Pulmonary resection and conservative management for infection-related destroyed lung: a systematic review and meta-analysis

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Abstract

Background: Destroyed lung is extensive and irreversible pulmonary parenchymal damage after chronic infection and may cause recurrent infection, hemoptysis, respiratory failure, and death. The relative outcomes of resection and nonresection management remain uncertain **Methods:** PubMed, Scopus, Cochrane CENTRAL, ScienceDirect, and Google Scholar were searched for adult studies published from January 2005 through 30 October 2025. Observational studies were assessed with the Newcastle-Ottawa Scale. Single-arm proportions were pooled separately for operative and conservative cohorts using fixed- or random-effects models, and clinically heterogeneous pulmonary-function outcomes were synthesized narratively **Results:** Fourteen observational studies involving 9,060 participants were included; 11 contributed to quantitative synthesis. Pooled long-term mortality was 0.10 (95% confidence interval [CI] 0.05-0.15) after pulmonary resection and 0.22 (95% CI 0.13-0.32) with conservative management. Pooled overall complications were 0.27 and 0.44, recurrent pulmonary infection was 0.14 and 0.44, respiratory failure was 0.04 and 0.43, and short-term mortality was 0.05 and 0.43, respectively. Pulmonary-function evidence was too heterogeneous for pooling **Conclusion:** Pulmonary resection was associated with lower pooled mortality and morbidity among selected surgical candidates. Because all evidence was observational and comparisons were predominantly indirect, the findings support individualized multidisciplinary selection rather than routine surgery for all patients
Keywords: conservative management; destroyed lung; meta-analysis; pulmonary resection; tuberculosis

1. Introduction

Destroyed lung is characterized by extensive and irreversible loss of functioning pulmonary parenchyma after chronic infection. It is most frequently described after pulmonary tuberculosis, although severe post-infectious bronchiectasis and chronic fungal infection can produce a similar structural phenotype. Typical radiologic findings include marked volume loss, fibrosis, cavitation, bronchiectasis, pleural thickening, and mediastinal shift. Patients may experience recurrent infection, chronic productive cough, progressive dyspnea, massive or recurrent hemoptysis, pneumothorax, pulmonary hypertension, and respiratory failure (Gyabaah et al., 2024; Ivanova et al., 2023; Liu et al., 2024; Meghji et al., 2025).

Management is difficult because antimicrobial treatment may control active infection but cannot restore destroyed parenchyma. Conservative care therefore emphasizes pathogen-directed therapy, airway clearance, bronchodilators, oxygen, pulmonary rehabilitation, and bronchial artery embolization when hemoptysis occurs. These strategies are essential for patients with bilateral disease, limited cardiopulmonary reserve, or prohibitive operative risk, but they may not eliminate the nonfunctioning lung as a persistent source of infection and bleeding (Hill et al., 2019; Subotic et al., 2016).

Pulmonary resection, including lobectomy, bilobectomy, and pneumonectomy, can definitively remove nonfunctioning infected tissue in carefully selected patients. Observational surgical series have reported durable control of infection and hemoptysis, but the procedure remains technically demanding because of dense adhesions, distorted hilar anatomy, collateral vessels, and poor baseline pulmonary reserve (Bai et al., 2012; Byun et al., 2012; Ruan et al., 2021). The balance between early operative risk and potential long-term benefit has not been clearly established, and previous evidence largely consists of single-center cohorts without direct comparison with conservative care.

This systematic review and meta-analysis synthesized available evidence on pulmonary resection and conservative management for infection-related destroyed lung. The primary objectives were to estimate pooled short- and long-term mortality within each management strategy. Secondary objectives were to evaluate overall complications, recurrent pulmonary infection, respiratory failure, recurrent hemoptysis, pneumothorax, pulmonary function, rehospitalization, and quality of life.

2. Methods

2.1. Study design and reporting

This systematic review and meta-analysis was prepared in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021). The review protocol was not prospectively registered.

