Clinical Outcomes and Postoperative Complications of VATS Versus Open Thoracotomy for Pulmonary Decortication

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Abstract

Background: Decortication is a surgical procedure aimed at removing fibrous pleural peel to allow lung re-expansion in chronic pleural diseases such as empyema, hemothorax, and pleural thickening. Over time, surgical approaches have evolved from traditional open thoracotomy to minimally invasive Video-Assisted Thoracoscopic Surgery (VATS). This review outlines the anatomical basis, indications, contraindications, outcomes, and complications of decortication, with a focus on comparing VATS and open thoracotomy. **Conclusion:** VATS offers advantages including reduced postoperative pain, shorter hospital stay, lower morbidity, and faster recovery, while maintaining comparable effectiveness in appropriate cases. In contrast, open thoracotomy remains the standard approach in advanced or complex cases, providing better exposure and allowing complete decortication when dense adhesions are present. Outcomes are generally favorable for both techniques, with improvement in symptoms and lung function; however, results depend on patient factors such as age, comorbidities, and preoperative lung status. Despite its benefits, decortication is associated with potential complications including air leaks, bleeding, infection, bronchopleural fistula, and respiratory impairment. Careful patient selection and surgical expertise are essential to optimize outcomes and minimize risks.

Keywords: Chronic lung conditions, Open Thoracotomy, decortication, Video Assisted Thoracoscopic Surgery (VATS)

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Introduction

A Pleura is a two layered serous membrane with a pleural sac in-between. The outer layer that covers the chest wall, mediastinum and diaphragm is called the parietal pleura. The inner layer is called the visceral pleura and it covers the lungs, nerves, blood vessels and bronchi [1].

The visceral pleura is firmly attached to the lung surfaces from the hila outward. To the extent that each fissure is developed, it lines the major and minor ones [2]. The visceral pleura is connected to the lung parenchyma. There isn't a cleavage plane in nature. The lung parenchyma is left with a bare surface that has many air leaks and sporadically tiny blood capillaries after the visceral pleura is removed [3].

The parietal pleura covers the diaphragm, mediastinum, and costal pleura on the chest wall to form the cupula, or plural dome, at the thoracic inlet. The mediastinal pleura, which extends from the sternum ventrally to the thoracic spine dorsally, covers the pericardium and mediastinal organs [4].

Blood supply of the pleura

Unlike the visceral pleura, which is primarily supplied by bronchial arterial blood supply and venous drainage in pulmonary veins, the parietal pleura is supplied by various systemic arterial branches from the chest wall, diaphragm, and mediastinum with venous drainage into corresponding veins draining into the superior vena cava [5].

Lymphatic drainage of the pleura

The visceral pleura is mostly drained by the subpulmonary lymphatic network and the deep pulmonary lymphatic plexuses. The lymphatic drainage of the parietal pleura is received by the parietal pleural lymphatic channels [5].

Nerve supply of the pleura

The parietal pleura is innervated by the somatic, sympathetic, parasympathetic, and intercostal nerves. The diaphragmatic pleura is supplied by the phrenic nerves. The visceral pleura is not somatically innervated [6].

Pleural Thickening

Pleural thickening refers to the abnormal thickening of the pleura, which may involve one or both lungs. This thickening typically occurs due to scarring or inflammation following an injury, infection, or long-term exposure to harmful substances like asbestos [7].

In normal circumstances, the pleura is a thin, elastic membrane that allows the lungs to expand and contract effortlessly during breathing. When the pleura thickens, it loses elasticity, which can hinder lung expansion and cause difficulty in breathing. Pleural thickening can be classified as localized or diffuse, depending on the extent and spread of the thickening across the pleura [1, 8].

Symptoms

Symptoms of pleural thickening often develop gradually and depend on the extent of the condition. The most common symptom is shortness of breath, which worsens with physical activity. Chest pain or discomfort may also occur, especially when breathing deeply. Patients might experience a persistent dry cough and general fatigue [9].

Pathophysiology

Pleural thickening begins when the pleura is exposed to irritants, such as asbestos fibers, infections, or trauma. This exposure triggers inflammation, leading to the deposition of fibrous tissue in the pleura. Over time, this fibrotic process thickens and stiffens the pleura, reducing its elasticity and limiting lung expansion. The condition can also lead to the formation of adhesions, which are bands of fibrous tissue that bind the lung to the chest wall, further impairing lung function. Chronic inflammation can perpetuate the scarring process, exacerbate symptoms and reduce respiratory efficiency [10].

