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Article

Analysis of Risk Factors for Recurrent Pneumothorax in Patients after Primary Spontaneous Pneumothorax Surgery: A Single-Center Retrospective Study

Tiantian Chen[1], Yuanwei Liang[1], Yi Xiao[1], Lishuai Yao[1,*]

[1]Department of Cardiothoracic Surgery, The Third Affiliated Hospital of Sun Yat-sen University, 510630 Guangzhou, Guangdong, China
*Correspondence: lshuai0222@yeah.net (Lishuai Yao)

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Abstract

Background: Recurrent pneumothorax is a prevalent issue following primary spontaneous pneumothorax (PSP) surgery. This study identifies risk factors for PSP recurrence after surgery. **Methods**: This study included participants who had undergone surgery for PSP at our hospital from February 2021 to February 2024. Relevant demographic, clinical, radiological, and laboratory data were collected for each participant, and statistical analysis was performed using SPSS 29.0 statistical software (SPSS Inc., Chicago, IL, USA). Chi-squared tests, *t*-tests, and binary logistic regression analysis were utilized to assess the associations between risk factors and the likelihood of pneumothorax recurrence. **Results**: A total of 100 participants who underwent surgery for PSP at a single center were included in the analysis. The participants were 18–39 years old, with 53 participants in the no recurrent pneumothorax group and 47 participants in the recurrent pneumothorax group. No significant differences in demographic and clinical characteristics were observed between the two groups. The binary logistic regression analysis showed that c-reactive protein (odds ratio (OR) = 2.144, $p < 0.001$), white blood cell count (OR = 2.493, $p = 0.011$), neutrophil-to-lymphocyte ratio (OR = 3.031, $p < 0.001$), and chest tube duration (OR = 9.716, $p = 0.010$) were independent risk factors for the recurrence of PSP. **Conclusion**: This study emphasizes the crucial role of postoperative inflammatory response in the recurrence of PSP. Clinicians should monitor and manage these inflammatory markers to optimize postoperative management strategies, reduce recurrence rates, and improve long-term patient outcomes.

Keywords

risk factors; recurrent; pneumothorax

Introduction

Primary spontaneous pneumothorax (PSP) is defined as the occurrence of pneumothorax in individuals without clinically apparent lung disease or known precipitating factors [1,2]. The condition typically affects young, otherwise healthy individuals and is often characterized by the sudden onset of chest pain and dyspnea [3,4]. The typical presentation of PSP involves acute chest pain and dyspnea, frequently requiring urgent medical attention [5]. The management of PSP has evolved over the years, with surgical interventions playing a crucial role in preventing recurrence and reducing associated morbidities [6]. Video-assisted thoracoscopic surgery (VATS) and open thoracotomy with pleurectomy are the two primary surgical methods employed in the management of PSP [7]. VATS involves the insertion of a thoracoscope and surgical instruments through small incisions, allowing for visualization and mechanical pleurodesis or pleurectomy, while open thoracotomy provides direct access to the pleural space for extensive pleural abrasion or pleurectomy [8,9].

VATS is associated with reduced postoperative pain, shorter hospital stays, and faster recovery compared with open thoracotomy, which often requires a larger incision and may be associated with a higher risk of postoperative pain and paresthesia [10,11]. However, the technical complexity of VATS and the potential for incomplete pleural symphysis may increase the risk of recurrence in some patients [12]. Despite the advancements in surgical techniques, a proportion of patients undergoing PSP surgery are at risk of experiencing recurrent pneumothorax [13]. The etiology of postoperative recurrent pneumothorax is multifactorial, involving patient-specific factors and variations in surgical approaches. Recurrence often necessitates additional interventions, leading to prolonged hospital stays, increased healthcare costs, and potential effect on patients' quality of life. Prior studies have investigated the potential risk factors associated with recurrent pneumothorax following surgical intervention for PSP [14,15]. A systematic review and meta-analysis identified smoking, age, and surgical technique as potential risk factors for recurrence, emphasizing the need for further research to elucidate the

underlying mechanisms and optimize patient management strategies [16]. In another study, the potential role of preoperative radiographic findings in influencing the risk of recurrent pneumothorax postsurgery was suggested [17].

