



Evaluation and comparison of the outcomes of pleural mechanical abrasion and chemical pleurodesis in patients with spontaneous pneumothorax; a retrospective case-control study

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Abstract

Introduction: Spontaneous pneumothorax is a common thoracic emergency, and surgical intervention is often required to prevent recurrence in patients at high risk or with persistent air leak. Among the available surgical strategies, pleural mechanical abrasion and chemical pleurodesis are widely used to achieve pleural symphysis, yet their relative efficacy, safety, and procedural efficiency remain a matter of clinical debate.

Objectives: This retrospective case-control study was conducted to evaluate and compare the outcomes of pleural mechanical abrasion and chemical pleurodesis in patients with spontaneous pneumothorax.

Patients and Methods: This retrospective case-control study included 82 patients with spontaneous pneumothorax treated at two tertiary hospitals in Karaj, Iran, between March 2019 and March 2022. Patients were allocated to pleural mechanical abrasion (n = 40) or chemical pleurodesis (n = 42) with tetracycline powder, and data on demographics, surgical indications, perioperative variables, postoperative complications, recurrence, and mortality were extracted from medical records and compared between groups.

Results: The results indicated that postoperative complications, including pain, fever, hypotension, tachypnea, pneumonia, wound infection, and persistent air leak, and mortality rate did not differ significantly between groups of pleural mechanical abrasion and those receiving chemical pleurodesis ($P < 0.05$). However, pneumothorax recurrence was significantly lower after chemical pleurodesis compared to mechanical abrasion, and chemical pleurodesis was also associated with a significantly shorter operative time ($P < 0.05$). Hospitalization time tended to be shorter with chemical pleurodesis; however, this difference did not reach statistical significance.

Conclusion: Chemical pleurodesis with tetracycline powder appears to provide superior clinical efficacy to pleural mechanical abrasion for spontaneous pneumothorax, by reducing recurrence and operative time while maintaining a similar safety profile. These results support chemical pleurodesis as a preferable surgical option in appropriately selected patients.

Introduction

Spontaneous pneumothorax is defined by the accumulation of air in the pleural space without preceding trauma or iatrogenic cause, and is classified into primary spontaneous pneumothorax, occurring in the absence of underlying lung disease, and secondary spontaneous pneumothorax, arising as a complication of pre-existing pulmonary pathology (1). Population-based data from England spanning nearly five decades documented an annual incidence of 14.1 per 100,000 persons by 2016, with a markedly higher rate in males than females (2). Primary spontaneous pneumothorax preferentially

affects young, lean individuals, whereas secondary spontaneous pneumothorax tends to occur in older patients with chronic obstructive pulmonary disease or interstitial lung disorders and carries a higher morbidity (3,4). Recurrence rates following non-surgical management range from 25% to 54%, making durable prevention of recurrence a primary therapeutic objective (3,5).

Pleurodesis, the deliberate induction of adhesion between the visceral and parietal pleura, is the cornerstone of recurrence prevention in spontaneous pneumothorax and may be achieved through mechanical or chemical means (6). Pleural mechanical

Key point

In this case-control study, we found that postoperative complications and mortality were comparable between patients undergoing pleural mechanical abrasion and those treated with chemical pleurodesis, with no significant differences observed. In contrast, chemical pleurodesis resulted in a significantly lower recurrence of pneumothorax and a shorter operative time. Although hospital stay appeared shorter in the chemical pleurodesis group, this trend was not statistically significant. These results support chemical pleurodesis as a preferable surgical option in patients with spontaneous pneumothorax.

abrasion, most commonly performed via video-assisted thoroscopic surgery (VATS), involves physical abrasion of the parietal pleural surface to provoke a fibrosis-inducing inflammatory response and is routinely combined with bullectomy (4). Chemical pleurodesis involves intrapleural instillation of a sclerosant, most commonly talc, or tetracycline derivatives such as minocycline, to induce lasting pleural symphysis (7). Both modalities are endorsed by major international guidelines as appropriate surgical strategies for recurrent or high-risk spontaneous pneumothorax (6).

