

## SURGICAL OUTCOMES OF SINGLE CHEST TUBE DRAINAGE IN OPEN DECORTICATION FOR TUBERCULOSIS EMPYEMA

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### Abstract

**Background:** Chronic tuberculous empyema continues to be one of the major thoracic surgical challenges in high tuberculosis-burden countries. Open decortication for re-expansion of the lung is usually indicated in stage III empyema. However, the most appropriate postoperative drainage technique remains widely debated. Double chest tubes have traditionally been utilized, but recent evidence indicates that single-tube drainage provides comparable efficacy with decreased morbidity and greater patient comfort.

**Objective:** To evaluate the clinical effectiveness and safety of single chest tube drainage following open decortication in patients with chronic tuberculous empyema.

**Methods:** A total of 270 patients diagnosed with stage III tuberculous empyema and undergoing open decortication were enrolled in the retrospective cross-sectional study that was conducted at Lady Reading Hospital from January 01, 2023 to December 31, 2024. Sample size was estimated for an using the single-proportion formula, assuming a 95% confidence level ( $Z = 1.96$ ) and a margin of error of 5%. Patients were managed with a single chest tube under direct vision following decortication. The variables, namely, duration of postoperative air leak, length of stay in the hospital, drainage volume, lung expansion, and complications, were analyzed using SPSS version 26.

**Results:** The mean age of patients was  $38.4 \pm 12.6$  years, and 66.7% of the patients were male. The vast majority of patients had pulmonary tuberculosis (85.9%) and right-sided pathology (57.4%). Intraoperatively, dense pleural peel and multiloculated collections were noted in 88.5% and 74.8% of cases, respectively. The average operative time was  $90 \pm 25$  minutes and average blood loss was  $100 \pm 20$  mL. Postoperatively, average duration of drainage was  $14 \pm 2.3$  days and average hospital stay was  $3 \pm 1.4$  days. Overall, 19.6% of patients suffered complications, which included in the largest proportion prolonged air leak (8.9%) and surgical site infection (5.2%). At discharge, 85.6% of patients had total lung expansion and there were no deaths. The strongest predictors of lung expansion were a disease duration  $>2$  months, the presence of multiloculated empyema, dense pleural peel and diabetes mellitus ( $p < 0.05$ ).

**Conclusion:** A single chest tube in open decortication for post TB empyema is effective with decreased length of hospital stay, early mobilisation, and fewer complications.

## INTRODUCTION

Empyema thoracis is the collection of pus in the pleural space.<sup>1</sup> This condition is a complication of pulmonary infections, especially in regions where TB is prevalent.<sup>2</sup> TB empyema is caused by chronic pleural infections due to *Mycobacterium tuberculosis*. It results in pleural thickening, loculated pus, and fibrothorax. Lung entrapment and poor chest wall compliance can restrict respiratory function and diminish the quality of life. No matter how far the medical therapeutics and the Anti Tuberculous Treatment gets, surgery is still a necessity in the treatment of advanced or organized empyema.<sup>3</sup>

The World Health Organization estimated that Tuberculosis was still the first major global health problem in 2023. 10.6 million new cases and 1.3 million deaths were attributed to TB. This challenge is particularly prominent in low and middle-income countries like Pakistan.<sup>4</sup> The country has high burdens of both pulmonary and extra-pulmonary TB. Of the extrapulmonary forms, tuberculous empyema carries the highest morbidity due to the combination of poorly timed diagnoses, incomplete treatments, and limited surgical care. Chronic infections will frequently lead to organized pleural collections and fibrothorax which will require open surgical decortication to allow the lung to re-expand and recover function.<sup>5</sup>

The understanding of tuberculous empyema starts from its pathophysiology, which consists of exudate, serous to progressive fibrinopurulent and organizing stages, with thickening of the pleural membranes in such a way that it entraps the underlying lung. ATT, along with intercostal chest drain conservative measures, can fail if the pleural peel becomes rigid and lung expansion is blocked.<sup>6</sup> Open Decortication is in such extreme phases and is aimed towards removing the thickened pleura along with the purulent material to restore expansion of the lung. Postoperative management concerning chest tube count is still being debated.<sup>7</sup> In the past, it was the practice to use more than one chest tube to drain the pleural space adequately. However, more recent studies have suggested that a single tube may work just as well while possibly resulting in less postoperative pain,

shorter hospital stay, and lower infection rates.<sup>8</sup> Regardless of these findings, there is a paucity of data from TB-endemic areas regarding the outcomes of single chest tube drainage after open decortication. Furthermore most studies available are based on a non-tuberculous or mixed empyema population, and thus their applicability to the clinical scenario of tuberculous empyema in developing countries is quite limited.<sup>9,10</sup>

This research intends to assess the results of surgery, postoperative outcomes, and recovery for patients who have undergone open decortication for tuberculous empyema with a single chest tube drainage. This streamlined focus investigates the evidence pertaining to its safety, efficacy, and benefits in a low-resource setting. The results should improve postoperative protocols for better patient outcomes while enhancing comfort and surgical results for patients with empyema from tuberculosis in endemic areas.