Given the complexity of factors influencing recurrent pneumothorax and the variations in findings from previous research, a focused investigation within a single-center cohort is clearly needed. By conducting a retrospective analysis, we aim to systematically evaluate a range of demographic, clinical, and perioperative variables to identify specific risk factors associated with recurrent pneumothorax following PSP surgery at our institution. Our study is designed to address gaps in the existing literature and provide valuable insights that can inform risk stratification, refine treatment protocols, and improve the long-term management of patients with PSP.

Materials and Methods

Study Participants

This case–control study aimed to analyze the risk factors associated with recurrent pneumothorax in patients following PSP surgery. The study was conducted at a single center and approved by the Institutional Review Board and Ethics Committee of The Third Affiliated Hospital of Sun Yat-sen University (II2023-183-03). It complied with the relevant statements of the Helsinki Declaration. The study included participants who had undergone surgery for PSP at our hospital from February 2021 to February 2024. In total, 100 participants, 18–39 years old, were included in the analysis, with 53 participants in the no recurrent pneumothorax group and 47 participants in the recurrent pneumothorax group. All participants included in this study gave informed consent.

Inclusion and Exclusion Criteria

Inclusion Criteria: The inclusion criteria were as follows: patients who underwent surgery for PSP at the designated single center within the specified study period; aged 18 years or older at the time of surgery; diagnosis of PSP confirmed by relevant medical records and imaging studies [18]; willingness to provide informed consent for participation in the study.

Exclusion Criteria: The exclusion criteria were as follows: patients with secondary pneumothorax due to known underlying lung diseases, trauma, or iatrogenic causes; history of thoracic surgery other than PSP surgery; incomplete or insufficient medical records, including missing data on key variables for analysis.

Diagnosis of PSP

The diagnosis of PSP is typically based on the patient's medical history and clinical symptoms, including sudden chest pain and difficulty breathing. Diagnostic measures may also involve X-rays, computed tomography (CT) scans, or thoracic ultrasonography to confirm the presence of gas accumulation in the pleural cavity. Generally, the diagnosis of PSP requires meeting the following criteria: sudden chest pain; chest X-ray (CXR) or CT scan revealing the presence of extrapulmonary gas (typically spontaneous); exclusion of pneumothorax resulting from trauma, pulmonary infection, or other obvious causes. All of the above processes should be conducted by the same experienced clinician.

Grouping Method

After being discharged from the hospital, patients were assessed in the outpatient clinic at 1 week, 1 month, 3 months, 6 months, and 12 months, where CXR and clinical observations were performed. Telephone follow-ups were then conducted every 6 months by a registered nurse, who was blinded to the group allocation, using a standardized questionnaire to determine whether recurrence occurred, when it happened, and how it was treated. The gold standard for detecting recurrence is CXR. Pneumothorax recurrence was defined as the presence of an ipsilateral pneumothorax of any size during the follow-up period on CXR. CXRs were reviewed by the principal investigator and radiologists blinded to the treatment.

Data Collection

Relevant demographic and clinical data, including age, body mass index, smoking history, family history of pneumothorax, previous episode of pneumothorax, duration of symptoms, presence of bilateral pneumothorax, and emergency department visits within 6 months postsurgery, were collected for each participant. Additionally, their radiological findings, inflammatory marker levels, surgical procedure details, and comorbidities were documented.

Statistical Analysis

Before conducting data analysis, this study executed a standardized data cleansing procedure aimed at identifying and rectifying any inconsistencies, errors, or missing values present in the dataset. This procedure involved conducting a comprehensive examination of the dataset to remove duplicate entries, correct data entry errors, and address missing values. Missing values were imputed using deep neural networks with the DataWig and Pandas libraries in Python 3.6.0 (Python Software Foundation, Amsterdam, Holland). Efforts were made to ensure that the percentage of missing data remained below 5% to mitigate potential selection

bias, and sensitivity analyses were carried out. These analyses involved calculating outcomes for cases lost to follow-up using worst- and best-case scenarios. The deep neural network model architecture utilized for imputing missing data involves multiple layers of interconnected nodes that enable the model to capture complex patterns and relationships within the dataset, leading to accurate imputations. This method was selected over traditional imputation techniques because of its ability to handle nonlinear relationships and complex interactions between variables, which may not be effectively addressed by conventional imputation methods. If the conclusion indicated no significant difference, then the loss to follow-up exerted a minimal effect on the study's conclusions, rendering them reliable. The final results were reported after missing values were imputed.

