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Lung Decortication: Nursing Assessment, Perioperative Care, and Postoperative Rehabilitation Strategies

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Abstract

Background: Empyema thoracis and chronic pleural diseases impose significant morbidity due to lung entrapment by fibrous pleural rind, leading to restrictive ventilatory defects and persistent infection. Lung decortication remains a definitive surgical intervention to restore lung expansion and pleural mechanics.

Aim: To review the indications, contraindications, operative principles, and nursing strategies associated with lung decortication, emphasizing multidisciplinary care and postoperative rehabilitation.

Methods: A comprehensive literature-based analysis was conducted, integrating anatomical, physiologic, and clinical perspectives. The review synthesizes operative techniques (open thoracotomy, VATS, robotic approaches), perioperative preparation, equipment requirements, and nursing roles across the care continuum.

Results: Lung decortication effectively removes the fibrous pleural peel, enabling lung reexpansion, improving compliance, and reducing infection risk. Indications include chronic empyema, organized hemothorax, and fibrothorax, while contraindications encompass nonviable lung parenchyma, bronchial stenosis, and uncontrolled systemic infection. Postoperative success hinges on pain control, chest tube management, pulmonary physiotherapy, and vigilant monitoring for complications such as hemorrhage, air leaks, and sepsis. Evidence supports minimally invasive approaches (VATS) for early-stage disease, with comparable outcomes to thoracotomy in selected cases.

Conclusion: Lung decortication is a physiologically restorative procedure that demands precise surgical execution and coordinated multidisciplinary care. Optimal outcomes depend on timely intervention, rigorous patient selection, and structured postoperative rehabilitation to prevent complications and enhance functional recovery.

Keywords: Lung decortication, empyema thoracis, pleural peel, thoracotomy, VATS, postoperative nursing care, pulmonary rehabilitation.

Introduction

Pneumonia continues to impose a substantial burden on health systems and remains a leading cause of hospitalization in the United States. Contemporary estimates indicate that approximately one million individuals are admitted annually with this diagnosis. Among hospitalized patients, pleural space involvement is a frequent and clinically significant complication. Parapneumonic effusions develop in a sizeable proportion of cases, occurring in roughly 20% to 40% of patients admitted with pneumonia. Although many effusions resolve with antimicrobial therapy and supportive care, a clinically important subset progresses along an inflammatory continuum toward infected pleural collections. It is estimated that approximately 5% to 10% of parapneumonic effusions evolve into empyema, translating to an annual incidence of about 32,000 empyema cases in

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the United States.[1][2] This progression has major implications for morbidity, resource utilization, and outcomes, as empyema frequently necessitates escalation of care, prolonged hospitalization, and complex multidisciplinary management. The prognosis of empyema is not trivial. Mortality remains notable, with approximately 15% of affected patients dying despite contemporary advances in antimicrobial therapy, imaging, and procedural management.[1][2] Moreover, empyema frequently proves refractory to conservative strategies alone. An estimated 30% of patients ultimately require operative intervention to achieve adequate pleural drainage and infection source control.[1][2] These epidemiologic observations underscore that pleural infection is not merely an ancillary complication of pneumonia but rather a distinct, high-stakes entity that can destabilize respiratory physiology, perpetuate systemic inflammatory responses, and compromise functional recovery. They also highlight why timely recognition, appropriate staging, and definitive intervention are central to improving outcomes, especially in patients who fail to respond to chest tube drainage, fibrinolytic therapy, or antibiotic management.

Within this context, lung decortication represents a definitive surgical strategy that has long been integrated into the therapeutic armamentarium for pleural space disease. Historically, decortication is a well-established procedure with origins in the late nineteenth century, first performed by Delorme in 1895 as a treatment for empyema.[3] Its endurance in surgical practice reflects the fundamental pathophysiologic problem it addresses: the development of a restrictive pleural "peel" that traps the lung and prevents adequate re-expansion. Although the specific operative approach and perioperative support have evolved considerably since the initial descriptions, the conceptual basis remains consistent—namely, the mechanical liberation of the lung from a fibrous encasement that perpetuates collapse, impairs ventilation, and provides a protected niche for ongoing infection. Clinically, decortication is primarily indicated in chronic empyema thoracis, whether pyogenic or tuberculous in etiology, and it is also employed in other pleural and thoracic conditions characterized by an organized fibrinous rind and functional restriction. These conditions include retained hemothorax, diffuse pleural thickening, and comparable disease states in which pleural fibrosis produces persistent lung entrapment and physiologic compromise. In chronic empyema, the pleural space often transitions from an exudative phase into fibrinopurulent organization and, eventually, into a late stage characterized by dense fibrocollagenous deposition. In this advanced setting, simple drainage may be insufficient because the lung remains constrained by a rigid shell, and residual loculations can maintain infection and inflammation even when pleural fluid output diminishes.

The operative essence of decortication is the meticulous excision of the restrictive fibrous layer overlying the lung, chest wall, and diaphragm. This thick fibrinous "peel" is removed to restore lung compliance and enable re-expansion, and the surgical dissection typically extends across the visceral pleura covering the lung surface, including the interlobar fissures, as well as along the parietal pleura lining the chest wall and diaphragmatic surfaces. The technical objective is not merely to evacuate purulent material but to eliminate the structural barrier that mechanically prevents alveolar recruitment and predisposes to persistent atelectasis. By removing this constricting rind, decortication aims to re-establish negative-pressure mechanics within the hemithorax, facilitate effective ventilation-perfusion relationships, and improve the patient's capacity for oxygenation and secretion clearance during recovery. A notable operative consideration is the relative sparing of the mediastinal surface of the lung. In standard practice, the mediastinal pleural interface is generally left intact, except in areas where adhesions can be safely divided without exposing the patient to undue risk involving critical mediastinal structures. This restraint reflects the proximity of major vessels, the heart, and other vital anatomic components, and it underscores the balance that surgeons must maintain between achieving adequate lung liberation and avoiding iatrogenic injury. Decortication therefore requires both anatomic precision and a careful risk-benefit appraisal, particularly in patients with dense adhesions, prior thoracic interventions, or complex infectious anatomy. The pathogenesis of the pleural peel provides the physiologic rationale for the procedure. The thick fibrinous layer characteristic of advanced empyema develops through an organizing inflammatory process in which fibroblasts proliferate and infiltrate the fibrin matrix. Over time, this process produces a robust, restrictive fibrous scaffold that transforms the pleural space from a fluid-filled, potentially drainable collection into a compartmentalized, rigid environment that constrains the lung.[4] The resulting entrapment contributes to persistent dyspnea, impaired lung mechanics, and diminished functional reserve. It may also perpetuate infection by limiting antibiotic penetration, preventing effective drainage of residual loculations, and maintaining an inflammatory microenvironment that supports ongoing tissue injury. In extreme cases, the end-stage manifestation can be fibrothorax, a condition in which diffuse pleural fibrosis produces long-term restriction and chest wall deformity, complicating both respiratory mechanics and post-illness rehabilitation.

While decortication has traditionally been emphasized in advanced-stage empyema where conservative measures have failed or organization is established, emerging clinical experience has also supported its value in earlier decision-making paradigms. Favorable outcomes have been described when decortication is adopted as a first-line intervention in selected empyema cases, as reported by Shin et al, suggesting that timely definitive surgery may reduce prolonged morbidity in appropriately chosen patients.[5] This perspective does not diminish the role of less invasive strategies; rather, it highlights that delayed escalation can allow progressive organization, increasing surgical complexity and prolonging recovery. Accordingly, contemporary practice increasingly emphasizes individualized staging and early reassessment of clinical trajectory, particularly when persistent sepsis, inadequate lung expansion, or loculated pleural disease is evident. The overarching objectives of lung decortication are fundamentally restorative and preventive. First, the procedure seeks to re-establish full lung expansion, thereby improving respiratory mechanics and gas exchange capacity. Second, it aims to eradicate the source of infection by enabling removal of infected material and eliminating the protected pleural environment in which infection persists. Third, it serves a preventive function by reducing the likelihood of long-term deformity and restrictive physiology associated with fibrothorax. In this sense, decortication is not simply an intervention for immediate infection control but also a strategy that can shape long-term pulmonary function, post-discharge quality of life, and rehabilitation potential. Given the substantial morbidity and mortality associated with empyema and its progression from pneumonia-related pleural effusions,[1][2] lung decortication remains a critical procedure within thoracic surgery and multidisciplinary respiratory care, offering a pathway to definitive resolution when pleural organization and lung entrapment threaten recovery.

