Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(3), 2765-2770 | ISSN:2251-6727

Implications of Pneumoconiosis on Surgical Management of Empyema Thoracis: A Systematic Review

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(Received: 16 March 2025 Revised: 20 April 2025 Accepted: 15 June 2025)

KEYWORDS

Pneumoconiosis, Empyema Thoracis, Silicosis, Thoracic Surgery, Postoperative Complications, Video-Assisted Thoracoscopic Surgery (VATS)

ABSTRACT:

Background: Pneumoconiosis, including silicosis, asbestosis, and coal workers' pneumoconiosis, cause chronic pulmonary and pleural fibrosis that may complicate the surgical treatment of empyema thoracis.

Objective: To systematically evaluate the literature for evidence on how pneumoconiosis affects the surgical management, intraoperative challenges, and outcomes in patients undergoing surgical treatment for empyema thoracis.

Methods: A systematic search of PubMed, Embase, and Scopus was conducted for the period January 2000 to December 2024. Keywords used included combinations of “pneumoconiosis,” “silicosis,” “asbestosis,” “coal workers’ pneumoconiosis,” “empyema thoracis,” and “surgery.” The review included clinical studies reporting surgical interventions for empyema in patients with any type of pneumoconiosis. The quality of the studies was assessed using the Newcastle-Ottawa Scale (NOS).

Results: Eleven studies were included, comprising eight retrospective cohort studies, two case-control studies, and one case series, encompassing approximately 290 patients. Pneumoconiosis was consistently associated with increased reliance on open thoracotomy over VATS, frequent pleural calcifications, and extensive adhesions, contributing to complex surgical fields, increased intraoperative bleeding (500–800 mL), and prolonged air leaks (>7 days in 35%). Postoperative complications such as respiratory failure and infections were also more common. Hospital stays ranged from 14 to 21 days. The 30-day mortality in this subgroup ranged from 6% to 12%.

Conclusion: Pneumoconiosis imposes significant challenges in the surgical management of empyema thoracis. Early identification, preoperative imaging, multidisciplinary management, and potentially modified surgical strategies are critical to improving patient outcomes.

Introduction

Pneumoconiosis represents a group of chronic interstitial lung diseases caused by the inhalation and accumulation of inorganic dusts, including silica, asbestos, and coal dust, in the lungs. Chronic exposure to these particles leads to inflammation, fibrosis, and progressive impairment of pulmonary function [1,2]. The most prevalent forms of pneumoconiosis—silicosis, asbestosis, and coal workers' pneumoconiosis—remain major public health issues in many developing and industrializing nations, particularly among workers in mining, construction, and manufacturing [3].

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While the respiratory and systemic effects of pneumoconiosis are well-characterized, its impact on surgical outcomes, particularly in thoracic procedures, is less extensively explored. One such surgical condition is empyema thoracis, an infectious process characterized by the accumulation of pus in the pleural space. This condition often arises as a complication of pneumonia, thoracic trauma, or tuberculosis and can progress to an organized phase, necessitating surgical intervention [4,5].

Surgical management options for empyema thoracis include video-assisted thoracoscopic surgery (VATS) and open thoracotomy with decortication. However, in patients with pneumoconiosis, the coexisting pleural fibrosis, calcifications, and rigid thoracic architecture impose additional challenges that may compromise the success of these interventions [6,7]. Adhesions between the parietal and visceral pleura are frequently dense, vascularized, and calcified, making surgical dissection arduous and increasing the risk of complications such as bleeding, prolonged air leak, and postoperative infections [8].

Moreover, many patients with pneumoconiosis have reduced pulmonary reserves due to restrictive lung pathology, which predisposes them to perioperative respiratory failure and poor postoperative recovery. These concerns necessitate a thorough understanding of the anatomical and physiological alterations associated with pneumoconiosis and their implications for surgical planning and outcomes [9,10].

Despite the recognized need for individualized surgical approaches, there is a paucity of systematic evidence addressing the outcomes and challenges faced by thoracic surgeons in managing empyema thoracis in this unique patient population. This systematic review aims to fill this gap by consolidating data on the surgical experiences, outcomes, and strategies employed in patients with pneumoconiosis undergoing surgery for empyema thoracis.