2.2. Information sources and search strategy

PubMed, Scopus, Cochrane CENTRAL, ScienceDirect, and Google Scholar were searched for studies published from January 2005 through 30 October 2025. The core Boolean strategy was: ("destroyed lung" OR "tuberculosis destroyed lung" OR "post-tuberculosis lung disease") AND ("lung resection" OR "pulmonary resection" OR "pneumonectomy" OR "lobectomy") AND ("conservative therapy" OR "medical management" OR "non-surgical treatment") AND ("outcome" OR "mortality" OR "complications" OR "quality of life"). Reference lists of relevant reports were also reviewed.

2.3. Eligibility criteria

Eligible designs were prospective or retrospective cohorts, observational studies, and randomized trials. Single-arm studies were eligible because direct comparative cohorts were expected to be uncommon. Participants were adults with clinically and radiologically diagnosed destroyed lung caused predominantly by tuberculosis, post-infectious bronchiectasis, or another chronic pulmonary infection. Mixed populations were eligible when at least 70% had infection-related destroyed lung or when relevant subgroup data were extractable.

Pulmonary resection included segmentectomy, lobectomy, bilobectomy, or pneumonectomy performed by open or minimally invasive approaches. Conservative management included pathogen-directed antimicrobial therapy, bronchodilators, supportive care, oxygen, pulmonary rehabilitation, repeated hospitalization, and bronchial artery embolization without definitive resection during the evaluation period. Studies were required to report at least one prespecified clinical outcome and sufficient numerical data for extraction.

Case reports, small uncontrolled case series without clearly defined outcomes, cross-sectional studies, narrative or systematic reviews, editorials, conference abstracts without complete data, duplicate datasets, noninfectious destroyed lung, transplantation studies, and reports without extractable outcomes were excluded. For mortality, eligible follow-up was in-hospital or 30 days for short-term mortality and at least 12 months for long-term mortality.

2.4. Study selection, data extraction, and risk of bias

Two reviewers independently screened titles and abstracts, assessed full texts, extracted data using a predefined form, and evaluated study quality. Disagreements were resolved through discussion or consultation with a third reviewer. Extracted items included author, publication year, study location and design, sample size, population characteristics, management strategy, type of resection or conservative treatment, follow-up, and clinical outcomes.

Observational studies were assessed using the Newcastle-Ottawa Scale, covering selection, comparability, and outcome domains. The maximum score was nine points, and studies scoring below six were excluded. Cochrane Risk of Bias 2.0 was planned for randomized trials, but no randomized trial met the eligibility criteria.

2.5. Outcomes and statistical analysis

Primary outcomes were short-term mortality, defined as in-hospital death or death within 30 days, and long-term mortality at 12 months or longer. Secondary outcomes were overall complications, recurrent pulmonary infection, respiratory failure, recurrent hemoptysis, pneumothorax, post-treatment forced expiratory volume in one second (FEV1), forced vital capacity (FVC), rehospitalization, and health-related quality of life.

The source analysis was performed in Review Manager version 5.4. Proportions were pooled separately for operative and conservative cohorts using generic inverse-variance models with 95% confidence intervals (CIs). Heterogeneity was assessed using Cochran's Q and I^2. Fixed-effect models were permitted when heterogeneity was low, whereas random-effects models were used when clinical or statistical heterogeneity was substantial. Pulmonary-function outcomes were synthesized narratively because measurements and follow-up intervals were not sufficiently comparable. As most studies evaluated only one management strategy, between-group contrasts were indirect subgroup comparisons and were not interpreted as causal treatment effects.

3. Results

3.1. Study selection

The search identified 1,250 records. After 300 duplicates were removed, 950 records underwent title and abstract screening and 890 were excluded. Sixty full-text reports were assessed; 46 were excluded because relevant postoperative outcome data were absent (n=18), the study design was ineligible (n=12), the population was inconsistent with infection-related destroyed lung (n=9), or data were insufficient or non-extractable (n=7). Fourteen studies were included in the systematic review; 11 contributed to quantitative synthesis and three were retained for narrative synthesis.