Anatomy and Physiology

Lung decortication is predicated on a clear anatomic and physiologic principle: effective ventilation requires that the lung be able to expand freely within the thoracic cavity, and any process that mechanically constrains the visceral pleura or disrupts normal pleural mechanics can produce clinically significant respiratory compromise. In chronic pleural disease—most commonly chronic empyema, retained hemothorax, or fibrothorax—a dense fibrous “peel” forms over the lung surface and behaves like an inelastic shell. This cortex limits lung compliance and prevents full expansion, creating a restrictive process that can persist even after infection is controlled or fluid is drained. Decortication is therefore undertaken to remove this pathological rind, restore the capacity for lung reexpansion, and re-establish the physiologic relationship between the lung, pleural membranes, and chest wall that is necessary for normal respiratory mechanics. The pleural space is a potential space situated between the visceral pleura and the parietal pleura. The visceral pleura is intimately adherent to the lung surface, investing the lobes and fissures and moving synchronously with lung inflation and deflation. In contrast, the parietal pleura lines the inner surface of the thoracic cage, extends over the diaphragm, and reflects onto the mediastinal structures. Together, these layers create a sealed compartment that plays a critical role in maintaining the mechanical coupling between the lung and the chest wall. Under normal conditions, the pleural space contains only a minimal volume of pleural fluid, which functions primarily as a lubricant to facilitate near-frictionless movement between the pleural surfaces during respiration. This fluid is produced predominantly by the parietal pleura and is absorbed through lymphatic stomata, maintaining a dynamic equilibrium that prevents excessive accumulation.[6][7] The physiologic balance between fluid production and lymphatic absorption ensures that the pleural layers remain closely apposed, enabling the generation and transmission of negative intrapleural pressure required to keep the lungs expanded.

Empyema thoracis represents a profound disruption of this equilibrium. It is defined as the accumulation of purulent material within the pleural space and most commonly arises as a complication of pneumonia, although it may also occur after lung abscess, thoracic trauma, or postoperative contamination.[6][7] Once infection develops, pleural physiology shifts from a low-volume lubricating system to an inflammatory exudative state. Increased vascular permeability leads to exudation of protein-rich fluid, bacterial proliferation may occur within loculated compartments, and lymphatic drainage can become impaired due to inflammation, fibrin obstruction, or pleural thickening.[6][7] This combination—ongoing exudate formation, microbial burden, and reduced clearance—permits fluid accumulation and, over time, fosters progressive pleural organization. As empyema advances, the inflammatory process promotes deposition of fibrin on pleural surfaces. Initially, fibrin may be loosely distributed and potentially reversible with effective drainage and antimicrobial therapy. However, persistent inflammation promotes fibroblast infiltration and collagen deposition, converting the fibrinous material into a dense fibrotic layer that encases the lung, characteristic of the organized or chronic stage.[6][7] This fibrous cortex anchors the visceral pleura to the chest wall and diaphragm, creating lung entrapment—an anatomic state in which the lung is physically prevented from expanding despite adequate inspiratory effort and even when the pleural space is otherwise drained. The resulting physiologic consequences are significant. Lung entrapment produces a restrictive ventilatory defect because total lung capacity and vital capacity are reduced by mechanical limitation. In addition, ventilation–perfusion mismatch can develop because poorly expanded regions may be relatively under-ventilated while perfusion continues, contributing to hypoxemia and reduced gas exchange efficiency.

Normal lung expansion depends on two interrelated mechanical conditions: the maintenance of negative intrapleural pressure and the ability of the pleural membranes to glide and deform in a compliant manner as the thoracic cage moves. When a rigid pleural peel forms, it compromises both conditions. The peel restricts pleural sliding, reduces the effective compliance of the lung–pleura unit, and disrupts the normal transduction of chest wall movement into lung expansion. As a result, respiratory mechanics deteriorate. Work of breathing may increase, inspiratory effort becomes less effective, and the patient may experience dyspnea, exercise intolerance, and persistent oxygenation impairment. In chronic cases, prolonged restriction may also promote atelectasis and secondary changes in pulmonary parenchyma, further reducing respiratory reserve. The physiologic rationale for decortication is therefore to reverse these mechanical constraints by surgically removing the inelastic fibrous layer from the visceral pleura. During the procedure, the surgeon performs careful dissection to separate the fibrous rind from the underlying lung surface, aiming to preserve the integrity of the visceral pleura and avoid injury to the lung parenchyma. Once the peel is removed, lung compliance can improve substantially, allowing the lung to reexpand and reoccupy the hemithorax. This reexpansion helps eliminate residual pleural space, which is clinically important because persistent pleural cavities can serve as a locus for recurrent infection or ongoing fluid collection. By restoring the anatomical apposition between lung and chest wall, decortication re-establishes more normal pleural mechanics, reduces restrictive physiology, and improves ventilation distribution. The downstream effects include improved oxygenation, better ventilation–perfusion matching, and enhanced capacity for effective pulmonary ventilation and gas exchange, which together support recovery and functional rehabilitation.[6][7]

Indications

Lung decortication is undertaken when pleural disease produces a mechanically restrictive "peel" that prevents the lung from expanding adequately, thereby sustaining respiratory compromise and perpetuating infection or chronic functional limitation. The procedure is designed to remove a fibrous pleural rind or markedly thickened pleural cortex that has developed along the visceral pleura and, when extensive, may also involve the parietal pleural surfaces of the chest wall and diaphragm. The clinical logic for decortication is grounded in pleural anatomy and pleural physiology. The pleural space, situated between the visceral pleura that closely invests the lung and the parietal pleura that lines the chest wall, diaphragm, and mediastinum, normally contains only a minimal film of lubricating fluid. This fluid is produced primarily by the parietal pleura and absorbed via lymphatic stomata, maintaining a low-volume environment that enables frictionless movement of pleural surfaces and efficient transmission of negative intrapleural pressure to support lung expansion. When infection or inflammation disrupts pleural fluid homeostasis, exudation increases, microbial proliferation may occur, and lymphatic drainage becomes impaired; the pleural compartment can then evolve from a lubricated potential space into a pathologic collection that is progressively organized by fibrin and fibrosis.[6][7] The most frequent and clinically consequential indication for decortication is pleural empyema, whether of pyogenic or tuberculous origin, particularly when organization and lung entrapment have developed or when less invasive measures have failed to achieve source control and functional reexpansion. Empyema represents the accumulation of purulent fluid within the pleural space and most often arises as a complication of pneumonia, but it may also occur following lung abscess, thoracic trauma, or postoperative contamination.[6][7] In practice, decortication becomes most relevant when the pleural space is no longer amenable to simple drainage because the disease has entered a stage where the lung is constrained by a fibrous rind, residual loculations persist, or chronic pleural thickening prevents reexpansion despite appropriate antimicrobial therapy and tube thoracostomy. The microbial profile associated with empyema supports the need for timely definitive management, as common causative organisms include *Streptococcus mitis*, *Streptococcus pneumoniae*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*, pathogens that can drive aggressive inflammation and, in some cases, persistent infection despite initial interventions.[8]

Although empyema is the prototypical setting, decortication is also indicated in other pleural disorders that produce restrictive pleural fibrosis and functional compromise. Chronic hemothorax is a notable example, particularly when clotted blood becomes organized and prevents lung reexpansion or sustains pleural inflammation. Similarly, pleural thickening secondary to inflammatory systemic disease—rheumatoid arthritis is a commonly cited example—may produce clinically significant restriction and persistent symptoms that warrant surgical consideration in selected cases.[5][9] Pleural malignancies can also create a restrictive pleural cortex, and decortication may be considered as part of symptom-focused management or as an adjunct to oncologic strategies in conditions such as malignant mesothelioma, where thickened pleura may severely limit lung expansion and contribute to dyspnea and functional decline.[5][9] In these noninfectious settings, the indication is typically framed in terms of restoring mechanics, relieving dyspnea, and improving functional capacity, with careful attention to the patient's overall prognosis, operative risk, and expected benefit. Objective functional indicators can help support the decision to proceed with surgery, particularly when clinical symptoms and imaging findings suggest pleural restriction but the extent of physiologic impact requires quantification. A vital capacity reduced to approximately 70% or less of predicted has been described as an objective parameter that may support the indication for surgical decortication, reflecting a clinically meaningful restrictive ventilatory defect attributable to pleural constraint.[10] While no single spirometric threshold should be interpreted as an absolute criterion, functional testing can add rigor to decision-making, assist in preoperative risk stratification, and provide a baseline against which postoperative recovery can be evaluated. Such objective markers are particularly valuable when pleural disease is chronic and symptoms may be multifactorial, such as in patients with coexisting chronic obstructive pulmonary disease, heart failure, or deconditioning.

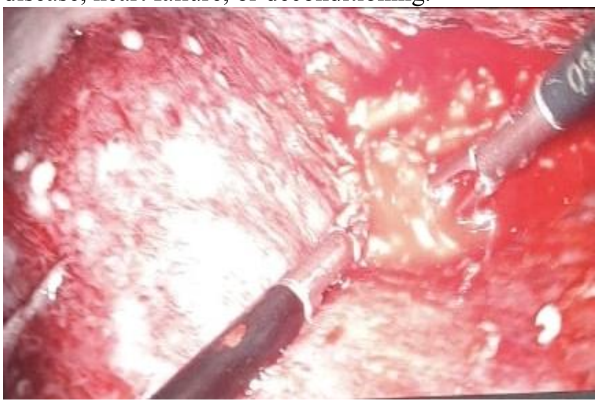

Fig. 1: Empyema Seen During Video-Assisted Thoracoscopic Surgery.