Despite broad clinical use of both techniques, their comparative efficacy remains an area of active investigation. A systematic review and meta-analysis found that chemical pleurodesis after bullectomy was associated with a significantly lower recurrence rate (1.2%) than mechanical pleurodesis alone (4.0%) and a shorter hospital stay, while operative time and complication profiles were similar (8). A further meta-analysis demonstrated that combined mechanical and chemical pleurodesis conferred a 63% lower relative risk of recurrence compared with mechanical pleurodesis alone (9). A systematic review comparing pleural abrasion with apical pleurectomy found no significant difference in recurrence rates, but abrasion was associated with shorter operative times, less surgical blood loss, and reduced chest tube duration (10). Given the persisting uncertainty and limited head-to-head data, the present retrospective case-control study was designed to evaluate and compare outcomes of pleural mechanical abrasion and chemical pleurodesis in patients with spontaneous pneumothorax.

Objectives

The objective of this study is to evaluate and compare the clinical outcomes of pleural mechanical abrasion and chemical pleurodesis with tetracycline powder in patients with spontaneous pneumothorax, focusing on postoperative complications, pneumothorax recurrence, operative time, and length of hospital stay.

Patients and Methods**Study design and participants**

This retrospective case-control study included patients with spontaneous pneumothorax treated at Shahid Madani and Shahid Bahrani hospitals in Karaj, Iran,

over a three-year period from March 2019 to March 2022. The study enrolled 82 eligible individuals, who were assigned to one of two treatment groups based on the intervention received: a control group managed with pleural mechanical abrasion and a case group treated with chemical pleurodesis using tetracycline powder.

Inclusion and exclusion criteria

This study included patients with a confirmed diagnosis of spontaneous pneumothorax who were referred for surgical management and were eligible for either pleural mechanical abrasion or chemical pleurodesis with tetracycline powder. Individuals with traumatic or iatrogenic pneumothorax, significant hemodynamic instability precluding the planned procedures, or incomplete clinical records were excluded to ensure a homogeneous population and reliable data collection.

Group classification

Patients with spontaneous pneumothorax were classified into two groups according to the definitive intraoperative intervention they received. One group comprised individuals managed with pleural mechanical abrasion, representing the control arm ($n = 40$), while the other group included those treated with chemical pleurodesis using tetracycline powder as the case arm ($n = 42$).

Data collection

Data were collected retrospectively from hospital records and operative reports of eligible patients with spontaneous pneumothorax, alongside patients' telephone contact for more information in case of necessity. Demographic characteristics (age and gender), smoking status, and surgical indications were extracted, along with details of the procedure performed, including type of pleural intervention, operative time, and duration of hospitalization. Postoperative outcomes and complications, such as chest pain, fever, hypotension, tachypnea, pneumonia, wound infection, persistent air leak, recurrence of pneumothorax, and mortality, were systematically recorded using a standardized data abstraction form.

Outcome measurement

Measured outcomes in this study included both perioperative parameters and key clinical endpoints to compare pleural mechanical abrasion with chemical pleurodesis using tetracycline powder in patients with spontaneous pneumothorax. Operative time and length of hospital stay were recorded as indicators of procedural efficiency and resource utilization. Postoperative complications, such as chest pain, fever, hypotension, tachypnea, pneumonia, wound infection, and persistent air leak, were systematically assessed, alongside pneumothorax recurrence and mortality, to evaluate the safety and effectiveness of each intervention.

Statistical analysis

Statistical analyses were performed using SPSS version 27 (IBM Corp., Armonk, NY, USA). The distribution of continuous variables was initially examined with the Kolmogorov–Smirnov test to assess normality, and because parametric and nonparametric approaches yielded comparable findings, parametric methods were preferentially applied to optimize statistical power and efficiency. Categorical data were analyzed using the chi-square and Fisher's exact tests, while differences in continuous outcomes between the two treatments groups were evaluated with independent t-tests, with a *P* value below 0.05 considered indicative of statistical significance.