Diagnosis

Diagnosing pleural thickening involves a combination of medical history, physical examination, and imaging studies. A history of asbestos exposure, chest trauma, or infections is a significant clue. During a physical exam, a healthcare provider may detect reduced breath sounds or dullness to percussion over the affected area [11].

Imaging tests such as chest X-rays and CT scans are essential for identifying thickened pleura and assessing its extent. In some cases, additional tests like pulmonary function tests or biopsies may be needed to evaluate lung capacity and rule out other conditions, such as cancer or infections [12].

Pleural Empyema

Pleural empyema is the main condition for which lung decortication is recommended, whether pyogenic or tubercular. Klebsiella pneumoniae, Staphylococcus aureus, Streptococcus pneumoniae, and other bacteria can cause pyogenic empyema. Hemothorax, pleural thickening brought on by inflammatory diseases like rheumatoid arthritis, and malignancies like malignant mesothelioma are additional reasons for lung decortication [13].

Parapneumonic pleural effusion and thoracic empyema

Pneumonia patients frequently have pleural effusions. Parapneumonic effusions occur in around 40% of patients with bacterial pneumonia and 60% of patients with pneumococcal pneumonia. While most patients get remission after receiving antibiotic treatment, some experience a more fibrinous reaction; in the worst cases, frank pus may be present. The latter is called an empyema thoracis or empyema [14].

A parapneumonic pleural effusion can be linked to almost any kind of pneumonia, including bacterial, viral, and atypical pneumonia. However, each organism has a different relative incidence of parapneumonic pleural effusions. Twenty percent of individuals with viral and Mycoplasma pneumonia develop minor pleural effusions. 70% of cases of thoracic empyema are caused by bacterial pneumonia. 30% of cases of empyema thoracis are complications from prior surgery, which is becoming more common. Pleural space infection can be a complication of trauma [15].

Hemothorax

Hemothorax has been consistently defined as a collection of blood in the pleural space or a pleural fluid hematocrit of greater than 50%. It is estimated that 300,000 cases of hemothorax occur annually in the United States, the majority of which are due to thoracic trauma. Although more infrequent, spontaneous and iatrogenic or vascular causes of hemothorax may also occur [16].

Pathophysiology

Bleeding into the hemithorax may arise from diaphragmatic, mediastinal, pulmonary, pleural, chest wall and abdominal injuries. Each hemithorax can hold 40% of a patient's circulating blood volume. Studies have shown that injury to intercostal vessels (e.g., internal mammary arteries and pulmonary vessels) lead to significant bleeding requiring invasive management [17].

Decortication

The surgical process of lung decortication entails the removal of the parietal pleura, full lung mobilization and fissure correction, removal of fibrous peels covering the visceral pleura, and full pleural space suctioning. It involves the excision of the restrictive layer of the thick fibrinous peel overlying the lung, chest wall, and diaphragm [13].Removing the thick peel allows the lung to expand and deflate, restores compliance in the chest wall, and quickly alleviates the patient's symptoms [18].

The pleural space is often less than 1 mm thick. Numerous pathologic conditions can affect the distribution of specific cells and fluids within this space, which can have major medical repercussions [19]. Fibrothorax, an aberrant buildup of fibrous structures over the lung or visceral pleura, is a common pathologic condition that impacts the pleural space [20]

Indications of decortication:

Pleural empyema, whether pyogenic or tubercular, is the main condition for which lung decortication is recommended. Klebsiella pneumoniae, Staphylococcus aureus, Streptococcus pneumoniae, and other bacteria can cause pyogenic empyema. Hemothorax, pleural thickening brought on by inflammatory diseases like rheumatoid arthritis, and malignancies like malignant mesothelioma are additional reasons for lung decortication [13].

For the following situations, the majority of surgeons will perform a decortication: The pleural peel has been present for more than 4-6 weeks, the lung symptoms are incapacitating, and radiologic evidence of a trapped lung is present. [13].

Contraindications of decortication:

Contraindications of decortication include both absolute and relative factors. Absolute contraindications include severely compromised lung function, where preoperative lung function testing indicates minimal lung reserve, making the procedure too risky. Bronchial stenosis is also a contraindication, as these patients require resection of the stenosed segment and bronchial anastomosis in addition to decortication. Unresectable malignant disease, such as advanced-stage pleural malignancies, may not benefit from decortication and can worsen the patient’s condition. Patients with significant cardiac conditions or renal failure are at higher risk for complications, as surgical stress may exacerbate these conditions. Diffuse, non-localized infection is another contraindication, as it increases the risk of spreading infection and causing sepsis. Uncontrolled coagulopathy also poses a high risk of intraoperative and postoperative bleeding [13, 21].

