored inflation of the right lung. **e**, **f** Follow-up chest CT at 3 months after MT showing full re-expansion of the right lung with pleural thickening but no pleural effusions. MT, medical thoracoscopy.

apy and adequate pleural drainage with or without a combination of intrapleural fibrinolytic and DNase therapy [4]. Surgical treatment includes video-assisted thoracic surgery (VATS) and thoracotomy, which allow for more adequate drainage, lavage, and debridement of the pleural space, and can in turn accelerate the control of infection and reduce the adhesion of pleura which would otherwise aggravate lung function.

Thoracoscopy, invented by the Swedish internist Hans-Christian Jacobaeus over 100 years ago [5], is a minimally invasive video-assisted procedure with wide implications in the diagnosis and treatment of pleural dis-

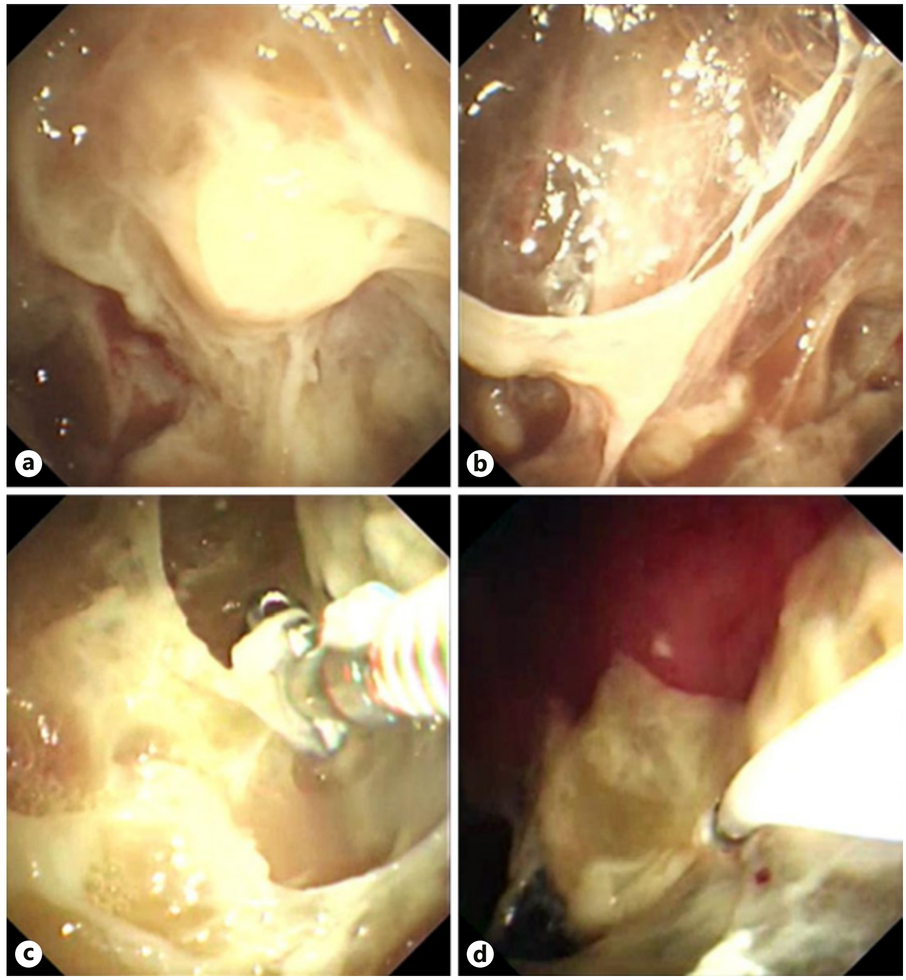

Fig. 2. MT images. **a** Loculation within the right pleural cavity and pseudomembranes on the pleura. **b** Extensive adhesive banding. **c** Extraction of purulent membranes by flexible forceps. **d** Extraction of purulent membranes by cryoprobe. MT, medical thoracoscopy.

eases. Compared with the more invasive VATS, which is performed by surgeons under general anesthesia and single-lung ventilation, medical thoracoscopy (MT) can be performed by a trained interventional pulmonologist with the patient breathing spontaneously under local anesthesia and conscious sedation, allowing for a broader patient selection and fewer complications. MT was traditionally performed with rigid thoracoscopes, but later on semirigid thoracoscopy was designed, with a handle similar to that of flexible bronchoscopes and a flexible distal tip, making it more compliant with the habit of pulmonary physicians. MT has been shown to be a safe and successful approach to treating both free-flowing and multiloculated pleural empyema, with the reported rate of success at 100% and 91.7%, respectively [6].