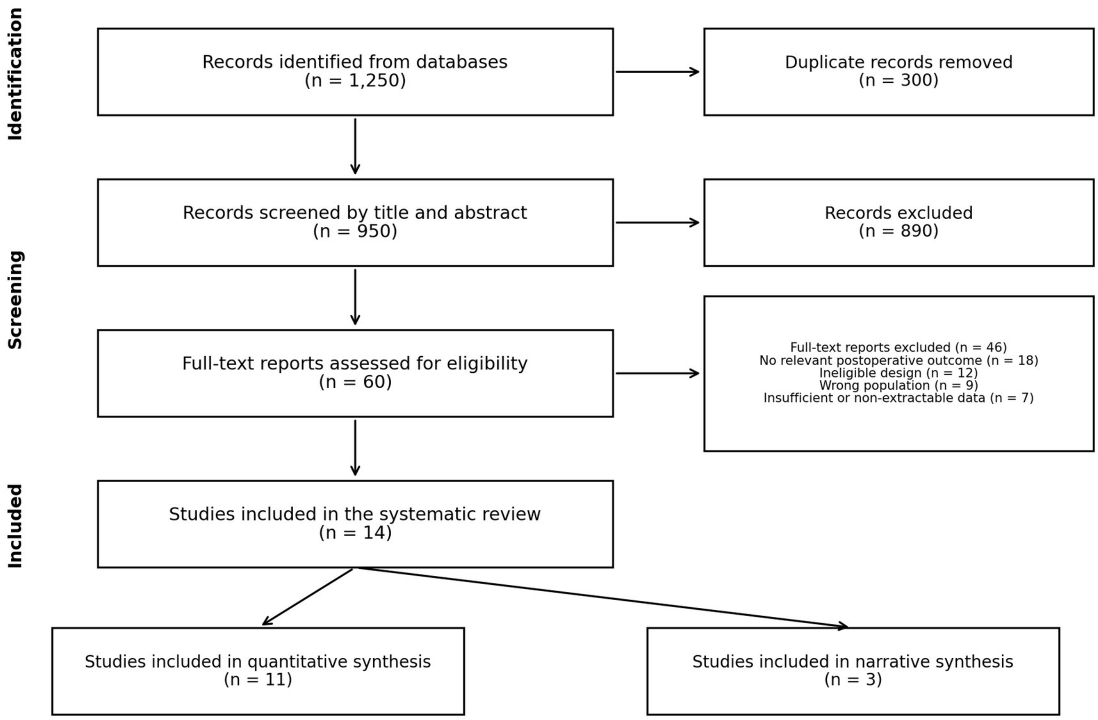

Fig. 1. Study-selection flow diagram based on PRISMA 2020.

3.2. Study characteristics

The 14 studies included 9,060 participants: seven operative cohorts with 622 participants and seven conservative cohorts with 8,438 participants. All studies were observational and most were retrospective. Surgical cohorts evaluated pneumonectomy or other pulmonary resections in patients with severe post-infectious destruction, recurrent infection, or hemoptysis. Conservative cohorts evaluated mortality, respiratory disability, pulmonary-function impairment, recurrent hemoptysis, pneumothorax, and rehabilitation outcomes. No study with a Newcastle-Ottawa Scale score below the prespecified threshold was retained.

Table 1. Characteristics of the included studies

Study	Design and sample	Management	Reported outcomes	Pooled
Bai et al. (2012)	Retrospective; n=172	Operative	Mortality, complications, respiratory failure	Yes
Byun et al. (2012)	Retrospective; n=73	Pneumonectomy	Mortality, complications, pulmonary function	Yes
D'Ambrosio et al. (2023)	Retrospective; n=56	Pneumonectomy	Complications, 1-year survival	Yes
Misirlioglu et al. (2018)	Retrospective; n=39	Pneumonectomy	Complications, pulmonary function	Yes