Understanding the staged evolution of empyema is central to clarifying when decortication is likely to be necessary and beneficial. Empyema is commonly conceptualized as progressing through three phases, each defined by distinct pleural pathology and varying responsiveness to less invasive interventions. In the exudative stage, occurring within approximately the first one to three days, a sterile pleural effusion develops in association with increased vascular permeability and inflammatory exudate. At this stage, pleural fluid is generally free-flowing, loculation is minimal, and timely antibiotic therapy with or without drainage may be sufficient to prevent progression.[11] The fibrinopurulent stage, typically evolving over four to fourteen days, is characterized by bacterial invasion with pus formation, deposition of fibrin, and the development of septations and loculations within the pleural space. This stage often requires more active drainage strategies, as septated collections limit the effectiveness of a single chest tube and impede complete evacuation of infected material.[11] If infection is untreated or inadequately treated, the process advances to the organizing stage, usually after two to three weeks, during which fibroblast proliferation and collagen deposition produce a dense pleural peel that encases the lung and mechanically restricts expansion.[11] It is within this organizing stage that decortication becomes most clearly indicated, because the restrictive cortex is no longer a transient inflammatory product but rather a structurally mature fibrous layer that must be removed to restore compliance and ventilation. The physiologic consequences of chronic empyema provide additional justification for operative intervention. Restriction of the lung by a fibrous rind reduces overall lung compliance and limits tidal ventilation, contributing to dyspnea, reduced exercise tolerance, and impaired oxygenation. Chronic pleural disease can also compromise chest wall and diaphragmatic mechanics, reducing effective ventilatory excursion and worsening ventilation–perfusion mismatch, which further impairs gas exchange. Beyond respiratory mechanics, empyema can drive systemic illness through persistent fever, ongoing sepsis, and catabolic stress, all of which degrade nutritional status, weaken respiratory musculature, and impair recovery capacity. Normal lung expansion depends on the maintenance of negative intrapleural pressure and the compliance of pleural membranes; when pleural fibrosis disrupts these conditions, ventilation becomes inefficient and oxygenation can remain suboptimal even when the airways and parenchyma are otherwise potentially recruitable. Decortication directly targets this pathophysiology. By meticulously removing the fibrous cortex from the visceral pleura, the surgeon seeks to re-enable lung reexpansion, eliminate residual pleural space that can harbor infection, improve oxygenation by restoring ventilation distribution, and re-establish pleural mechanics that support efficient respiratory function.

Timing is a critical dimension of indication, because the stage and etiology of pleural disease influence both technical feasibility and expected benefit. The optimal window for operative management is not uniform; rather, it is often aligned with the biologic maturity of pleural organization and the clinical trajectory under nonsurgical therapy. When multiloculated empyema is inadequately drained or when an early clotted hemothorax persists, space deloculation within approximately one to two weeks may be considered to break down loculations and improve drainage before dense organization becomes established.[12] Early decortication—often described within four to twelve weeks—may be indicated for organizing hemothorax, unresolved effusion, or empyema that has entered a stage of developing pleural rind where lung entrapment is evident and functional impairment persists despite drainage and antibiotics.[12] Late decortication, beyond three months, is generally reserved for established fibrothorax, chronic empyema, idiopathic fibrothorax, or pleural tuberculosis, where pleural thickening and restriction have become longstanding and are unlikely to reverse without surgical removal of the fibrous cortex.[12] These timing categories emphasize that decortication is not a single fixed intervention but rather a procedure whose indication is shaped by the evolving interplay between pleural pathology, infection control, lung mechanics, and the patient's physiologic reserve. Ultimately, lung decortication is indicated when pleural pathology has progressed to a state in which mechanical restriction, persistent infection risk, or chronic functional limitation cannot be adequately resolved by medical therapy and drainage alone. By restoring the anatomic integrity of the pleural space and the physiologic conditions required for lung expansion, decortication can improve pulmonary compliance, ventilation efficiency, and overall respiratory function, thereby supporting both acute recovery and longer-term rehabilitation trajectories.[6][7]

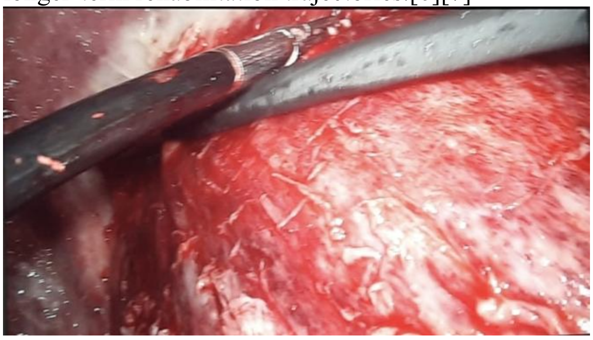

Fig. 2: Thickened Pleura Seen During Video-Assisted Thoracoscopic Surgery.

Contraindications

The decision to proceed with lung decortication requires careful appraisal of whether the anticipated physiologic benefit—restoration of lung expansion, improved ventilation, and elimination of infected pleural space—outweighs the operative risks inherent to a major thoracic procedure. Although decortication is often definitive for lung entrapment due to an organized pleural peel, it is not universally appropriate for all patients with pleural disease. Contraindications are typically framed according to whether surgery is expected to be futile, unsafe because of prohibitive perioperative risk, or unlikely to improve patient-centered outcomes given the severity of underlying pulmonary pathology or systemic illness. In this sense, contraindications are not merely procedural checklists; they reflect fundamental principles of surgical appropriateness, including the likelihood of meaningful functional gain, the feasibility of safe reexpansion, and the patient's capacity to tolerate operative stress. Among the most important absolute contraindications is the presence of an underlying lung that is severely diseased to the extent that meaningful reexpansion is not expected. Although decortication is specifically intended for a collapsed or "trapped" lung, the procedure presupposes that the lung parenchyma retains sufficient elasticity and viable alveolar units to re-expand once the restrictive pleural rind is removed. In cases where the lung is profoundly damaged—whether by chronic infection, extensive fibrosis, irreversible destruction, or other advanced parenchymal disease—removing the pleural peel may not restore function. Clinically, such patients may fail to demonstrate postoperative improvement, particularly in symptom resolution and functional capacity. In these scenarios, decortication may be ineffective and can expose patients to the morbidity of surgery without commensurate benefit. For carefully selected individuals, after comprehensive evaluation, an alternative strategy such as pneumonectomy may be considered either during the same operative sitting or later during follow-up, recognizing that lung removal may sometimes provide better source control or symptom relief when the affected lung is nonfunctional.[3]

Bronchial stenosis is also described as an absolute contraindication to performing decortication as a standalone procedure.[3] The rationale is that bronchial obstruction prevents adequate ventilation of the distal lung, undermining the very objective of decortication—restoring expansion and functional gas exchange. If an airway segment is significantly stenosed, the trapped lung may not re-expand effectively even if the pleural peel is removed, and the patient's symptoms may persist because the underlying ventilatory limitation remains uncorrected. Accordingly, these patients typically require a more complex surgical plan that includes resection of the stenosed bronchial segment, bronchial anastomosis to restore airway continuity, and decortication to free the lung surface.[3] In this context, bronchial stenosis is not simply a risk factor; it represents an anatomic barrier that makes isolated decortication inadequate. Pleural malignancy is often treated as a relatively absolute contraindication, depending on the extent and nature of disease. When pleural thickening reflects malignant infiltration rather than benign organization, decortication may not deliver durable benefit, as tumor involvement can continue to restrict lung expansion and may be associated with progressive effusions or loculated malignant disease. Additionally, the surgical planes may be less distinct, increasing bleeding and technical difficulty. While there are clinical contexts in which pleural procedures may be considered for palliation, pleural malignancy generally diminishes the likelihood that decortication will restore normal pleural mechanics in a sustained way and therefore warrants heightened caution in operative decision-making. Beyond these relatively fixed barriers, several conditions serve as strong contraindications because they substantially increase operative risk or compromise postoperative recovery. Uncontrolled invasive infection is a key example. While decortication is often performed to treat pleural infection, the distinction lies in whether the infection is localized and amenable to surgical source control versus systemic and uncontrolled to a degree that makes major surgery hazardous. In patients with severe sepsis, ongoing uncontrolled infection, or inability to stabilize physiologic parameters, operative intervention may exacerbate instability, increase the risk of postoperative organ dysfunction, and worsen outcomes. Similarly, significant operative risk constitutes a major contraindication, particularly for patients who are hemodynamically unstable, have clinically significant coagulation disorders, manifest multiorgan failure, or demonstrate poor general functional status. Such patients may not tolerate the physiologic stress of thoracotomy or video-assisted thoracoscopic surgery with extensive dissection, blood loss potential, and postoperative ventilatory demands. In these settings, decortication is generally avoided because the morbidity of major surgery may exceed any potential benefit, and alternative supportive or temporizing strategies may be preferred until stabilization is achieved.