## METHODOLOGY

### Study Design and Setting

This retrospective cross sectional study conducted at Department of Thoracic Surgery at Lady Reading Hospital in Peshawar, Pakistan, while from January 01, 2023, until December 31, 2024. The study got approval from the institutional ethical review board and written consents from all patients were taken before the study commenced. All the standard aseptic surgical procedures were undertaken and all the patients were operated on by trained thoracic surgeons.

### Study Population

We included patients who, having been diagnosed with tuberculous empyema thoracis, had opened decortication with the placement of a single chest tube. The diagnosis of empyema tuberculous was made based on clinical technique, imaging as well as diagnostic tests where tuberculous pneumonia was confirmed via pleural fluid, acid-smear positive for acid fast bacilli, gene amplification tests or AFB tests, AFB, or tissue samples tested for tuberculosis.

## Sample Size and Sampling Technique

The sample size was calculated using the single-proportion formula, assuming a 95% confidence level ( $Z = 1.96$ ) and a margin of error of 5%. Based on previous literature reporting approximately 80% satisfactory lung expansion following decortication, the expected prevalence ( $p$ ) was taken as 0.8. Substituting these values yielded an estimated sample size of 246, which was increased by 10% to account for potential dropouts and incomplete data, resulting in a final target of 270 patients. A consecutive sampling technique was employed, enrolling all eligible patients who met the inclusion criteria and underwent open decortication with single chest tube drainage during the study period until the required sample size was achieved.

## Inclusion Criteria

- Adult patients ( $\geq 18$  years) with confirmed tuberculous empyema.
- Patients undergoing open surgical decortication.
- Use of a single chest tube for postoperative drainage.
- Patients who provided informed consent.

## Exclusion Criteria

- MDR/XDR TB, Non-tuberculous or pyogenic empyema of other etiologies.
- Patients with bilateral empyema or prior thoracic surgery.
- Cases requiring double chest tube placement or thoracoplasty as the primary procedure.
- Incomplete or missing clinical data.

## Data Collection Procedure

Data collection was performed systematically using a proforma for this study which captures demographic data and baseline features, general and TB medical history, clinical manifestations and symptom duration, disease particulars like empyema side and stage with preceding drainage, imaging findings (multiloculated, fibrothorax, colonized lung, mediastinal shift, and so forth), intraoperative data (duration, blood loss, and lung

expansion), postoperative complications (prolonged air leak, infection, and sepsis), and surgical outcomes (length of stay, chest tube duration, lung expansion at discharge, and readmission).

All operations were performed under general anesthesia and through a posterolateral thoracotomy approach. After thorough decortication, a single chest tube (32 Fr) is inserted and attached to an underwater seal drainage. The chest tube is removed when the drainage is  $< 100$  mL and the lung is fully expanded with no air leak.

## Statistical Analysis

Data were entered and analyzed using IBM SPSS Statistics version 26.0. Continuous variables such as age, height, and weight were expressed as average with range (mean  $\pm$  standard deviation (SD)) and median (interquartile range) depending their distribution. Other data was placed in tables and the results were recorded as frequency and percentage. The Shapiro and Wilk test was used to assess the normality of data. Comparisons between groups categorical were done with the use of the Chi square test and in cases of smaller samples the Fisher's exact test. For groups comparison with one continuous variables, the t-test and in cases of deviation from normality the Mann-Whitney U test is used. A  $p$ -value  $< 0.05$  was considered statistically significant.

## Ethical Considerations

Patient information was kept private, as required during the study. No personal identities were linked to data for statistical analysis. The study followed the Declaration of Helsinki (2013 revision) ethical principles for medicine and research concerning humans.

## RESULTS

### Patient Enrollment and Baseline Characteristics

Table 1 shows that a total of 270 patients who fulfilled the inclusion criteria were enrolled in this study. All underwent open surgical decortication with single chest tube drainage for tuberculous empyema. The mean age was  $38.4 \pm 12.6$  years (range: 18–70 years). A male predominance ( $n = 180, 66.7\%$ ) was noted. The majority of patients

(62.6%, n = 169) belonged to rural areas, and most were either labourers (43.7%) or office workers (34.8%). A previous history of tuberculosis was present in all cases, with 85.9% having pulmonary TB and 14.1% extra-pulmonary involvement. The mean duration of anti-tuberculous therapy (ATT) before surgery was  $3.4 \pm 1.2$  months.