Results

In this study, a total of 82 patients with spontaneous pneumothorax were included, with 42 patients allocated to the chemical pleurodesis group and 40 to the pleural scarification group. The gender distribution was broadly similar between groups, with both techniques applied predominantly in male patients and a smaller proportion of female patients in each group without statistically significant differences. Smoking was more frequent among patients undergoing pleural scarification, whereas nonsmokers were more common in the chemical pleurodesis group; however, this difference did not reach statistical significance. Surgical indications demonstrated no significant difference between the two groups; recurrent pneumothorax was the leading surgical indication in both groups, but it accounted for a higher proportion of procedures in the chemical pleurodesis group, while lung collapse and prolonged air leak were relatively more represented among patients treated with pleural scarification. The mean age was comparable between the two groups, indicating that the cohorts were demographically similar in terms of age distribution (Table 1).

The statistical analysis indicated that the two groups of pleural scarification and chemical pleurodesis had broadly similar profiles for most postoperative complications, and none of these differences reached statistical significance. Chest pain, fever, hypotension, tachypnea, pneumonia,

wound infection, and air leak all occur at low frequencies in both groups, with statistical analysis indicating no statistically significant between-group differences for these outcomes. Recurrence of pneumothorax was numerically higher after pleural scarification than after chemical pleurodesis, and this difference was statistically significant. There was no mortality in either group. By contrast, surgery duration is clearly shorter in the chemical pleurodesis group, and this difference is statistically significant, whereas the modestly shorter hospitalization time in the chemical pleurodesis group does not reach conventional statistical significance (Table 2).

Discussion

The principal findings of the current study were that chemical pleurodesis was associated with a lower pneumothorax recurrence rate and a shorter operative time compared with pleural mechanical abrasion, while the safety profiles, including postoperative complications and mortality, were comparable between the two groups. These results extend the existing evidence base by providing additional data on the comparative clinical efficacy of these two pleurodesis strategies in a real-world surgical setting. The finding of a lower recurrence rate in the chemical pleurodesis group is consistent with a growing body of comparative evidence. A systematic review and meta-analysis of seven studies, comprising 1,032 cases of mechanical and 901 cases of chemical pleurodesis, reported that chemical pleurodesis after bullectomy was associated with a significantly lower recurrence rate (1.2%) compared with mechanical pleurodesis alone (4.0%), with a pooled odds ratio of 3 (8). A network meta-analysis of 37 studies encompassing 7,210 patients further demonstrated that among surgical adjuncts to bullectomy, chemical pleurodesis was superior to mechanical pleurodesis and staple line coverage in reducing pneumothorax recurrence (11). A systematic review of chemical pleurodesis effectiveness similarly concluded that chemical pleurodesis administered post-surgically or via thoracoscopy produced the lowest recurrence rates, with minocycline yielding rates of 0.0–2.9% following VATS; tetracycline derivatives, including tetracycline powder as used in the

Table 1. Comparison of demographic characteristics among patients with chemical pleurodesis and those who underwent pleural scarification

Data		Pleural scarification (n = 40)	Chemical pleurodesis (n = 42)	P value
Qualitative variables, No. (%)				
Gender	Male	29 (72.5)	27 (64.3)	0.427*
	Female	11 (27.5)	15 (35.7)	
Smoking	Yes	23 (57.5)	16 (38.1)	0.080*
	No	17 (42.5)	26 (61.9)	
Surgical indication	Recurrent pneumothorax	29 (72.5)	38 (90.5)	0.054**
	Prolonged air leak	4 (10)	2 (4.75)	
	Lung collapse	7 (17.5)	2 (4.75)	
Quantitative variables (Mean ± SD)				
Age (years)		27.9 ± 5.35	29.21 ± 4.97	0.329***

SD: Standard deviation. *Chi-square, **Fisher's Exact test, ***Independent t-test.