The use of cryotherapy in respiratory settings was first reported nearly half a century ago [7]. It can be used for cryobiopsy, cryoablation, or cryoextraction. Cryoextraction can be used for foreign body or tissue removal. After the probe is frozen and adhered to the target material, they can then be withdrawn together. Cryoextraction is widely used in bronchoscopy but seldom reported in MT. In bronchoscopy, cryoextraction is superior for handling viscid secretion or clots as they are difficult to remove by flexible forceps or suction. In MT, cryobiopsy has been shown to be a safe and efficient tool for pleural disease diagnosis [8–10], prompting us to use cryotherapy for the treatment of pleural diseases. Here, we present such a case.

Case Report

A 42-year-old man, with moderate smoking and drinking habit without any other medical history, presented with subacute onset of low-grade fever, fatigue, and myalgia 2 months prior to admission. At the time, he had no complaint of chest pain, dyspnea, cough, chills, or night sweats. He had previously visited a local hospital where tests showed an elevated WBC of 12,480/mm^3 and chest CT revealed multiple bilateral lung opacities. Treatment with intravenous cephalosporin temporarily relieved his symptoms.

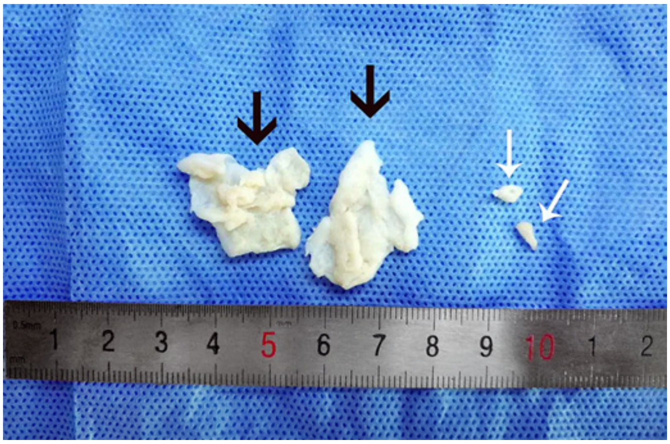

Fig. 3. Comparison of extracted fibrin membrane sizes. Fibrin membranes extracted by cryoprobe (black arrows) were larger than those extracted by flexible forceps (white arrows).

However, his fever and fatigue recurred twice, relieved by oral cephalosporin each time. Five days prior to admission to our hospital, his symptoms recurred and worsened, with maximum axillary temperature at 39.3°C accompanied by chills. On admission, physical examination showed dullness to percussion and absent breath sounds of the right lower anterior chest, with no other meaningful finding. His WBC was 22,900/mm^3 and NE% was 82.9%. PCT was 2.24 ng/mL. Interferon gamma release assay and tuberculin skin test were negative. Chest CT showed right encapsulated pleural effusion (Fig. 1a, b). Pleural fluid aspiration was cloudy yellow with laboratory findings consistent with exudative pleural effusions (nucleated cell count 7,370/mm^3, neutrophil 97%, protein 55 g/L, glucose <0.6 mmol/L, LDH 3,999 IU/L, and pH 6.736), although acid-fast bacilli stain and bacterial culture were negative. After 8 days of antibiotic therapy (moxifloxacin → meropenem + vancomycin), the patient's inflammatory markers decreased. However, pleural drainage was unsuccessful, and the patient remained febrile. As control of infection was unsatisfactory due to pleural encapsulation and poor drainage, we determined to perform MT.