Comorbidities were present in 18.8% of patients, the most common being diabetes mellitus (10.7%) and hypertension (8.1%). The mean duration of symptoms prior to surgery was  $5.7 \pm 2.9$  months, and the right side was more frequently affected (57.4%).

**Table 1. Baseline Demographic and Clinical Characteristics (n = 270)**

Variable	Category	n (%) / Mean $\pm$ SD
Age (years)	—	38.4 $\pm$ 12.6
Gender	Male	180 (66.7%)
	Female	90 (33.3%)
Residence	Rural	169 (62.6%)
	Urban	101 (37.4%)
Occupation	Labourer	118 (43.7%)
	Office worker	94 (34.8%)
	Unemployed	58 (21.5%)
Type of TB	Pulmonary	232 (85.9%)
	Extra-pulmonary	38 (14.1%)
TB treatment status	On ATT	216 (80.0%)
	Completed ATT previously	54 (20.0%)
Duration of ATT (months)	—	3.4 $\pm$ 1.2
Comorbidities	Diabetes	29 (10.7%)
	Hypertension	22 (8.1%)
	None	219 (81.2%)
Smoking history	Current	44 (16.3%)
	Former	37 (13.7%)
	Never	189 (70.0%)
Side of empyema	Right	155 (57.4%)
	Left	115 (42.6%)
Stage of empyema	Stage II	98 (36.3%)
	Stage III	172 (63.7%)
Duration of symptoms (months)	—	5.7 $\pm$ 2.9

**Intraoperative Findings**

All patients had open decortication by posterolateral thoracotomy as shown in table 2. Intraoperative data documented dense pleural peel in 88.5%, multiloculated collections in 74.8%, and fibrothorax in 61.9%. Average operative time was  $90 \pm 25$  minutes and average blood loss was  $100 \pm 20$  mL. Complete

intraoperative lung expansion occurred in 78.9%, partial in 16.3%, and poor in 4.8%. The most common complication was minor intraoperative bleeding (4.4%), which was conservatively managed. No conversion to double tube drainage was required.

Table 2. Intraoperative Parameters of Study Population (n=270)

Parameter	Finding	n (%) / Mean ± SD
Pleural peel	Dense	239 (88.5%)
	Moderate	21 (7.8%)
	Mild	10 (3.7%)
Multiloculated empyema	Yes	202 (74.8%)
Fibrothorax	Yes	167 (61.9%)
Lung entrapment and collapse	Yes	118 (43.7%)
Operative time (minutes)	–	90 ± 25
Intraoperative blood loss (mL)	–	100 ± 20
Intraoperative lung expansion	Full	213 (78.9%)
	Partial	44 (16.3%)
	Poor	13 (4.8%)
Intraoperative complications	Minor bleeding	12 (4.4%)
	None	258 (95.6%)

**Postoperative Outcomes**

Table 3 shows that the mean chest drainage volume was 1220 ± 410 mL, and the mean chest tube duration was 14 ± 2.3 days. The average hospital stay was 3 ± 1.4 days. Postoperative complications were noted in 58 patients (21.5%). The most frequent were prolonged air leak

(8.9%), surgical site infection (5.2%), residual pleural collection (3.7%), and sepsis (1.1%). No postoperative mortality was recorded. At discharge, 231 patients (85.6%) achieved full lung expansion, 32 (11.9%) had partial expansion, and 7 (2.6%) had poor expansion on chest radiography.

Table 3. Postoperative Outcomes and Complications (n=270)

Variable	Finding	n (%) / Mean ± SD
Chest drainage volume (mL)	–	1220 ± 410
Chest tube duration (days)	–	14 ± 2.3
Hospital stay (days)	–	3 ± 1.4
Complications	Prolonged air leak (>5 days)	24 (8.9%)
	Surgical site infection	14 (5.2%)
	Residual pleural collection	10 (3.7%)
	Sepsis	3 (1.1%)
	Respiratory failure	2 (0.7%)
Mortality	Bleeding requiring transfusion	5 (1.9%)
	–	0 (0%)
Lung expansion at discharge	Full	231 (85.6%)
	Partial	32 (11.9%)
	Poor	7 (2.6%)

**Factors Influencing Lung Expansion**

People who had symptoms for more than 2 months, had multiloculated empyema, or had dense pleural peel had significantly lesser chances of complete lung expansion documented. Additionally, extensive lung disease substantially

lowered lung expansion. However, age, gender, and laterality of disease did not significantly influence outcomes.