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Study	Design and sample	Management	Reported outcomes	Pooled
Rifaat et al. (2014)	Retrospective; n=45	Pulmonary resection	Mortality, complications, massive hemoptysis	Yes
Ruan et al. (2021)	Retrospective; n=113	Operative	Postoperative complications, pulmonary function	Yes
Zhao et al. (2024)	Retrospective; n=124	Operative	Mortality, complications, recurrent hemoptysis	Yes
Byrne et al. (2025)	Retrospective; n=7,386	Conservative	Long-term mortality, respiratory outcomes	Yes
Pasipanodya et al. (2007)	Observational; n=107	Conservative	Pulmonary function, recurrent infection	Yes
Ralph et al. (2013)	Observational; n=200	Conservative	Residual disability, recurrent infection	Yes
Ryu et al. (2011)	Retrospective; n=169	Conservative	Recurrent hemoptysis, long-term mortality	Yes
Cui et al. (2024)	Retrospective; n=331	Conservative	Pneumothorax, critical illness, mortality	No
Kim et al. (2018)	Retrospective; n=124	Conservative	Terminal respiratory failure, spirometry	No
Mtei et al. (2025)	Prospective; n=121	Rehabilitation	Pulmonary function	No

3.3. Pooled clinical outcomes

Four operative studies with 267 participants and two conservative studies with 7,555 participants contributed to long-term mortality. The pooled mortality proportion was 0.10 (95% CI 0.05-0.15; I^2=36%) after pulmonary resection and 0.22 (95% CI 0.13-0.32; I^2=87%) with conservative management. Seven operative cohorts and three conservative cohorts contributed to overall complications, with pooled proportions of 0.27 and 0.44, respectively. Recurrent pulmonary infection was 0.14 in operative cohorts and 0.44 in conservative cohorts. Respiratory failure was 0.04 and 0.43, while short-term mortality was 0.05 and 0.43, respectively. Conservative estimates demonstrated substantial heterogeneity, and the contrasts remained indirect.

Table 2. Summary of pooled clinical outcomes

Outcome	Studies Op/Con	Patients Op/Con	Operative proportion (95% CI)	Conservative proportion (95% CI)	I^2 (%) Op/Con
Long-term mortality (>1 year)	4/2	267/7,555	0.10 (0.05-0.15)	0.22 (0.13-0.32)	36/87
Overall complications	7/3	622/7,693	0.27 (0.20-0.34)	0.44 (0.13-0.76)	76/99
Recurrent pulmonary infection	7/3	622/7,693	0.14 (0.07-0.21)	0.44 (0.13-0.76)	90/99
Respiratory failure	6/2	509/456	0.04 (0.02-0.05)	0.43 (0.32-0.55)	0/97
Short-term mortality (<=30 days)	4/2	292/456	0.05 (0.02-0.07)	0.43 (0.32-0.55)	0/70

Note: Op, operative; Con, conservative; CI, confidence interval. Values are pooled single-arm proportions and do not constitute direct risk ratios.