The presence of an intrapulmonary abscess or extensive parenchymal necrosis also argues against routine decortication, because pleural peel removal alone may not address the dominant pathologic process within the lung tissue itself. When the parenchyma is extensively necrotic, the risk of persistent infection, prolonged air leak, bronchopleural fistula, or failure of lung expansion increases. In such cases, definitive management may require additional resectional procedures or a staged approach rather than decortication alone, and proceeding directly to decortication may not achieve the intended physiologic restoration. Relative contraindications focus on situations in which surgical benefit is likely to be marginal. Patients with minimal symptoms and little evidence of physiologic impairment may not gain meaningful improvement from decortication, particularly if pleural thickening is stable and lung restriction is modest. In such cases, conservative management and close monitoring may be more appropriate than exposing the patient to operative risk. The relative nature of these contraindications emphasizes individualized decision-making: symptom burden, spirometric impairment, radiographic progression, and patient preferences should all be considered. Ultimately, contraindications to decortication reflect a balance between feasibility, safety, and expected outcome, ensuring that the procedure is reserved for patients most likely to experience substantive functional and clinical benefit.[3]

Equipment

Lung decortication is a technically demanding thoracic procedure that requires meticulous tissue dissection, robust hemostatic capability, reliable lung handling instruments, and a safe system for postoperative pleural drainage. From an operative readiness perspective, the equipment set must support three essential aims: establishing and maintaining a sterile field, enabling controlled exposure and dissection of pleural planes, and ensuring immediate capacity for hemostasis and chest drainage. Because decortication may be performed via an open approach or by video-assisted thoracoscopic surgery (VATS), the equipment requirements differ in form but overlap in functional objectives. In both settings, appropriate preparation reduces intraoperative delays, supports procedural safety, and facilitates efficient teamwork among surgeons, anesthesiologists, scrub nurses, and circulating staff. For open lung decortication, preparation begins with standardized skin antisepsis to minimize surgical site infection risk. Skin preparation is typically performed using either 10% povidone-iodine or a combination solution containing 2% chlorhexidine gluconate with 70% isopropyl alcohol. Selection is generally guided by institutional protocol, patient allergy profile, and operative field considerations. Comprehensive personal protective equipment is essential for all members of the sterile team and commonly includes a sterile gown, surgical mask, eye protection such as goggles or a face shield, and sterile gloves. These measures not only protect the patient from contamination but also protect staff from exposure to blood and pleural fluid that may be infected, particularly in cases performed for empyema. Core cutting and dissection instruments are required to initiate the thoracotomy incision and progress through soft tissues to the pleural cavity. A scalpel provides controlled initial incision, while electrocautery and bipolar forceps are critical for tissue dissection and immediate hemostasis. In decortication, where inflamed pleura and adhesions can bleed significantly, reliable cautery is not optional; it is foundational to maintain visualization and minimizing blood loss. Once the thoracic cavity is entered, exposure is achieved using a rib spreader, most commonly a Finochietto rib retractor, which allows the surgeon to maintain access to the pleural space and lung surface for peel removal. Depending on the extent of pleural thickening and the operative plan, rib resection may be required to enhance exposure. In such cases, bone instruments become necessary, including a periosteal elevator to separate periosteum, a rib raspatory for controlled rib dissection, and bone-cutting tools such as a bone cutter and bone nibbler to remove segments as needed [3].

Safe manipulation of the lung during open decortication requires dedicated atraumatic grasping instruments. Duval lung grasping forceps are commonly used because their design minimizes parenchymal crushing while providing sufficient hold for retraction and positioning. Additional supporting instruments, such as sponge-holding forceps, facilitate blunt dissection, handling of gauze sponges for field control, and atraumatic tissue management. Hemostats—curved or right-angle—are required for clamping bleeding vessels, controlling small pedicles, and assisting with dissection in narrow planes. Sutures of appropriate types and sizes must be available for layered closure, vessel ligation, and reinforcement of any air-leak sites. Because restoration of pleural mechanics after decortication depends on evacuation of air and fluid and maintenance of negative pressure, intercostal drains are a critical component of the equipment set. These drains enable postoperative lung reexpansion, prevent re-accumulation of pleural collections, and allow ongoing monitoring of air leaks and drainage characteristics. Finally, postoperative wound management requires dressings, including sterile gauze and fixation materials, to protect the incision and support infection prevention. Thoracoscopic decortication (VATS) requires a different equipment architecture, centered on endoscopic visualization and minimally invasive instrumentation. A basic operating room setup and a standard thoracic surgery instrument set remain necessary, but the approach additionally depends on specialized anesthesia equipment and a video platform. A double-lumen endotracheal tube is typically required to enable single-lung ventilation, creating a motionless operative field and sufficient working space within the hemithorax. The operative team must have access to a thoracoscopy tower equipped with a high-definition monitor, light source, and camera system, because visualization is the cornerstone of safe endoscopic pleural dissection. Some centers may employ a CO_2 insufflation system to enhance space creation and improve visualization, although this is optional and depends on institutional preference and patient physiology [3].

Thoracoscopic access requires trocar and cannula sets, commonly including 5 mm and 10 to 12 mm ports, which permit introduction of the thoracoscope and working instruments. Visualization is typically provided by a rigid thoracoscope, often 30° for angled viewing or 0° depending on surgeon preference, with high-definition systems favored to optimize identification of pleural planes and reduce the risk of parenchymal injury. Endoscopic light cables are necessary to deliver illumination from the tower to the scope tip. For the dissection itself, an array of endoscopic graspers and forceps—both blunt and toothed—allow tissue manipulation and traction on pleural peel. Endoscopic scissors, in curved and straight variants, support precise cutting of adhesions and fibrous septations. Endoscopic dissectors, such as Maryland dissectors and peanut dissectors, are used for blunt dissection in sensitive planes, aiding peel elevation while minimizing lung injury. A suction–irrigation system with endoscopic suction tips is essential for clearing blood and debris, maintaining visualization, and facilitating irrigation to remove purulent material in infected cases. Energy delivery in thoracoscopic decortication commonly relies on electrocautery attachments such as a hook, spatula, or Maryland dissector with cautery capability, enabling simultaneous dissection and hemostasis. Optional advanced energy devices—such as harmonic scalpels, LigaSure, or bipolar sealing systems—may be used to improve efficiency and hemostatic control, particularly when adhesions are dense or vascular. As with open surgery, thoracoscopic procedures require reliable postoperative drainage. Intercostal drains are inserted at the end of the procedure to evacuate air and pleural fluid and to support lung reexpansion. Dressings for port sites and drain fixation typically include sterile gauze and adhesive tape to secure the system and reduce the risk of contamination or accidental dislodgement. Overall, the equipment requirements for decortication reflect the need for controlled exposure, meticulous dissection, and dependable drainage, with the specific platform—open or thoracoscopic—determining whether direct thoracic retractors or endoscopic visualization and port-based instruments form the operational core [3].

Personnel

Lung decortication is a complex thoracic operation that demands advanced procedural expertise, coordinated perioperative planning, and vigilant postoperative surveillance. Accordingly, it should be performed by trained thoracic surgeons who possess proficiency in pleural space surgery, management of dense adhesions, and intraoperative decision-making related to lung reexpansion, hemostasis, and air-leak control. Surgeon experience is particularly important because decortication frequently involves operating in inflamed or scarred tissue planes where anatomic landmarks may be distorted and where inadvertent injury to the lung parenchyma, intercostal vessels, or adjacent mediastinal structures can produce significant morbidity. The thoracic surgeon's role extends beyond the technical execution of peel removal; it includes appropriate patient selection, determination of operative approach (open versus thoracoscopic), and integration of operative findings into the overall care plan. The operative team is multidisciplinary by necessity. An anesthesiologist with experience in thoracic anesthesia is central to safe intraoperative management, particularly because decortication commonly requires single-lung ventilation, careful control of oxygenation and ventilation, and rapid response to hemodynamic fluctuations. Patients undergoing decortication often have compromised respiratory reserve due to empyema, restrictive physiology, or systemic infection, and anesthetic management must therefore anticipate perioperative hypoxemia, hypercapnia, fluid shifts, bleeding risk, and postoperative pain control requirements. The anesthesiologist is also integral to postoperative transition planning, including decisions regarding extubation, regional analgesia strategies, and postoperative monitoring intensity [4][5][6].