Relative contraindications include advanced age and frailty, where recovery from such an invasive procedure may be difficult. Early-stage empyema responsive to conservative management may not require decortication, as non-surgical treatments can be effective. Minimal pleural fibrosis, which does not significantly restrict lung function, may not justify the procedure. Poor nutritional status increases the risk of wound healing complications and infections. Limited life expectancy due to other severe conditions may reduce the benefit of surgery. Additionally, chronic obstructive pulmonary disease

(COPD) or other advanced lung diseases can complicate the procedure, as the lung tissue may be more fragile and less responsive to re-expansion. [13].

Outcomes of decortication:

After decortication, the outcomes are frequently positive. Following this procedure, the patient's age, underlying comorbidities, the emergence of surgical complications, and post-operative chest physiotherapy all affect morbidity and mortality. Young individuals generally respond quite well to decortication [9].

Younger individuals with benign causes of fibrothorax usually have very good results and significantly better quality of life [22].The majority of patients have symptom improvement shortly after surgery. While symptom alleviation is better, recovery is frequently slower in older patients with many comorbidities. Most patients are able to resume their original work after regaining their prior exercise endurance.

However, there may be a significant rate of morbidity if the surgery is performed on individuals who have impaired lung function. In addition to the actual surgery, patients without lung reserve are at significant risk for complications from the thoracic incision and general anesthesia. According to earlier research, overall mortality in healthy individuals is less than 1%, but in those with underlying lung illness, it may reach 4-6%. However, mortality rates have generally been marginally lower with VATS [23].

In order to prevent complications, the surgeon needs to be meticulous. Care should be taken when removing the peel to prevent harm to surrounding organs. Lung function significantly improves with proper decortication. However, preoperative lung disease determines the final recovery of lung function. Complete lung expansion and pleural space obliteration are undoubtedly conceivable if the lung parenchyma was normal before surgery. Although it is uncommon to observe a return to preoperative values, lung volumes typically improve following decortication [24].

Complications:

Many complications, such as infections (perioperative sepsis syndrome), bronchopleural fistulas, hemorrhage, and ongoing air leaks, are linked to decortication. In certain situations, a bronchopleural fistula or prolonged air leak may require a second surgery. Large air leaks might last for weeks, although most leaks stop within a few days. A 50% hypertonic glucose solution administered intraoperatively may shorten the length of air leakage following prolonged pleurectomy-decortication for malignant pleural mesothelioma, according to a retrospective case-control study by Testori et al [25].

Bleeding may originate from adhesion lysis, the lung, or the pleural surface. So, before you leave the operating room, make sure you have adequate hemostasis. The majority of surgeons use both a suture and a clip to bind blood arteries. [25].

Sepsis and retained infectious focus: During decortication, the pus must be completely removed and the pleural toileting must be completed. Sepsis during the postoperative phase can result from retained pus, which is an infection nidus. [25].

Persistent lung collapse: In the postoperative phase following decortication, lung parenchymal collapse and non-expansion are commonly observed. Chest physiotherapy and incentive spirometry are essential for the underlying parenchyma's re-expansion. However, because of damaged or diseased lungs, certain patients could not exhibit sufficient lung expansion. [25].

When a residual air space remains, infection of the pleural space may develop. To seal off the remaining space and get rid of the infection, the patient can occasionally require an apical tent or a muscle flap. [25].

Surgery does not directly result in respiratory failure. Compared to healthy individuals, patients with questionable lung function are more likely to have respiratory discomfort throughout the recovery phase. Long-term ventilation and maybe a tracheostomy may be necessary for a high-risk patient who had surgery or if the preoperative workup was inadequate. [25].

Damage to important structures: Skilled surgeons must carefully perform decortication. Vital structures like as the diaphragm, esophagus, pericardium, and subclavian arteries are frequently injured if the peel

removal limits are not followed. [25].
Excruciating pain following surgery: Any thoracotomy, particularly those involving rib resection, may cause excruciating agony following surgery. A mix of intravenous and epidural analgesia may be necessary for adequate postoperative analgesia [13, 25].

Video Assisted Thoracoscopic Surgery (VATS) for Decortication

The first thoracoscopy was carried out in 1910 by medical professor Hans Christian Jacobaeus. In order to achieve therapeutic pneumothorax in a patient suffering from pulmonary tuberculosis, he employed a modified cystoscopy for the destruction of pleural adhesions [26].
With the arrival of drug treatment of tuberculosis and the end of the era of pneumothorax therapy, the use of thoracoscopy declined. However, its use was retained by respiratory physicians in several European centers as a diagnostic tool. [26].