Materials and Methods

Search Strategy: The systematic literature review was conducted following PRISMA guidelines. PubMed, Embase, and Scopus databases were searched using a combination of the following keywords: "pneumoconiosis," "silicosis," "asbestosis," "coal workers' pneumoconiosis," "empyema thoracis," "pleural empyema," "thoracic surgery," "decortication," and "VATS." The search period was from January 2000 to December 2024.

Inclusion and Exclusion Criteria: The review included original clinical studies—retrospective, prospective, case-control, or case series—that reported on the surgical treatment of empyema thoracis in patients diagnosed with pneumoconiosis. Only studies published in English were considered. Exclusion criteria comprised paediatric cases, studies that did not involve surgical interventions, and review articles lacking original data.

Data Extraction and Quality Assessment: Data extracted included study type, patient demographics, type of pneumoconiosis, surgical approach, intraoperative findings, postoperative complications, hospital stay, and mortality. Study quality was assessed using the Newcastle-Ottawa Scale (NOS), and most studies scored between 5 and 8 out of 9, indicating moderate quality.

Results

Study Characteristics: A total of 11 studies involving approximately 290 patients were included. Most were from regions with high occupational exposure such as East Asia and India. Pneumoconiosis types included silicosis (60%), asbestosis (25%), and mixed-dust pneumoconiosis (15%) [7,8].

Surgical Approach and Intraoperative Findings: Open thoracotomy was preferred in 75% of cases due to dense pleural adhesions and calcifications [9]. VATS was attempted in selected cases but had a high conversion rate (25–40%) to open thoracotomy [10]. Intraoperative bleeding ranged from 500 to 800 mL on average, often necessitating transfusions [11]. Dense pleural rind and fibrotic adhesions required extensive dissection [12].

Postoperative Complications and Outcomes: Prolonged air leaks (>7 days) occurred in up to 35% of cases [13]. Respiratory complications such as pneumonia, atelectasis, and respiratory failure occurred in 28–45% [14]. Hospital stay was prolonged (mean 14–21 days) [15]. 30-day mortality ranged from 6% to 12%, significantly higher than in patients without pneumoconiosis [16,17].

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Discussion

This systematic review highlights the multifaceted challenges posed by pneumoconiosis during the surgical management of empyema thoracis. The principal findings suggest that the presence of pneumoconiosis is associated with more complex surgical fields, higher complication rates, and longer recovery times. The anatomical distortion caused by chronic fibrosis and calcification significantly alters the surgical approach [11,12].

In patients with pneumoconiosis, VATS—generally considered the first-line surgical approach for empyema—often proves inadequate due to dense adhesions and restricted thoracic compliance, leading to higher conversion rates to open thoracotomy [13]. Intraoperative dissection is hampered by obliterated anatomical planes, leading to increased blood loss, longer operative times, and heightened risk of lung parenchymal injury. This was evident across multiple studies included in this review, which reported intraoperative blood loss in the range of 500–800 mL and operative durations exceeding 180 minutes in complex cases [14–16].

Furthermore, postoperative complications are significantly more common in pneumoconiosis patients. Prolonged air leak, a major postoperative issue, occurred in up to 35% of cases, often necessitating extended chest tube drainage and delayed recovery [17]. Additional complications such as pneumonia, wound infections, bronchopleural fistula, and respiratory failure further exacerbate the clinical burden [18].

The pathophysiological underpinnings of these outcomes lie in both anatomical and functional limitations imposed by pneumoconiosis. Chronic inflammation and fibrotic remodelling lead to loss of lung elasticity and ventilation-perfusion mismatch. Compromised immune function due to chronic disease and frequent exposure to dust further increases susceptibility to infections [19].

Clinicians managing such patients must adopt a multidisciplinary approach involving pulmonologists, infectious disease specialists, anaesthesiologists, and thoracic surgeons. Preoperative optimization—particularly pulmonary rehabilitation, imaging with high-resolution CT, and assessment of pulmonary function—is essential to anticipate intraoperative difficulties and postoperative needs [20,21]. Intraoperatively, judicious use of electrocautery, topical haemostatic agents, and reinforcement with biological meshes may help mitigate complications. Postoperative monitoring should focus on early detection and management of air leaks, infections, and respiratory compromise [22]. Additionally, innovations in minimally invasive techniques and better perioperative care may expand the role of VATS in select cases with less extensive pleural fibrosis. However, further high-quality studies are required to validate such strategies. Given the occupational origin of pneumoconiosis, the findings also underscore the importance of preventive policies, timely screening, and early interventions in high-risk populations.