Surgical assistants, including first assistants and, where applicable, trainees under supervision, contribute to exposure, retraction, suctioning, and instrument handling, supporting operative efficiency and safety. Technical assistants and operating room technologists facilitate equipment readiness, management of thoracoscopic systems when used, and timely availability of instruments, energy devices, and chest drainage components. Their role is particularly important in decortication, where intraoperative needs can evolve quickly depending on the density of pleural organization, the presence of bleeding, or the requirement for additional procedures such as wedge resection or repair of air leaks. Nursing staff are essential across the preoperative, intraoperative, and postoperative continuum. Scrub nurses support sterile technique, anticipate instrument requirements, and coordinate the surgical field workflow. Circulating nurses ensure procedural readiness, medication and equipment availability, accurate documentation, and adherence to safety protocols, including surgical checklists and infection prevention measures. Beyond the operating room, ward and critical care nurses provide ongoing assessment of respiratory status, chest tube function, pain control, fluid balance, and early identification of complications such as bleeding, persistent air leak, or sepsis recurrence. Effective nursing surveillance and communication are pivotal in ensuring timely escalation when clinical deterioration is detected. Preoperative and postoperative management also requires close engagement of an experienced pulmonologist and radiologist. Pulmonologists contribute to diagnostic clarification, optimization of respiratory function, management of comorbid pulmonary disease, and guidance on perioperative ventilatory strategies. Radiologists provide critical interpretation of imaging studies, including chest radiographs and computed tomography, which are central to staging empyema, identifying loculations, assessing pleural thickness, and evaluating postoperative lung reexpansion and residual collections. Their input supports procedural planning and helps guide postoperative decisions regarding chest tube positioning, need for additional drainage, or suspicion of complications [6][7]. Finally, patients undergoing decortication for chronic empyema may require intensive monitoring in an intensive care unit during the early postoperative period. ICU-level care may be indicated to support respiratory function, manage hemodynamics, titrate analgesia, monitor chest drainage and air leaks, and rapidly treat complications in patients who often have limited physiologic reserve. In this setting, coordinated interprofessional collaboration remains essential, ensuring that surgical, anesthetic, pulmonary, radiologic, and nursing perspectives converge to optimize recovery and long-term functional outcomes [3].

Preparation

Preoperative preparation for lung decortication is a structured, risk-sensitive process that begins well before the patient enters the operating theater. Because decortication is typically performed in the context of advanced pleural disease—often with ongoing inflammation, infection, restrictive respiratory mechanics, and reduced physiologic reserve—meticulous patient selection and operative planning are essential determinants of outcome. The aim of preparation is twofold: first, to confirm that the patient’s pleural pathology is amenable to decortication and that meaningful lung reexpansion is realistically achievable; and second, to optimize the patient’s systemic condition so that they can tolerate a major thoracic intervention with acceptable perioperative risk. This requires careful synthesis of clinical history, radiologic staging, pulmonary assessment, and laboratory evaluation, with explicit anticipation of intraoperative challenges such as bleeding, dense adhesions, and postoperative ventilatory demands. A comprehensive diagnostic assessment is central to determining candidacy and guiding operative strategy. A chest radiograph provides an initial overview of pleural opacification, effusion volume, lung collapse, mediastinal shift, and gross postoperative baselines when serial comparison is needed. However, radiography alone is insufficient to characterize the complexity of organized pleural disease. Therefore, contrast-enhanced computed tomography (CT) of the thorax is typically considered indispensable for contemporary surgical planning. CT allows detailed appraisal of pleural peel thickness, the degree and distribution of lung entrapment, the presence of loculations, and the relationship of pleural pathology to the diaphragm, mediastinum, and chest wall. Equally important, CT provides information regarding the underlying lung parenchyma, enabling the surgical team to assess whether the lung is likely to reexpand after peel removal or whether significant parenchymal destruction, necrosis, or chronic fibrosis might limit postoperative functional gain. Imaging also assists in identifying associated abnormalities such as bronchopleural fistula, residual abscess cavities, or mediastinal deviation, all of which influence operative complexity and postoperative monitoring priorities [3].

In selected centers, bronchoscopy is incorporated into the preoperative workup. The rationale is that airway patency is a prerequisite for effective postoperative ventilation and lung reexpansion. Bronchoscopy can help exclude endobronchial obstruction, which might otherwise mimic pleural restriction or undermine the benefit of decortication. It can also assist with secretion clearance and provide information relevant to anesthesia planning, particularly in patients with heavy secretions, prior intubation, or suspected airway anomalies. When bronchial stenosis, tumor obstruction, or foreign body is present, management may need to include airway intervention in addition to pleural surgery, and preoperative bronchoscopy can therefore refine the operative plan and prevent avoidable intraoperative surprises. Laboratory evaluation is mandatory and should be interpreted in the context of both infectious and operative risk. A complete blood count provides baseline hemoglobin to gauge anemia correction needs and identifies leukocytosis patterns consistent with ongoing infection or systemic inflammation. A coagulation profile is essential because pleural decortication may be associated with significant bleeding due to dissection in vascularized inflammatory planes and potential injury to intercostal vessels or adhesions tethered to the chest wall. Renal and hepatic function tests guide medication selection, antibiotic dosing, and perioperative fluid management, and they also inform the anticipated ability to tolerate physiologic stress. Screening for infectious diseases is often included according to institutional protocols, particularly when blood products are anticipated or when occupational exposure considerations apply. Importantly, the surgical team must treat blood availability as a core preparation requirement rather than a contingency, because stripping the fibrous rind from the visceral pleura and chest wall may cause substantial bleeding. Therefore, adequate quantities of cross-matched blood and, when appropriate, additional blood products should be arranged preoperatively to maintain hemodynamic stability and enable prompt correction of coagulopathy should it occur intraoperatively [3].

Optimization of the patient's clinical status should accompany diagnostic evaluation. In empyema-related cases, appropriate antimicrobial therapy should be established, and drainage should be optimized where indicated to reduce systemic sepsis burden and improve functional reserve before surgery. Nutritional assessment is clinically relevant because chronic infection and catabolic stress commonly impair nutritional status, which can delay wound healing and weaken respiratory musculature. Pulmonary optimization may include bronchodilator therapy for reactive airway disease, chest physiotherapy to improve secretion clearance, and careful evaluation of oxygenation and ventilation requirements. Pain management planning is also critical, because inadequate postoperative analgesia can limit deep breathing and coughing, increasing the risk of atelectasis, secretion retention, and pneumonia. Accordingly, preoperative planning often includes discussion of regional analgesia options, multimodal pain strategies, and postoperative respiratory physiotherapy protocols to support early lung recruitment. Once the patient is deemed appropriate for surgery and optimized as feasible, preprocedure positioning becomes a key technical and safety step. The patient is typically placed in the lateral decubitus position with the diseased side uppermost, which provides optimal exposure of the operative hemithorax and facilitates surgical access to pleural planes. Correct positioning must balance exposure requirements with prevention of pressure-related injury. A folded towel or roll is commonly placed beneath the dependent side to elevate and stabilize the thorax, helping align the intercostal spaces and improving operative ergonomics. The dependent leg is flexed to approximately 90 degrees to reduce strain on the hip and lower back, while the upper leg is supported with a pillow between the knees to prevent pressure injury and maintain neutral alignment. Meticulous padding of bony prominences—such as the elbows, knees, iliac crest, and ankles—is essential to prevent neuropraxia, skin breakdown, and postoperative discomfort, particularly in lengthy cases [3]. Additional adjuncts may be used to enhance intraoperative safety depending on the laterality and anticipated dissection planes. For left-sided decortication, insertion of an esophageal dilator, bougie, or a wide-bore nasogastric tube may be undertaken in some practices to help identify the esophagus intraoperatively and reduce the risk of accidental esophageal injury during dense mediastinal or posterior pleural dissection. This step reflects the proximity of the esophagus to the left pleural space and the potential for adhesions to distort anatomy in chronic infection. After final positioning and completion of adjunct placements, the chest wall is prepared and draped using standard aseptic technique with an approved skin-preparation solution. This establishes a sterile operative field and reduces surgical site infection risk, ensuring that the procedure begins under optimal conditions for safe dissection, effective hemostasis, and reliable postoperative recovery.

Technique or Treatment

Lung decortication is a definitive pleural procedure aimed at eliminating the mechanical constraint imposed by an organized fibrous rind and, in infectious cases, achieving robust source control by evacuating purulence and restoring pleural mechanics. The operative technique is best understood as a sequence of interdependent goals rather than a single maneuver: access must be achieved safely; the pleural cavity must be entered in a manner that limits contamination and protects mediastinal structures; loculations and adhesions must be released to recreate a functional pleural space; the visceral pleural peel must be removed comprehensively to allow lung reexpansion; air leaks and bleeding must be controlled; and postoperative drainage must be established to maintain lung inflation and prevent reaccumulation. Choice of approach—open thoracotomy, video-assisted thoracoscopic surgery (VATS), or robot-assisted surgery—depends on empyema stage, the density of pleural organization, patient physiology, surgeon expertise, and institutional resources. Regardless of approach, the technical endpoints remain consistent: complete or near-complete lung liberation, elimination of residual pleural space, and restoration of ventilatory efficiency [10].