Table 4. Association Between Clinical Factors and Lung Expansion Outcome (n=270)

Variable	Full Expansion (n = 231)	Partial/Poor (n = 39)	p-value
Duration of disease > 2months	46 (19.9%)	19 (48.7%)	0.001*
Multiloculated empyema	162 (70.1%)	34 (87.2%)	0.031*
Dense pleural peel	197 (85.3%)	37 (94.9%)	0.048*
Diabetes mellitus	20 (8.7%)	9 (23.1%)	0.009*
Fibrothorax	133 (57.6%)	30 (76.9%)	0.034*
Side (Right)	133 (57.6%)	22 (56.4%)	0.88
Age > 40 years	94 (40.7%)	20 (51.3%)	0.21

\*Significant at  $p < 0.0$

### Follow-up Outcomes

After 3 months, 93% of patients, which is 252 patients fully expanded their lungs, while 4.8% developed some minor pleural thickening and 1.9% had recurred empyema which needed re-decortication or thoracoplasty. About 91% of patients returned to their normal routine 4 to 6 weeks after the operation. There were no late deaths or major disabilities for the 6.4 month average period.

### DISCUSSION

Tuberculous empyema continues to be an immense medical hurdle- mainly in places where tuberculosis is endemic.<sup>11</sup> The inflammatory reaction from Mycobacterium tuberculosis causes changes like fibrothorax, pleural thickening, and even an obstructed lung, causing the need for surgical decortications to restore lung functionality. In the cases we reviewed, most patients were older males from rural regions. This coincides with the distribution of sophisticated and highly-developed regions in South Asia where tuberculous infections and mycobacterial inflammatory diseases remain advanced for prolonged periods.<sup>12,13</sup> This area also has little to no healthcare access, and patients typically receive treatment in later stages of the disease. The tendency for patients to have right-sided empyema correlates with other explained anatomical prepositions and increased ratios of ventilation and perfusion in the right lung.

The symptoms consisted of cough, chest pain, difficult breathing, and fever. These symptoms seem to line up with what the literature says. The average time a patient had symptoms before the operation was 3.8 months, which shows a delay in reference and response to anti-tubercular therapy. ATT, anti-tubercular therapy, was being used by the patients before the operation.<sup>14</sup> This indicates that in cases of chronic empyema where the pleura is fibrotic and prevents adequate drainage, ATT fails. This observation strengthens the guideline which suggests that in case of unresolved empyema after 4–6 weeks of ATT, surgical intervention is to be planned, and done without further delay.

Our study showed good results using one chest tube after open decortication: 84% of the patients demonstrated full lung expansion and there were very few complications after the procedure.<sup>15</sup> This is consistent with other researches who noted that the single-tube approach has adequate drainage with less pain and shorter hospital stays, and lower tube-related infection rates compared to dual-tube systems. Of note, prolonged air leak and incomplete lung expansion, post decortication common concerns occurred in only 6.7% and 10% of patients in our study, respectively, demonstrating the effectiveness of the surgical technique and careful assessment of lung expansion in the surgery.<sup>16</sup>

The mean hospital stay of 3 days and mean chest tube duration of 14 days in our cohort are comparable to results from other contemporary studies employing minimally invasive or modified open approaches.<sup>17,18</sup> Our results indicate that even in resource-limited settings, standardized perioperative management and the use of a single

drainage tube can achieve excellent results. Moreover, no mortality often falls within acceptable limits for surgery of TB empyema, ranging globally from 0 to 4% as per WHO.<sup>19,20</sup>

The study finds that single-tube drainage in open decortication employed for tuberculous empyema is both safe and effective, and is relatively less expensive than the multi-tube method. However, the single center approach and the lack of follow up (over six months) is a significant downside for the study. More multicenter follow up studies are necessary to conclusively prove re-expanded lungs to be functionally recovered.

## Conclusion

Open decortication with single chest tube drainage proved to be an effective and safe surgical approach for the management of chronic tuberculous empyema, achieving satisfactory lung re-expansion and low complication rates in the majority of patients. The procedure demonstrated reduced postoperative morbidity, shorter hospital stay, fewer complications and excellent drainage efficacy, making it a viable and cost-efficient option for resource-limited, TB-endemic settings. These findings reinforce that a single drainage tube, when placed under direct vision during decortication, can provide adequate pleural evacuation while minimizing patient discomfort and infection risk.

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