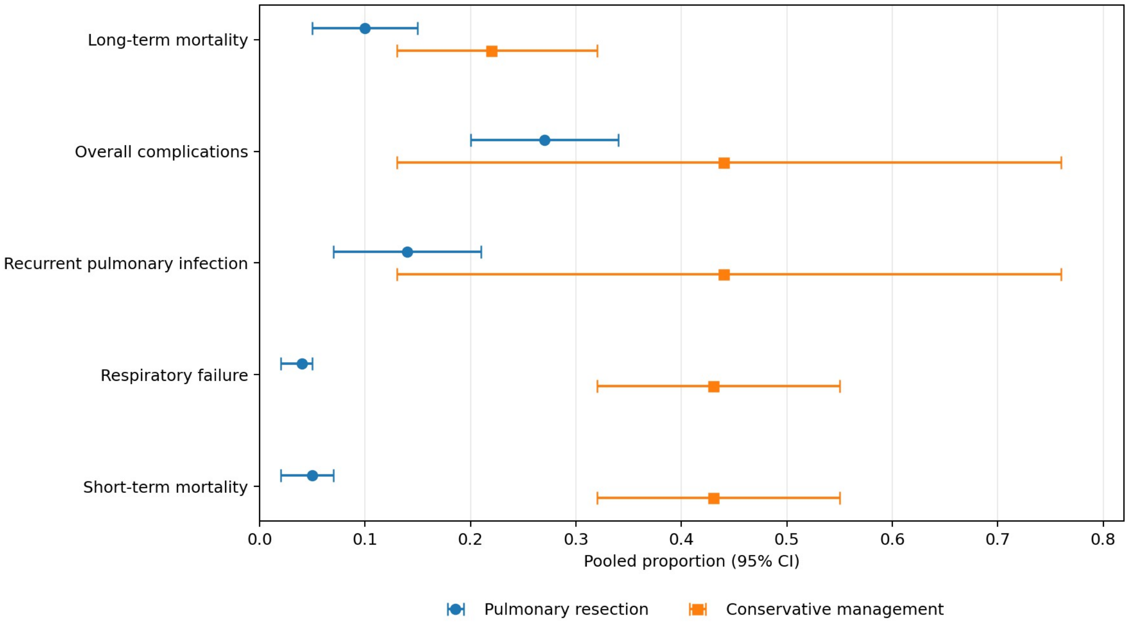

Fig. 2. Pooled outcome proportions by management strategy.

3.4. Narrative outcomes

Recurrent hemoptysis could not be pooled because comparative data were sparse. Operative reports did not document recurrent hemoptysis during follow-up, whereas Ryu et al. (2011) reported recurrence in 18.9% of conservatively managed patients. Nonresection approaches such as bronchial artery embolization can control acute bleeding but may be followed by recurrent hemorrhage (Zhao et al., 2024). Pneumothorax was also synthesized narratively. No postoperative pneumothorax was reported in the operative series, whereas Cui et al. (2024) reported pneumothorax in 8.8% of a conservatively managed cohort; generalization is limited because this outcome was represented by one conservative study.

Long-term postoperative spirometric outcomes were inadequately reported. Byun et al. (2012) described a mean preoperative FEV1 of 1.83 L and a predicted postoperative value of 1.25 L, while Misirlioglu et al. (2018) reported a mean preoperative FEV1 of 1.6 L, equivalent to 53% +/- 19% predicted. Conservative cohorts documented persistent impairment. Pasipanodya et al. (2007) reported a mean FEV1/FVC ratio of 76% after tuberculosis; Kim et al. (2018) reported median FVC of 48% predicted, FEV1 of 40% predicted, and a ratio of 0.58 among patients requiring mechanical ventilation; and Ralph et al. (2013) found moderate-to-severe residual impairment in 27% of patients. A 24-week survivor-led rehabilitation program did not significantly change spirometry (Mtei et al., 2025). Quality-of-life data were too sparse for quantitative synthesis.

4. Discussion

4.1. Principal findings and interpretation

This review found consistently lower pooled proportions of long-term mortality, overall complications, recurrent pulmonary infection, respiratory failure, and short-term mortality in operative cohorts. The direction of association is clinically plausible because resection removes severely damaged, poorly perfused tissue that can act as a reservoir for infection and a source of recurrent bleeding. Contemporary surgical series have similarly reported durable symptom control and acceptable long-term survival after pneumonectomy or other resection for post-tuberculosis destruction (Bai et al., 2012; Byun et al., 2012; D'Ambrosio et al., 2023; Misirlioglu et al., 2018; Rifaat et al., 2014; Ruan et al., 2021, 2022; Zhao et al., 2024).

The long-term mortality estimate was approximately 10% after resection and 22% with conservative management. Definitive source control may contribute to this difference, but case selection is an equally important explanation. Patients offered surgery generally undergo detailed assessment of residual pulmonary function, nutritional status, infection control, and comorbidity. Conservative cohorts may include patients with bilateral destruction, advanced respiratory failure, or contraindications to surgery. The pooled difference therefore cannot establish that surgery itself caused lower mortality.