Through G*Power 3.1.9.7 (University of Dusseldorf; Dusseldorf, Germany), the "Means: Difference between two independent means (two groups)" option based on *t*-tests was selected for conducting post hoc analysis. The parameters included the selection of the two-tailed mode, an effect size d = 0.6, and α err prob = 0.05. Subsequently, the sample sizes for both groups were entered to calculate power (1-β err prob), which resulted in 0.843.

For data analysis, SPSS 29.0 (SPSS Inc., Chicago, IL, USA) was employed. Categorical data were presented as [n (%)]. The chi-squared test was utilized for categorical data when the sample size was adequate, with the corrected chi-squared test applied for samples with expected counts between 1 and 5. In cases of smaller sample sizes or expected counts less than 1, Fisher's exact test was utilized.

The Shapiro–Wilk test was used to assess normal distribution in continuous variables. Variables that exhibited normal distribution were presented as (mean $\pm$ Standard Deviation (SD)) and analyzed using the *t*-test, whereas non-normally distributed data were expressed as median (P25, P75) and analyzed using the Wilcoxon rank-sum test. A bilateral $p < 0.05$ was considered statistically significant. Indicators that were statistically significant in the univariate analysis were included in the binary logistic regression analysis.

Results

Demographic and Clinical Characteristics

This study compared the demographic and clinical characteristics of 53 participants in the no recurrent pneumothorax group and 47 participants in the recurrent pneumothorax group (Table 1). No significant differences were found between the groups in terms of age (28.45 $\pm$ 4.67 *vs.* 29.72 $\pm$ 5.21, t = 1.274, $p = 0.206$), body mass index (23.14 $\pm$ 2.36 *vs.* 22.59 $\pm$ 2.14, t = 1.211, $p = 0.229$), smoking history in pack-years (7.31 $\pm$ 3.28 *vs.* 8.27 $\pm$ 3.95, t = 1.327, $p = 0.188$), pneumatocele (20.75% *vs.* 34.04%, t = 2.231, $p = 0.135$), previous episode of pneumothorax (28.3% *vs.* 42.55%, $\chi^2 = 2.224$, $p = 0.136$), duration of symptoms in months (9.56 $\pm$ 2.11 *vs.* 10.03 $\pm$ 3.52, $\chi^2 = 0.796$, $p = 0.429$), bilateral pneumothorax (13.21% *vs.* 25.53%, $\chi^2 = 2.458$, $p = 0.117$), and emergency department visits within 6 months (2.14 $\pm$ 0.83 *vs.* 2.45 $\pm$ 1.23, t = 1.469, $p = 0.146$). These findings suggest that the demographic and clinical characteristics were largely similar between the two groups. Further analysis may be needed to identify other potential contributing factors to recurrent pneumothorax. Significant differences existed between the two groups in terms of asthma (7.55% *vs.* 25.53%, $\chi^2 = 5.995$, $p = 0.014$), chronic obstructive pulmonary disease (5.66% *vs.* 27.66%, $\chi^2 = 8.970$, $p = 0.003$), and smoking-related lung disease (18.87% *vs.* 42.55%, $\chi^2 = 6.654$, $p = 0.016$), implying that these factors may be associated with the risk of recurrent pneumothorax.

Inflammatory Markers

The comparison of inflammatory markers between the no recurrent pneumothorax group and the recurrent pneumothorax group revealed significantly higher levels in the recurrent group for c-reactive protein (CRP; 2.67 $\pm$ 0.53 *vs.* 2.14 $\pm$ 0.42, t = 5.487, $p < 0.001$), white blood cell (WBC) count (9.83 $\pm$ 1.52 *vs.* 8.22 $\pm$ 1.23, t = 5.790, $p < 0.001$), and neutrophil-to-lymphocyte ratio (NLR; 3.01 $\pm$ 0.91 *vs.* 2.16 $\pm$ 0.71, t = 5.115, $p < 0.001$; Table 2). However, no significant differences were observed in interleukin-6 level (31.53 $\pm$ 4.82 *vs.* 31.24 $\pm$ 4.51, t = 0.305, $p = 0.761$) or tumor necrosis factor-α level (13.78 $\pm$ 2.61 *vs.* 13.57 $\pm$ 2.33, t = 0.418, $p = 0.677$). These findings suggest a robust inflammatory response in the recurrent pneumothorax group, as evidenced by the elevated levels of CRP, WBC count, and NLR, highlighting the potential role of inflammation in the pathophysiology of recurrent pneumothorax and suggesting avenues for further research and targeted therapeutic interventions.