The patient was in the left decubitus position with the ipsilateral arm above the head. After routine disinfection and standard local anesthesia with lidocaine, a 1-cm incision was made at the sixth intercostal space on the midaxillary line. Blunt separation was performed to reach the parietal pleura, and the trocar was inserted into the pleural cavity. A semirigid thoracoscope (Olympus LTF 240) was gently sent in for observation, revealing a moderate amount of cloudy yellow fluid in the pleural cavity with extensive adhesive tissue forming septa, loculations, and pseudomembranes (Fig. 2a, b). We used the scope and flexible forceps to separate loose adhesions and break into the encapsulated abscess but found it difficult to remove thick pseudomembranes effectively (Fig. 2c; online suppl. Video 1; for all online suppl. material, see www.karger.com/doi/10.1159/000509609). In addition, the viscid secretion could not be suctioned out. We then used cryotherapy for extraction. A flexible cryoprobe (1.9 mm) was inserted through the biopsy channel (Fig. 2d; online suppl. Video 1). Upon contact with the pseudomembrane or viscid pus, up to 7 s of freezing was initiated until a white frost formed. Once frozen to the pleural lesion, the probe was extracted abruptly together with the semirigid thoracoscope and dipped into normal saline for thawing, thus removing the lesion from the pleura. With dozens of cryoextraction, most pseudomembranes or pus were debrided and removed. After irrigation of the pleural cavity with saline and complete aspiration of fluids, a chest tube (24 Fr) was inserted and connected for drainage. The patient's vital signs remained stable throughout the procedure. Bleeding was minimal without the need of any management. No dyspnea or hypotension occurred except mild local pain. At the next day of the procedure, his fever faded and his inflammatory markers descended to normal range. One week later, his chest CT showed that the fluid was mostly drained (Fig. 1c, d). A small amount of clear drainage was observed from his chest tube, which was subsequently removed. On follow-up after 3 months, the patient remained asymptomatic and his chest CT scans showed right pleural thickening without any pleural effusions, and the right lung was normally expanded (Fig. 1e, f).

Discussion

Here, we demonstrate the successful application of MT combined with cryotherapy in treating a patient with multiloculated empyema. Pleural empyema is a severe infection of the pleura with a high mortality and morbidity rate in the absence of effective treatment. In addition to appropriate antibiotics and supportive treatment, drainage is the most important therapy. It can decrease bacterial colonies and reduce inflammation, thereafter making the infection more controllable. Nevertheless, when diagnosis or treatment is delayed, or the immunity of the host is inhibited, or the infected pathogen is too toxic, adhesion and encapsulation can form, requiring more invasive surgical procedures. Thoracotomy or VATS to remove the adhesion and open the encapsulation are standard treatment. But the procedures are expensive and more invasive, and performed under general anesthesia. When the patients are too fragile or have severe comorbidities, these procedures are relatively contraindicated. Compared with VATS, MT is less invasive and can be performed under local anesthesia, and thus is more cost-effective.

MT is performed with a rigid or semirigid thoracoscope. Rigid thoracoscopy with rigid forceps can break down and remove adhesions effectively but cannot reach the posterior and mediastinal aspects of the thoracic cavity as the scope can only travel in a straight line, and attempts for more thorough examination may cause the patient pain. With semirigid thoracoscopy, the pulmonologist has better flexibility when maneuvering around the lung and the procedure is more tolerable for the patient, but the flexible forceps lack the strength to debride thick pseudomembranes efficiently [11]. In the COFFEE trial, samples obtained by pleural cryobiopsy were larger than flexible forceps biopsies (median size: 7 vs. 4 mm) [12]. Since the cryoprobe can be used to extract larger samples, it is rational to use the technology to remove pseudomembranes more effectively and efficiently, which coincides with our observation in this case that fibrin membranes extracted by the cryoprobe were larger than those of flexible forceps (Fig. 3). Also, when encountering viscid pus, neither rigid nor flexible forceps combined with trans-thoracoscope suction prevail, but with the cryoprobe, the interventional pulmonologist can freeze the pus and then extract it. Debridement with cryoprobe is a better solution for less-responsive empyema, especially with loculation. Higher efficiency of the cryoprobe combined with semirigid thoracoscopy could mean fewer insertions through the thoracoscope than forceps, meaning shorter procedure time and possibly less pain for the patient. While we did not observe any complications during and after the procedure, the safety of cryotherapy in MT warrants further investigation.

Conclusion

The present case report suggests that cryoextraction combined with semirigid thoracoscopy may be a safe and efficient treatment for nonresponsive empyema to standard treatment as an alternative before thoracotomy or VATS. It may reduce the risks caused by surgical procedures and can decrease medical expenses. Those who are more fragile or contraindicated to thoracotomy or VATS can get more benefit from the treatment. As far as we know, it is the first report of cryoextraction under MT for the treatment of less-responsive pleural empyema. The therapeutic use of cryotherapy in MT deserves more attention from pulmonologists. More clinical trials or investigations are needed to figure out its indications, timing, and safety, as well as cost-effective profiles.

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Statement of Ethics

The patient was fully informed, and written consent was obtained.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

Q.Z. and G.F.W. wrote the manuscript, which was reviewed by all coauthors. G.F.W., X.W., and Y.H. performed the procedure. All of the authors approved the manuscript for publication.

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