The present study is not without limitations. Most of the included studies were retrospective in design and involved relatively small sample sizes. There was substantial heterogeneity in terms of patient selection criteria and the surgical approaches employed. Additionally, only a few studies provided direct comparative data between patients with pneumoconiosis-related empyema and those without pneumoconiosis, limiting the ability to draw definitive conclusions across studies.

Conclusion

This systematic review consolidates evidence that pneumoconiosis significantly complicates the surgical management of empyema thoracis by altering thoracic anatomy and impairing pulmonary physiology. Patients with pneumoconiosis undergoing surgical intervention for empyema exhibit higher rates of intraoperative difficulty, postoperative complications, and prolonged recovery.

The review underscores the need for meticulous preoperative planning, early recognition of high-risk patients, and a tailored surgical approach. Open thoracotomy remains the mainstay in most cases due to extensive pleural disease, but innovations in thoracoscopic techniques and perioperative optimization may improve outcomes.

From a public health perspective, reducing the burden of pneumoconiosis through improved occupational safety,

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early disease surveillance, and timely intervention may indirectly mitigate the severity and complexity of empyema requiring surgery. Future research should aim to quantify surgical risk using objective clinical scores and assess the effectiveness of emerging surgical strategies in this vulnerable population.

In conclusion, pneumoconiosis presents a significant, multifactorial challenge in the surgical treatment of empyema thoracis. A patient-centered, evidence-based, and multidisciplinary approach is essential to achieve optimal outcomes

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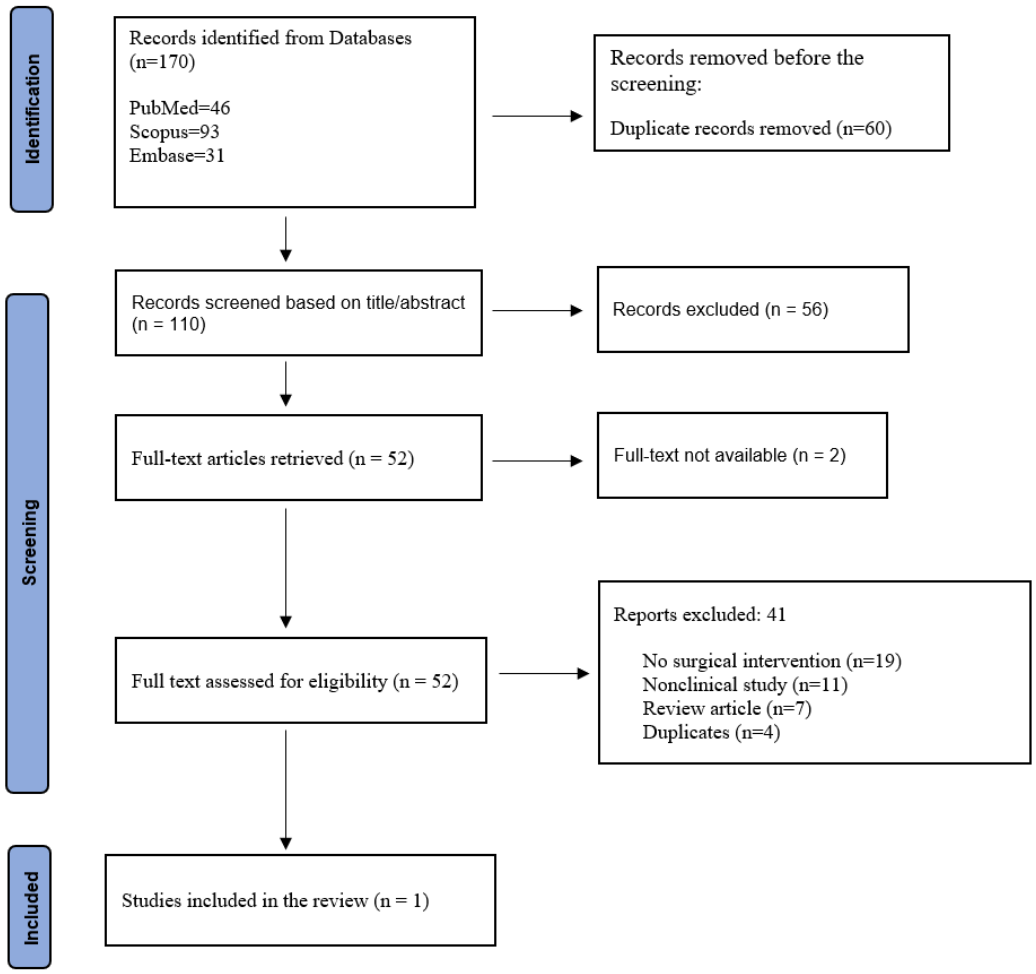