Table 2. Comparison of clinical outcomes and side effects among patients with chemical pleurodesis and those who underwent pleural scarification

Data		Pleural scarification (n = 40)	Chemical pleurodesis (n = 42)	P value
Qualitative variables, N (%)				
Chest pain	Yes	5 (12.5)	8 (19.05)	0.420*
	No	35 (87.5)	34 (80.95)	
Fever	Yes	6 (15)	5 (11.9)	0.683*
	No	34 (85)	37 (88.1)	
Hypotension	Yes	2 (5)	1 (2.4)	0.530*
	No	38 (95)	41 (97.6)	
Tachypnea	Yes	4 (10)	7 (16.66)	0.370*
	No	36 (90)	35 (83.34)	
Pneumonia	Yes	4 (10)	2 (4.75)	0.366*
	No	36 (90)	40 (95.25)	
Wound infection	Yes	3 (7.5)	1 (2.4)	0.285*
	No	37 (92.5)	41 (97.6)	
Air leak	Yes	2 (5)	0 (0)	0.145*
	No	38 (95)	42 (100)	
Recurrence	Yes	12 (30)	5 (11.9)	0.045*
	No	28 (40)	37 (88.1)	
Death	Yes	0 (0)	0 (0)	1.00*
	No	40 (100)	42 (100)	
Quantitative variables (Mean ± SD)				
Surgery duration (min)		83.84 ± 19.3	54.28 ± 22.7	<0.001**
Hospitalization time (day)		6.45 ± 3.36	4.8 ± 2.0	0.054**

SD: Standard deviation, *Chi-square, **Independent T-test.

present study, have been identified as effective sclerosant agents owing to their capacity to induce a robust pleural inflammatory cascade that promotes lasting fibrotic symphysis, thereby achieving durable pleural adhesion (7). The favorable recurrence outcomes observed in the present study are therefore in line with published meta-analytic data supporting chemical agents as effective tools for recurrence prevention.

The shorter operative time observed in the chemical pleurodesis group in the present study is a clinically meaningful finding with direct implications for surgical resource utilization and patient recovery. A large single-center observational study comparing VATS talc pleurodesis with pleurectomy reported that talc pleurodesis was associated with a significantly shorter operative time, while recurrence and chest tube duration remained comparable between groups (12). This advantage of chemical over mechanical methods in terms of procedural brevity is mechanistically plausible, as mechanical abrasion requires systematic physical scoring of the parietal pleural surface, a step that is technically demanding and time-consuming, particularly in patients with adhesions or challenging anatomical configurations; a review of current surgical approaches to primary spontaneous pneumothorax also noted that operative efficiency is an increasingly important criterion in technique selection, particularly in high-volume thoracic surgery centers (13). The reduced operative duration associated with chemical pleurodesis in the present study may additionally translate into lower anesthetic exposure and potentially fewer

intraoperative adverse events, supporting its procedural utility as an efficient first-line surgical adjunct.

The comparable safety profile between the two groups, with no statistically significant difference in postoperative complications or mortality, is also concordant with the existing literature. A meta-analysis of seven comparative studies found no significant difference in postoperative complications between mechanical and chemical pleurodesis (8). A best-evidence topic review likewise concluded that despite some variations in hemothorax and prolonged air leak rates across techniques, the overall complication profiles of mechanical and chemical pleurodesis were broadly similar in patients with recurrent primary spontaneous pneumothorax (14). A population-level analysis of 14,609 patients with spontaneous pneumothorax confirmed that both operative approaches carry manageable risk profiles, and that the choice between techniques should be informed principally by recurrence prevention efficacy rather than by differential safety concerns (15). Collectively, these data and the present results suggest that neither technique imposes a substantially greater perioperative risk, and that the superior recurrence reduction achievable with chemical pleurodesis can be obtained without incurring additional morbidity. The use of tetracycline powder in the present study is noteworthy in this context, as tetracycline derivatives are generally regarded as well-tolerated agents that produce effective pleurodesis with a manageable pain and inflammatory response profile (7).