Surgical technique

The standard VATS procedure involves using 3 to 4 incisions made in a triangular configuration for scope and instrument insertion **[27]** Alternatively, VATS with a single port has also been described **[28].**
The patient is administered anesthesia in the supine position. A DLT is the airway device of choice for most procedures. After DLT placement, the position of the tube is confirmed with a fiberoptic bronchoscope via the lumen of the DLT. Care is taken to ensure adequate positioning of the cuff. After confirming adequate tube and cuff placement, the patient is positioned in the lateral decubitus position with the arm over the head. Arching of the table is done to allow adequate surgical exposure. The position of the DLT is then rechecked after final positioning for the procedure. [28].

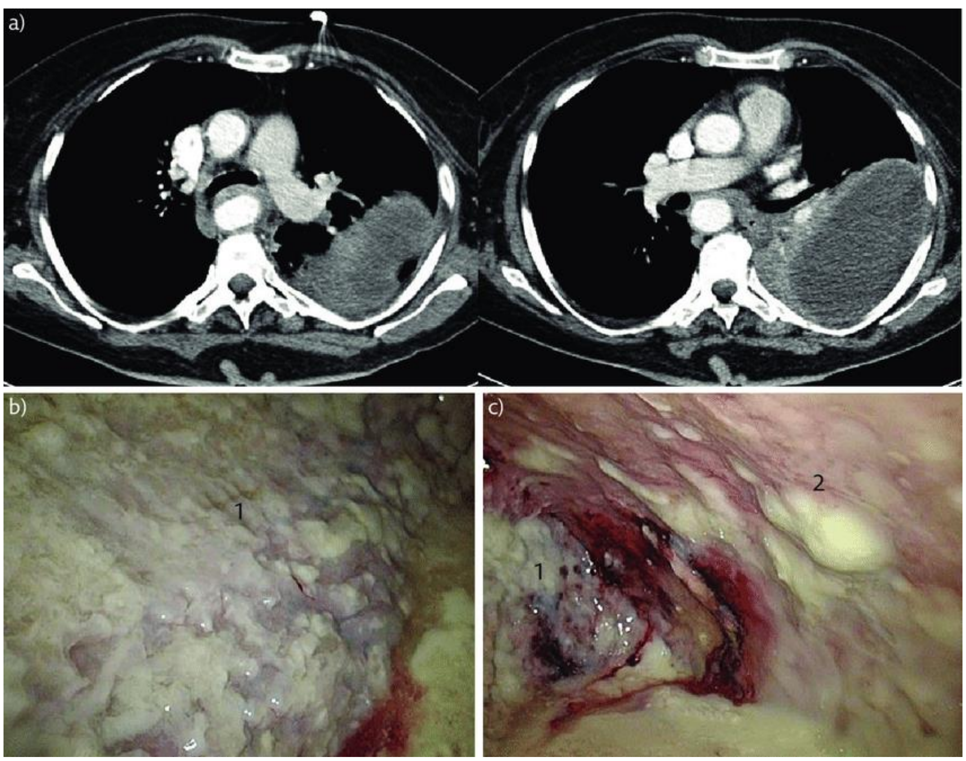

Figure 1: VATS decortication in pleural empyema stage III. a) Pre-operative CT of the thorax; b and c) operative views with thick fibrin layer over the parietal pleura and cortex overlying the lung. 1: lung; 2: chest wall. *[29]*.

Three incisions are made for the anterior approach. Together they form a triangular configuration with the utility incision at the apex of the triangle. The camera is inserted through this incision for the creation of other entry ports safely. [26].
A port is created to accommodate the camera in the auscultatory triangle. A third port is created in the mid-axillary line. This is created at the level of the utility port incision. After the creation of the 3 ports,

assessment is done using the video thoracoscope. Further steps of the surgery are usually guided by the specific procedure to be performed. [26].

Depending on the surgery performed, 1 or 2 pleural drains, connected to an underwater seal drain are usually placed at the end of surgery [30].