Open Decortication and the Rationale for a Lower Posterolateral Thoracotomy

Classically, decortication has been performed through a posterolateral thoracotomy, often via the sixth or seventh intercostal space. A lower thoracotomy level provides favorable access to the diaphragm and costophrenic recess, regions where adhesions and organized collections are frequently dense and where residual infected material commonly persists. Exposure of the diaphragmatic surface is particularly important because incomplete release in this area can leave the lower lobe constrained and create a dependent residual space, increasing the risk of persistent postoperative collections and impaired reexpansion. Although excision of the sixth rib is not universally required, it may be considered when pleural contraction has narrowed intercostal spaces and limited the ability to achieve adequate access. Rib resection can improve operative visualization, facilitate safer instrument handling, and reduce traction injury to intercostal neurovascular structures during prolonged retraction. Importantly, the thoracotomy site should be tailored to preoperative imaging. Computed tomography often delineates the dominant loculations, the distribution of peel, and the remaining capacity of the pleural cavity; aligning the incision with these findings optimizes access for drainage, adhesiolysis, and systematic decortication [3].

Posterolateral Thoracotomy: Operative Steps and Technical Principles

A posterolateral thoracotomy is performed with the patient in lateral decubitus position and typically under single-lung ventilation to enhance operative field exposure. The skin incision is designed to provide broad access to the pleural cavity while preserving shoulder mechanics as much as feasible. The incision generally sweeps downward, beginning at a point roughly midway between the spinous processes and the tip of the scapula, extending anteriorly toward the midaxillary or anterior axillary line, and reaching approximately two inches below the scapular tip. After incision, deeper tissues are divided with electrocautery to reduce bleeding and maintain clear planes. The latissimus dorsi and serratus anterior muscles are often divided using cautery, enabling retraction of the scapula and access to the rib spaces. Identification and counting of ribs in the subscapular region provides orientation, which is essential because the interspaces may be distorted by pleural thickening and chronic infection. Entry into the thoracic cavity is typically established through the fifth or sixth intercostal space, depending on the targeted exposure. Division of intercostal muscles should be performed along the upper border of the lower rib to minimize injury to the neurovascular bundle, which runs along the inferior border of each rib. When ribs are crowded, narrowed, or immobile due to chronic pleural contraction, limited rib resection may be required to widen access and allow safe placement of a rib spreader. Once the intercostal space is opened, the surgeon proceeds into the extrapleural space, carefully separating the parietal pleura from the chest wall for several centimeters on either side of the incision. This dissection creates room for insertion of the rib retractor and helps avoid immediate entry into the empyema cavity, which can spill infected contents and obscure visualization. When a free pleural space is present, it is opened and evacuated thoroughly, with removal of purulent fluid and fibrinous debris. When no free space exists, the operative strategy shifts: the peel is first mobilized from the parietal pleura, often beginning anteriorly over the mediastinal surface near the pericardial reflection, a region that may be relatively less adherent and can provide a safer initial plane. Throughout extrapleural entry and early dissection, protection of mediastinal structures is paramount. The mediastinum is often less involved by the inflammatory process than the lateral pleura, but adhesions can extend medially and distort anatomy. Left-sided dissection carries risk to the esophagus; right-sided medial work risks injury to the vena cava; and inferior dissection must proceed with careful attention to the diaphragm. Apical dissection requires special caution because the proximity of subclavian vessels means that aggressive traction or blind dissection can produce catastrophic hemorrhage. Consequently, experienced decortication technique emphasizes incremental exposure, deliberate identification of planes, and avoidance of forceful maneuvers, particularly near the apex and mediastinum [3].

Excision of the Fibrous Peel and Visceral Pleural Decortication

The defining technical phase of decortication is removal of the fibrous peel from the visceral pleura. The peel is typically incised with a scalpel until the thin, pliable visceral pleura is reached. This step requires tactile discrimination and visual judgment, because the interface between rind and pleura may be subtle, especially when inflammation has thickened the underlying pleura. Once the plane is established, the edge of the peel is grasped with forceps and gently separated from the visceral pleura using blunt dissection, often with a dedicated "pusher" or a gauze-covered finger. Surgeons may choose a vertical or horizontal initiating incision based on peel orientation, access, and the ease of developing the plane; multiple starter incisions may be created to allow the peel to be lifted in segments. A crucial principle is that separation should be gentle and progressive. Excessive force risks tearing the visceral pleura and injuring the underlying parenchyma, which can create air leaks, bleeding, and postoperative bronchopleural complications. Coordination with the anesthesia team can materially assist this phase. Gentle, controlled inflation of the lung by the anesthesiologist may help delineate the cleavage plane, as reexpansion tensions the peel and can facilitate separation from the pleural surface. However, inflation must be cautious to avoid barotrauma and to prevent forcing air through fragile parenchyma. Decortication must be comprehensive across the entire lung surface, including the interlobar fissures, because residual peel in fissures can prevent full expansion of lobes and perpetuate loculated residual spaces. The goal is not simply to remove the most visible rind but to restore uniform compliance across the lung, allowing each lobe to expand and eliminating the mechanical substrate for persistent atelectasis and impaired ventilation. For this reason, the rind is removed from the lung parenchyma and fissures in a systematic manner.[3]

Lung Inflation, Air-Leak Management, and Hemostasis

After the peel has been removed and the lung appears liberated, the anesthesiologist is asked to inflate the lung fully to assess reexpansion and identify air leaks. Air leaks are common because pleural peel separation can expose fragile parenchyma or open small bronchial communications. While minor leaks may seal with time, major leaks should be addressed definitively at the time of surgery. Formal closure typically involves suture repair of identifiable leak sites, potentially reinforced with pledgets or adjuncts based on surgeon preference. Achieving meticulous hemostasis is equally important. The decortication plane can ooze diffusely due to inflamed pleural surfaces, and intercostal or adhesional bleeding may be significant. Energy devices such as diathermy and bipolar forceps are commonly used to secure hemostasis, maintain visualization, and reduce postoperative hemothorax risk. The operative endpoint is a lung that expands well under controlled ventilation, without uncontrolled bleeding and with air leaks reduced to a level compatible with postoperative chest tube management.

Drain Insertion and Closure

Post-decortication pleural drainage is a functional extension of the operation. Intercostal drains are inserted to evacuate air and fluid, maintain negative pleural pressure, and promote sustained lung expansion. Some surgeons place two drains: one positioned basally and posteriorly to drain dependent fluid collections and one positioned apically and anteriorly to evacuate air and prevent pneumothorax. The drains remain in place until clinical and radiologic signs confirm adequate reexpansion and drainage output is acceptable. Closure is performed in layers, restoring chest wall integrity and ensuring secure approximation of muscles and soft tissue to reduce dead space and infection risk. In open surgery, postoperative pain control is a major determinant of respiratory function; therefore, closure planning is often integrated with analgesic strategies such as regional blocks, epidural analgesia, and multimodal systemic therapy.

Video-Assisted Thoracoscopic Surgery: Principles and Technique

VATS has become particularly useful for early-stage empyema, when the pleural cavity can be deloculated under direct endoscopic visualization, the lung can be reexpanded, and chest drains can be placed to fully drain the cavity with less surgical trauma than thoracotomy. VATS decortication is often performed via an anterior approach, though port placement is individualized. Many surgeons employ a three-port technique to allow triangulation, while others favor a uniportal approach when anatomy and disease distribution permit. A 30-degree thoracoscope is commonly used, as angled visualization improves inspection of the diaphragm, posterior pleura, and apical regions.[13] Preoperative CT is used to guide entry through a relatively uninvolved region of the thoracic cavity, which reduces the risk of placing ports directly into densely adherent or purulent compartments and helps establish working space early. Once access is established, a combination of suction and blunt dissection is used to evacuate purulence, break down septations, and perform adhesiolysis. Instruments such as a cautery hook and suction cannula are frequently effective for dissection because they allow simultaneous tissue handling, hemostasis, and field clearing. The conceptual boundaries of dissection mirror those of open surgery: loculations are disrupted, the pleural cavity is toileted, and the fibrous peel is removed to the extent necessary to permit lung expansion. Because VATS provides a limited angle of approach, surgeons may switch the camera port to improve access to different portions of the pleural cavity, facilitating systematic adhesiolysis and decortication without excessive instrument torque. Chest tubes may be inserted through port sites, minimizing additional incisions and simplifying postoperative wound care. Evidence has supported the efficacy of VATS for pleural toileting in early empyema, with comparative data suggesting that thoracotomy is associated with higher mortality, greater major morbidity, longer length of stay, and a higher likelihood of discharge to destinations other than home.[14] Meta-analytic evaluation has shown broadly similar outcomes between VATS decortication and open thoracotomy decortication in appropriate contexts, although relapse rates have not demonstrated a clear significant difference in some analyses.[15] These findings reinforce a pragmatic clinical stance: when disease stage and technical feasibility permit, minimally invasive approaches can offer important perioperative advantages; however, advanced organization, dense rind, or inability to achieve adequate lung release may still necessitate conversion to open thoracotomy to accomplish the physiologic goals of decortication safely and completely.