The complication analysis requires similar caution. Surgical complications are predominantly acute and include bleeding, empyema, bronchopleural fistula, prolonged ventilation, and postoperative respiratory failure. Conservative complications accumulate over longer follow-up and include recurrent infection, hemoptysis, pneumothorax, and progressive respiratory disability. Combining clinically different events contributes to heterogeneity. Nevertheless, the lower recurrent-infection proportion in operative cohorts supports the biological rationale for removing a chronically infected, nonfunctioning lung when disease is localized and physiological reserve is adequate.

4.2. Pulmonary function and clinical implications

Pulmonary-function evidence remained a major gap. Surgical studies generally used spirometry and predicted postoperative function for preoperative selection rather than reporting standardized long-term outcomes. Conservative cohorts documented persistent obstructive, restrictive, or mixed impairment after tuberculosis. Pulmonary rehabilitation remains important and may improve symptoms, exercise tolerance, and quality of life even when spirometric change is modest (Anidi et al., 2023; Mtei et al., 2025). Future studies should report standardized postoperative and nonoperative spirometry, diffusing capacity, exercise capacity, exacerbation frequency, rehospitalization, and validated quality-of-life measures.

Pulmonary resection should not be considered universal treatment for destroyed lung. It is most defensible for localized or unilateral disease associated with life-threatening or recurrent hemoptysis, persistent infection despite optimal medical therapy, or other severe complications, provided predicted postoperative function is adequate. Care should be delivered in experienced thoracic centers with multidisciplinary input. Conservative management remains appropriate for bilateral disease, limited cardiopulmonary reserve, uncontrolled systemic illness, or patient preference and should include optimized pathogen-directed therapy, airway clearance, vaccination, rehabilitation, oxygen when indicated, and timely embolization for bleeding (Hill et al., 2019; Subotic et al., 2016).

4.3. Strengths and limitations

The review used a broad database search, explicit eligibility criteria, independent review procedures, PRISMA-based selection, and synthesis of clinically important outcomes. Narrative evidence was retained when quantitative pooling was inappropriate. Several limitations materially reduced certainty. All included studies were observational and most were retrospective. Operative and conservative estimates were largely derived from different studies rather than direct adjusted comparisons, creating selection bias and confounding by indication. Sample sizes were highly imbalanced, with one large conservative cohort dominating several analyses. Outcome definitions and follow-up intervals varied, heterogeneity was high for most conservative estimates, and publication bias could not be assessed reliably because few studies contributed to each outcome. Database-specific search histories, individual Newcastle-Ottawa Scale scores, and a study-level list of full-text exclusions were not available in the source thesis dataset. Postoperative pulmonary function and quality of life were also inadequately reported. The findings should therefore be considered associative and hypothesis-generating.

5. Conclusion

In selected patients with infection-related destroyed lung, pulmonary resection was associated with lower pooled proportions of long-term mortality and major morbidity than conservative management. Resection may provide definitive control of recurrent infection and hemoptysis when disease is localized and physiological reserve is adequate. Because available evidence was observational, heterogeneous, and based mainly on indirect comparisons, treatment decisions should remain individualized and multidisciplinary. Future research should prioritize prospective multicenter cohorts with standardized outcome definitions, adjusted or propensity-matched comparisons, and complete reporting of postoperative pulmonary function and quality of life.

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Declarations

Ethics approval: Not required because this systematic review and meta-analysis used aggregate data from previously published studies and did not involve identifiable participant-level information.

Consent for publication: Not applicable.

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Competing interests: The authors declare that they have no competing interests.

Author contributions: H.K. conceived the study, developed the methodology, performed literature screening and data extraction, conducted the analysis, interpreted the findings, and drafted the manuscript. D.P.P. and M.A.S. supervised the study, validated the clinical interpretation, and critically revised the manuscript. All authors approved the final version and the order of authorship.

Data availability: All data analyzed in this review were extracted from the published studies listed in the references. The extraction dataset and analysis files may be made available by the corresponding author on reasonable request.

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