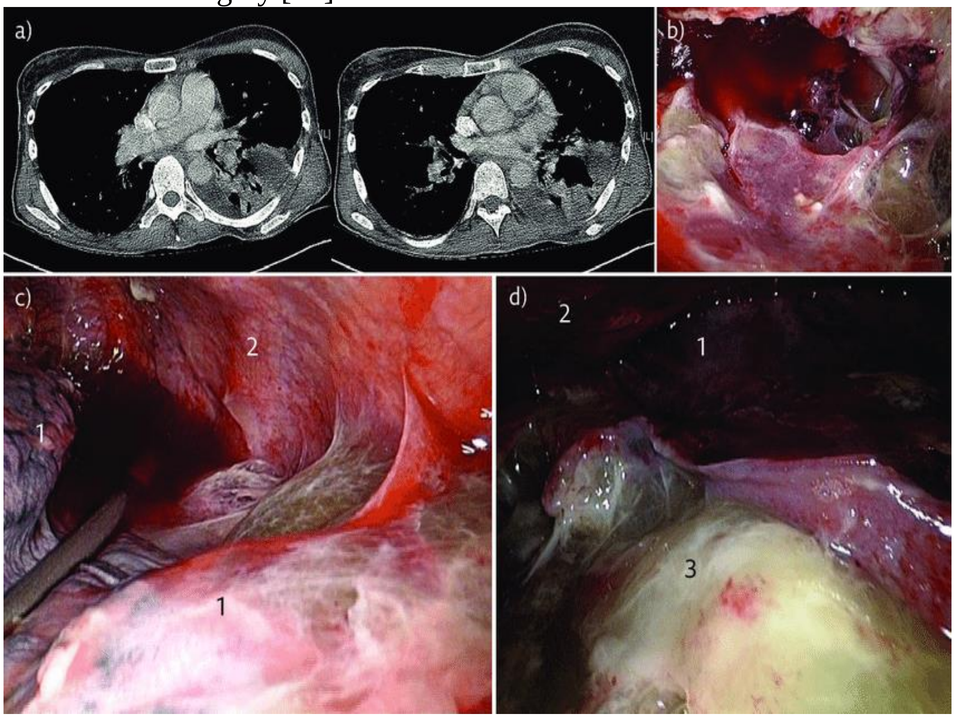

Figure 2: VATS decortication in pleural empyema stage II. a) Pre-operative CT of the thorax; b-d) operative views with multiple intrapleural loculations. 1: lung; 2: chest wall; 3: sub-pulmonary fibrin collection. [29].

Open thoracotomy for Decortication

Open thoracotomy is a surgical procedure involving an incision into the pleural space of the chest to access thoracic organs such as the heart, lungs, esophagus, or thoracic aorta. This major surgical maneuver requires general anesthesia with endotracheal intubation and mechanical ventilation. Postoperative pain management is crucial, as inadequate control can lead to complications like atelectasis or pneumonia due to ineffective breathing efforts [31].

Procedure

Anesthesia and Airway Management

The patient is administered general anesthesia to ensure unconsciousness and immobility during the procedure. A double-lumen endotracheal tube is typically used to allow for single-lung ventilation, facilitating better surgical exposure and reducing the risk of lung injury. The correct placement of the tube is verified using a fiber-optic bronchoscope [32].

Entering the Thoracic Cavity

After muscle division, the desired intercostal space is identified, commonly the fourth or fifth intercostal space, depending on the target area. The intercostal muscles are divided along the superior border of the lower rib to avoid injury to the intercostal neurovascular bundle. Care is taken to prevent damage to the internal thoracic vessels anteriorly. Once the pleural cavity is entered, a rib spreader is inserted, and the ribs are gently separated to provide adequate exposure [31].

Performing the Intended Procedure

The surgical approach in chronic empyema involves a posterolateral thoracotomy to access the pleural cavity. After entering the chest, the surgeon evacuates purulent material and performs decortication, which entails removing the restrictive fibrous peel from both the visceral and parietal pleura. This allows the lung to re-expand fully, restoring its function [13].

Outcomes and Efficacy

Studies have demonstrated that open thoracotomy with decortication can be performed with low morbidity and mortality, offering excellent long-term functional results. For instance, a retrospective review of 33 patients undergoing this procedure reported no mortality and a mean postoperative hospital stay of 10 days, with all patients achieving full lung re-expansion and resolution of infection [33].

Conclusion

Both VATS and open thoracotomy are effective surgical options for decortication in chronic pleural diseases, each with specific advantages and limitations. VATS is increasingly preferred due to its minimally invasive nature, reduced postoperative morbidity, and quicker recovery, making it suitable for early to moderate disease stages. However, open thoracotomy remains indispensable in complex or advanced cases where complete decortication cannot be achieved thoracoscopically. Overall, patient outcomes are favorable when appropriate surgical techniques are selected based on disease severity and patient condition. Complications, although relatively common, can be minimized through meticulous surgical technique and proper perioperative care. Therefore, individualized treatment planning is crucial to achieving optimal clinical results and improving patient quality of life.

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