Robotic Lung Decortication: Emerging Application and Technical Considerations

The expanding adoption of robotic surgical platforms in thoracic surgery has enabled application of robot-assisted techniques to pleural decortication, including in selected cases of organized empyema. Although broad peer-reviewed evidence remains limited, the theoretical advantages are intuitive: wristed instruments can facilitate fine dissection in dense planes, and precise camera control can improve visualization and ergonomics, potentially enabling more effective peel removal than traditional thoracoscopy in complex cases. The feasibility of robotic decortication, however, is contingent on establishing sufficient intrathoracic working space to place ports safely—often requiring initial bedside VATS maneuvers for adhesiolysis and cavity opening before docking the robot. In typical robotic setups, three to four 8-mm robotic ports are placed in inferior interspaces, often around the eighth intercostal space, though placement is dictated by disease distribution and patient anatomy. After docking, adhesiolysis is performed with electrocautery to recreate the pleural space and expose the peel. Monopolar shears can be used to identify and develop the correct plane for decortication, while a wristed robotic suction-irrigator serves dual functions: maintaining a clear, bloodless field and providing blunt dissection capability to separate the visceral pleura from the peel. Once decortication is complete, the rind is removed from the chest after undocking, and chest tubes are placed in standard fashion to manage air and fluid and support reexpansion. In practical terms, robotic decortication is best viewed as an evolving extension of minimally invasive pleural surgery rather than a replacement for VATS or thoracotomy; patient selection, stage of disease, and institutional experience remain decisive [15].

Postoperative Care and Supportive Treatment

Postoperative management is integral to the success of decortication because the physiologic gains achieved intraoperatively can be compromised by inadequate analgesia, poor pulmonary toileting, ineffective chest tube management, or uncontrolled infection. Analgesia is a priority because thoracic incisions and pleural manipulation can produce substantial pain that limits deep breathing, coughing, and early mobilization. Effective pain control supports lung recruitment, reduces atelectasis risk, and improves the patient's ability to participate in physiotherapy. Antibiotic therapy is continued or adjusted based on microbiologic data and clinical response, particularly in empyema cases where ongoing source control is paired with systemic infection treatment. Hydration and nutritional support are necessary because many patients are catabolic, deconditioned, and at risk for postoperative complications if caloric and protein needs are not met. A subset of patients, especially those presenting with advanced empyema, sepsis, or limited baseline pulmonary reserve, may require postoperative mechanical ventilation and intensive monitoring during the initial recovery period. In these patients, vigilant observation of oxygenation, ventilation, and hemodynamics is essential. Chest tube care is equally critical: the nursing and surgical teams must monitor output volume and quality, assess persistent air leaks, ensure patency of the drainage system, and coordinate timing for tube removal based on reexpansion and clinical progress. Serial chest radiographs are commonly used to confirm lung expansion and detect recurrent collections or pneumothorax. In sicker patients, periodic arterial blood gas analysis may be needed to guide ventilatory adjustments and to detect evolving respiratory failure early. Collectively, these postoperative strategies translate the technical success of decortication into durable clinical recovery by maintaining pleural mechanics, supporting gas exchange, and preventing relapse or secondary complications [15].

Complications

Lung decortication is a major thoracic intervention that can yield substantial physiologic benefit in appropriately selected patients; however, it is also associated with a recognized spectrum of complications arising from the extent of pleural dissection, the vulnerability of the underlying lung parenchyma, and the proximity of vital mediastinal and apical structures. Many patients presenting for decortication have chronic infection, malnutrition, anemia, or diminished cardiopulmonary reserve, all of which can amplify procedural risk and complicate recovery. For nursing and interprofessional teams, a detailed understanding of potential complications is essential because early recognition and prompt, coordinated responses frequently determine whether postoperative issues remain manageable or progress to significant morbidity. Hemorrhage is among the most clinically important complications. Decortication exposes large raw surfaces on the lung and pleura after the fibrous rind is removed, and these surfaces can ooze diffusely even when focal vascular injury has been avoided. Adhesiolysis may also disrupt intercostal vessels or neovascularized inflammatory tissue, leading to substantial blood loss. Intraoperative bleeding can be evident immediately, but postoperative hemorrhage may present more subtly as ongoing high-volume chest tube output, hemodynamic instability, decreasing hemoglobin, or signs of poor perfusion. Because bleeding can be progressive, a postoperative blood profile is commonly required to assess hemoglobin and hematocrit trends and determine whether transfusion is needed. Nursing vigilance is central: continuous monitoring of chest tube output characteristics, trending vital signs, and timely escalation when output is excessive can prevent delayed recognition of major bleeding. Additionally, hemorrhage can predispose to retained hemothorax, impaired lung expansion, and infection, creating a cascade of secondary complications if not addressed promptly [15].

Persistent air leak and bronchopleural fistula represent another major risk, reflecting the fact that separation of the peel from the visceral pleura may traumatize fragile parenchyma or expose small bronchial communications. Minor air leaks are common and often resolve spontaneously within days as the lung reexpands and pleural surfaces reappose. However, large or persistent leaks may require formal closure with suturing to prevent progression to a bronchopleural fistula, a high-morbidity condition characterized by sustained communication between the bronchial tree and pleural space. Clinically, this may manifest as continuous bubbling in the underwater seal drainage system, failure of lung reexpansion, subcutaneous emphysema, or persistent pneumothorax on imaging. Effective nursing management includes frequent assessment of the chest drainage system for bubbling patterns, ensuring proper connections and suction settings, and reporting persistent or worsening air leak to the surgical team. Prompt identification is crucial because a bronchopleural fistula can prolong ventilation, increase infection risk, and necessitate re-intervention. Persistent lung collapse or incomplete reexpansion is frequently observed after decortication, even when the rind has been removed successfully. Postoperative atelectasis may arise from pain-limited ventilation, retained secretions, diaphragm dysfunction, or residual pleural space, and it can be exacerbated by preexisting lung disease and deconditioning. Incentive spirometry and chest physiotherapy are therefore central to postoperative care, supporting recruitment of alveoli and clearance of secretions. Early mobilization, effective analgesia, and optimization of cough mechanics also contribute to reexpansion. Nonetheless, some patients may fail to achieve adequate lung inflation because the underlying lung is diseased or destroyed, meaning that the parenchyma lacks the compliance and functional capacity required for reexpansion. In such cases, clinicians may observe persistent radiographic collapse and ongoing oxygenation impairment despite appropriate supportive measures, underscoring the importance of preoperative assessment of parenchymal viability and realistic postoperative expectations [15].

Injury to vital structures is an uncommon but serious complication that reflects the anatomic complexity of pleural surgery. Decortication requires operating near critical structures, particularly during apical and mediastinal dissection. If peel removal extends beyond safe limits or if dense adhesions distort anatomy, injury to the subclavian vessels can occur during apical work, potentially causing catastrophic hemorrhage. Inferiorly, the diaphragm may be damaged, leading to bleeding, impaired ventilation mechanics, or diaphragmatic dysfunction. Medial dissection risks injury to the esophagus on left-sided procedures and to the pericardium or major vessels on either side. Such injuries may manifest unexpected intraoperative bleeding, postoperative hemodynamic instability, dysphagia, mediastinal air, or pleural contamination, and they often necessitate urgent surgical evaluation. These risks highlight why decortication should be undertaken by experienced thoracic surgeons and why intraoperative caution and stepwise plane development are critical. Retained infective focus and postoperative sepsis remain significant concerns, particularly when decortication is performed for empyema. The procedure must include thorough evacuation of pus and comprehensive pleural toileting; residual purulent material can serve as a nidus for ongoing infection, leading to recurrent fever, rising inflammatory markers, persistent leukocytosis, or clinical deterioration. Sepsis in the postoperative period may present with tachycardia, hypotension, altered mental status, and worsening respiratory status, and it requires rapid assessment and treatment, including culture acquisition, antibiotic optimization, fluid resuscitation, and potential re-imaging to identify undrained collections. Nursing teams play a pivotal role by identifying early signs of systemic inflammatory deterioration and ensuring timely escalation. Severe postoperative pain is particularly common after thoracotomy, and the risk may be heightened when rib resection is required. Pain can substantially impair deep breathing and coughing, promoting atelectasis and secretion retention, thereby increasing the risk of respiratory complications and prolonging recovery. Adequate analgesia is therefore not merely a comfort measure but a physiologic necessity. Many patients require multimodal analgesia combining intravenous agents with regional techniques such as epidural analgesia to achieve sufficient pain control while minimizing respiratory depression. Close nursing assessment of pain scores, sedation level, respiratory rate, and functional breathing capacity is essential to balance analgesic benefit against adverse effects. Finally, longer-term musculoskeletal sequelae can occur. Chest wall deformity and scoliosis are recognized complications, particularly in cases involving extensive thoracotomy, rib resection, prolonged postoperative immobility, or preexisting skeletal vulnerability. These outcomes may have functional implications, affecting posture, respiratory mechanics, and chronic pain burden. Early physiotherapy, attention to mobilization, and follow-up rehabilitation planning can help reduce long-term musculoskeletal complications, supporting improved functional recovery after this intensive thoracic operation [15].