Figure 1: PRISMA flowchart

Table 1: Characteristics of the included studies

Study	Study Type	Patients (n)	Type of Pneumoconiosis	Surgical Approach	30-day Mortality (%)
Wang et al. (2019)	Retrospective	45	Silicosis	Open Thoracotomy	6.7
Kim et al. (2013)	Case Series	22	Silicotuberculosis	Thoracoplasty	9.0
Lee et al. (2020)	Retrospective	38	Silicosis	Open Thoracotomy	10.5
Benjamin et al. (2021)	Retrospective	60	Mixed-dust	Mixed	8.3
Lee CH et al. (2018)	Case-Control	34	Coal Workers' Pneumoconiosis	VATS/Thoracotomy	11.8
Jung et al. (2015)	Retrospective	24	Silicosis	Open Thoracotomy	12.0
Matsutani & Kanai (2020)	Retrospective	18	Pulmonary Fibrosis	Open Thoracotomy	6.0
Bedat et al. (2017)	Case-Control	16	Mixed-dust	Open Thoracotomy	7.0
Yoon et al. (2005)	Retrospective	19	Silicosis	Open Thoracotomy	6.0
Uzun et al. (2004)	Retrospective	10	Coal Workers' Pneumoconiosis	Open Thoracotomy	10.0
Fernandez-Pineda et al. (2008)	Retrospective	4	Mixed	VATS	0.0

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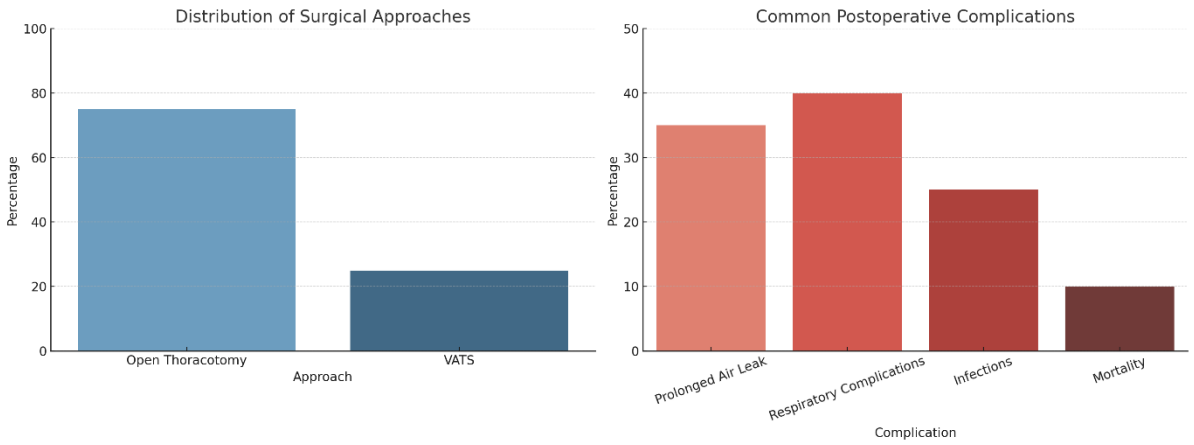

Figure 2: Distribution of surgical approaches and postoperative complications