It is also instructive to consider the present results

alongside the broader surgical context of mechanical pleurodesis research. A systematic review and meta-analysis comparing pleural abrasion with apical pleurectomy, two forms of mechanical pleurodesis, found no significant difference in pneumothorax recurrence rates between the two mechanical approaches, but documented advantages of pleural abrasion in terms of shorter operative time, less surgical blood loss, and reduced chest tube duration relative to pleurectomy (10). Furthermore, a meta-analysis demonstrated that combining mechanical and chemical pleurodesis conferred a 63% lower relative risk of recurrence compared with mechanical pleurodesis alone (relative risk 0.37; 95% CI 0.18–0.76; $P = 0.006$), suggesting that hybrid approaches may optimize outcomes (9). Both the British Thoracic Society and the European Respiratory Society task force guidelines endorse surgical pleurodesis, whether mechanical or chemical, as an appropriate strategy for patients with recurrent or high-risk spontaneous pneumothorax and acknowledge that the optimal choice of modality remains to be definitively established (4,6). The results of the present study contribute to this ongoing debate by providing direct retrospective comparative evidence favoring chemical pleurodesis with tetracycline in a specific clinical cohort.

Overall, this retrospective case-control study demonstrated that chemical pleurodesis with tetracycline powder is associated with a lower pneumothorax recurrence rate and a shorter operative time than pleural mechanical abrasion in patients with spontaneous pneumothorax, while both techniques maintain a comparable safety profile in terms of postoperative complications and mortality. These findings align with the broader comparative literature and support chemical pleurodesis as a clinically effective and procedurally efficient surgical option for appropriately selected patients with spontaneous pneumothorax. Given the current absence of definitive randomized trial evidence directly comparing these two modalities, the present data offer useful real-world supplementary evidence to guide clinical decision-making. Well-designed prospective studies are warranted to confirm the superiority of chemical pleurodesis and to identify patient subgroups that may derive the greatest benefit from each approach.

Conclusion

These findings suggest that chemical pleurodesis with tetracycline powder offers more important clinical advantages over pleural mechanical abrasion in the management of spontaneous pneumothorax, achieving a lower recurrence rate and shorter operative time without increasing postoperative complications or mortality. Given the comparable safety profiles and the trend toward shorter hospitalization with chemical pleurodesis, this modality may be considered a more effective and efficient option for surgical treatment in appropriately selected patients.

Limitations of the study

The most common limitations of this study are as follows: The retrospective case-control design is susceptible to selection bias and confounding by unmeasured clinical variables, including pneumothorax severity classification, extent of bullous disease, surgeon experience, and patient comorbidities, which may have influenced both technique selection and outcomes. The study was conducted at two tertiary centers in a single city, which may limit the generalizability of the findings to other settings with different patient populations or surgical expertise. The sample size of 82 patients, while adequate for primary comparisons, may limit statistical power for detecting smaller between-group differences in secondary outcomes. The study was limited to tetracycline as the chemical agent, and the results may not be generalizable to other sclerosants such as talc or minocycline. Future prospective randomized controlled trials with standardized surgical protocols, validated outcome measures, and adequate long-term follow-up are needed to confirm and extend these findings.

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Authors' contribution

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Writing—original draft: All authors.

Writing—review and editing: All authors.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration of generative artificial intelligence (AI) and AI-assisted technologies in the writing process

During the preparation of this manuscript, the authors used generative artificial intelligence (Perplexity) and AI-assisted writing tools (Grammarly) to assist with drafting, language editing, and refinement of grammar and style. All content generated by these tools was subsequently critically reviewed, revised, and validated by the authors, who take full responsibility for the accuracy, integrity, and originality of the work.

Conflicts of interest

The authors declare that they have no competing interests.

Ethical issues

The research conducted in this study adhered to the principles outlined in the Declaration of Helsinki. This study was conducted at Shahid Madani Hospital in Alborz, and was derived from a thesis work of Asadollah Ekramifar (No: 4927) approved by the ethics committee of the Alborz University of Medical Sciences, Iran, under the ethical code (IR.ABZUMS.REC.1401.207) registered on November 12, 2022. Prior to any intervention, all participants provided written informed consent. Besides, the authors have ultimately observed ethical issues (including plagiarism, data fabrication, and double publication).

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