Clinical Significance

Lung decortication is clinically significant because it directly targets a fundamentally mechanical cause of respiratory disability: lung entrapment by an organized pleural rind. In chronic empyema, organized hemothorax, fibrothorax, and diffuse pleural thickening, the lung may be physiologically capable of gas exchange yet rendered functionally ineffective because it cannot expand. In this setting, symptoms and impairment are driven less by intrinsic parenchymal disease and more by an external constraint that reduces compliance, restricts tidal ventilation, and sustains ventilation–perfusion mismatch. Decortication addresses this constraint by removing the dense, fibrous cortex that encases the visceral pleura, thereby restoring the lung's ability to reexpand and reoccupy the hemithorax. When reexpansion is achieved, measurable improvements can occur in lung mechanics: compliance increases, tidal volume rises, and ventilation distribution becomes more uniform. These changes typically translate into reduced dyspnea, improved oxygenation, and enhanced tolerance of activity, particularly in patients whose limitations were previously dominated by exertional breathlessness. Beyond improving immediate mechanics, decortication re-establishes the pleural conditions required for normal negative intrathoracic pressure dynamics. The physiologic coupling between the chest wall and the lung depends on the pleural space being a low-volume lubricated compartment in which the lung can glide and follow thoracic expansion. A fibrous rind disrupts this relationship by preventing pleural sliding and by maintaining a residual space that can serve as a reservoir for fluid, air, or persistent infection. By removing the peel and eliminating loculated cavities, decortication reduces the likelihood that residual pleural spaces will persist postoperatively. This has important downstream benefits, particularly in infectious disease contexts, because residual spaces can harbor bacterial burden, contribute to recurrent effusion, and perpetuate inflammatory stress. From a functional perspective, transforming a "trapped" lung into a reexpanded and ventilating organ can generate clinically meaningful improvements in spirometric indices such as forced vital capacity and forced expiratory volume in one second, reinforcing that decortication can produce objective changes in pulmonary function rather than merely subjective symptom relief [16].

However, the magnitude and durability of benefit are not uniform and depend heavily on the condition of the underlying lung. Decortication can only restore expansion of parenchyma that retains viability and recruitability. If the lung is extensively destroyed by chronic infection, necrosis, severe scarring, or other parenchymal pathology, removal of the pleural rind may not yield substantial gain. Importantly, the duration of fibrothorax alone does not reliably predict postoperative outcome; some patients with long-standing pleural restriction can experience notable improvement, whereas others with shorter disease duration may have limited response if parenchymal disease is dominant. In patients with extensive intrinsic lung disease, postoperative gains in lung volumes may be modest, and in some cases vital capacity may even decrease, reflecting complex interactions among surgical trauma, pain-limited ventilation, and limited recruitable parenchyma. These realities underscore why judicious patient selection is central to the clinical significance of the procedure. The patients most likely to benefit are those with substantial pleural fibrosis and documented physiologic restriction, but with relatively preserved parenchymal architecture and a quality of life substantially limited by exertional dyspnea.[16] In such individuals, decortication is not simply a technical intervention; it is a restorative procedure that can normalize pleural mechanics, reduce the likelihood of chronic infection persistence, decrease the risk of bronchopleural fistula by promoting pleural apposition and stable lung expansion, and avert long-term restrictive sequelae. When applied appropriately, these effects converge to improve functional capacity, recovery potential, and overall respiratory health.[16]

Enhancing Healthcare Team Outcomes

Optimizing outcomes for patients undergoing lung decortication requires a deliberately coordinated multidisciplinary approach, because the success of the operation depends not only on the surgeon's technical ability but also on effective diagnostic staging, perioperative optimization, meticulous postoperative surveillance, and sustained rehabilitation. Clinicians responsible for initial evaluation must identify candidates who are most likely to derive meaningful benefit—patients with significant pleural fibrosis and demonstrable lung entrapment but with sufficient parenchymal integrity to allow reexpansion. This selection process relies on rigorous integration of clinical symptoms, physiologic testing, and imaging. Radiologists play a pivotal role by providing detailed interpretation of chest radiographs and computed tomography, clarifying the thickness and distribution of pleural peel, identifying loculations, and assessing the underlying lung parenchyma. Accurate imaging interpretation supports surgical planning, informs the choice of operative approach (open versus minimally invasive), and helps the team anticipate intraoperative complexity and postoperative monitoring needs. In the operative phase, thoracic surgeons, anesthesiologists, and—in higher-acuity cases—intensivists form the core decision-making unit. Preoperatively, they collaborate to stabilize infection where relevant, optimize respiratory function, and mitigate modifiable risks such as anemia, malnutrition, and coagulopathy. Intraoperatively, anesthesia management is critical because single-lung ventilation, hemodynamic stability, temperature regulation, and blood loss management directly influence safety and the quality of the surgical field. Postoperatively, intensivists may be required for patients with limited reserve, ongoing sepsis physiology, or ventilatory dependency, ensuring timely adjustment of respiratory support, fluid management, and hemodynamic therapy. Nursing contributions are central across the continuum and are often the decisive factor in early recognition of complications and functional recovery. Perioperative nurses support infection prevention, safe positioning, and procedural readiness. Postoperatively, nurses provide continuous respiratory assessment, chest tube management, pain monitoring, and early mobilization support. Their role in executing incentive spirometry protocols, facilitating coughing and secretion clearance, and identifying early deterioration—such as increased work of breathing, rising oxygen requirements, hypotension, or abnormal drainage patterns—directly affects the risk of atelectasis, pneumonia, bleeding, persistent air leak, and recurrent sepsis. Effective pain management, often guided by nursing assessment and coordinated with anesthesia and surgical teams, is particularly consequential because uncontrolled pain impairs ventilation and delays mobilization [16].

Pharmacists contribute by optimizing antibiotic selection and duration, supporting antimicrobial stewardship, managing anticoagulation and venous thromboembolism prophylaxis, and assisting with multimodal analgesic regimens to balance pain control with respiratory safety. Respiratory therapists provide specialized pulmonary hygiene, including airway clearance techniques, nebulized therapies when indicated, ventilator management for patients requiring mechanical support, and coaching on breathing exercises that enhance reexpansion. Case managers and rehabilitation professionals extend the team's impact beyond the acute hospitalization by coordinating discharge planning, arranging home oxygen or equipment needs when required, and ensuring continuity of physiotherapy and follow-up appointments. Structured interprofessional communication—such as daily multidisciplinary rounds, standardized postoperative pathways, and shared documentation—reduces fragmentation, improves situational awareness, and supports timely decision-making. When these elements are consistently applied, team performance improves, errors decrease, and care becomes more patient-centered, ultimately enhancing functional recovery, quality of life, and long-term respiratory outcomes for patients undergoing lung decortication [16].

Conclusion:

Lung decortication remains a cornerstone in managing chronic pleural disease, particularly empyema and fibrothorax, where mechanical restriction rather than intrinsic parenchymal pathology drives respiratory compromise. By removing the fibrous pleural rind, the procedure restores lung compliance, re-establishes negative intrathoracic pressure dynamics, and eliminates residual pleural spaces that perpetuate infection. However, its success is contingent upon judicious patient selection, as benefit is limited when underlying lung tissue is nonviable or systemic instability precludes safe surgery. The clinical significance of decortication extends beyond immediate infection control; it shapes long-term pulmonary function, quality of life, and rehabilitation potential. Postoperative care is pivotal—effective analgesia, chest tube management, and pulmonary physiotherapy prevent atelectasis, secretion retention, and recurrent sepsis. Nursing vigilance in monitoring drainage, respiratory status, and early signs of complications such as hemorrhage or bronchopleural fistula is essential for favorable outcomes. Minimally invasive techniques, including VATS and emerging robotic approaches, offer reduced morbidity in selected cases, though open thoracotomy remains indispensable for advanced disease. Ultimately, lung decortication exemplifies the synergy between surgical precision and multidisciplinary collaboration, underscoring the need for integrated perioperative planning and structured rehabilitation to achieve durable functional recovery and minimize long-term restrictive sequelae.

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