Surgical Procedure Details

The comparison of surgical procedure details between the no recurrent pneumothorax group and the recurrent pneumothorax group revealed significant differences in the type of surgery performed (VATS *vs.* open, $p = 0.006$) and surgical duration (75.31 $\pm$ 12.56 *vs.* 79.66 $\pm$ 14.32 min, t = 1.607, $p = 0.111$; Table 3). Moreover, the recurrent pneumothorax group showed a higher incidence of intraoperative air leak (9.43% *vs.* 27.66%, $\chi^2 = 5.606$, $p = 0.018$), a longer chest tube duration (2.53 $\pm$ 0.87 *vs.* 3.41 $\pm$ 0.92 days, t = 4.950, $p < 0.001$), and a greater need for reoperation (1.89% *vs.* 17.02%, $\chi^2 = 5.241$, $p = 0.022$; Table 3). These findings suggest that intraoperative complications, prolonged chest tube duration, and the need for reoperation are more prevalent in the recurrent pneumothorax group, in-

Table 1. Demographic and clinical characteristics of participants.

Parameters	No recurrent pneumothorax group (n = 53)	Recurrent pneumothorax group (n = 47)	t/χ^2	*p* value
Age (years)	28.45 ± 4.67	29.72 ± 5.21	1.274	0.206
Body Mass Index (kg/m²)	23.14 ± 2.36	22.59 ± 2.14	1.211	0.229
Smoking History (pack-years)	7.31 ± 3.28	8.27 ± 3.95	1.327	0.188
Pneumatocele	11 (20.75%)	16 (34.04%)	2.231	0.135
Previous Episode of Pneumothorax	15 (28.30%)	20 (42.55%)	2.224	0.136
Duration of Symptoms (months)	9.56 ± 2.11	10.03 ± 3.52	0.796	0.429
Bilateral Pneumothorax (n)	7 (13.21%)	12 (25.53%)	2.458	0.117
Emergency Department Visits (6 months)	2.14 ± 0.83	2.45 ± 1.23	1.469	0.146
Asthma	4 (7.55%)	12 (25.53%)	5.995	0.014
Chronic Obstructive Pulmonary Disease	3 (5.66%)	13 (27.66%)	8.970	0.003
Smoking-related Lung Disease	10 (18.87%)	20 (42.55%)	6.654	0.016

Table 2. Comparison of inflammatory markers in two groups.

Parameters	No recurrent pneumothorax group	Recurrent pneumothorax group	t	*p* Value
CRP (mg/dL)	2.14 ± 0.42	2.67 ± 0.53	5.487	<0.001
WBC Count (10^9/L)	8.22 ± 1.23	9.83 ± 1.52	5.790	<0.001
NLR	2.16 ± 0.71	3.01 ± 0.91	5.115	<0.001
Interleukin-6 Level (pg/mL)	31.24 ± 4.51	31.53 ± 4.82	0.305	0.761
Tumor Necrosis Factor-α Level (pg/mL)	13.57 ± 2.33	13.78 ± 2.61	0.418	0.677

CRP, C-reactive protein; WBC, white blood cell; NLR, neutrophil-to-lymphocyte ratio.

Table 3. Comparison of surgical procedure details in two groups.

Parameters	No recurrent pneumothorax group	Recurrent pneumothorax group	t/χ^2	*p* value
Type of Surgery (VATS *vs.* Open)	37/16	20/27	7.551	0.006
Surgical Duration (min)	75.31 ± 12.56	79.66 ± 14.32	1.607	0.111
Intraoperative Air Leak	5 (9.43%)	13 (27.66%)	5.606	0.018
Chest Tube Duration (days)	2.53 ± 0.87	3.41 ± 0.92	4.950	<0.001
Need for Reoperation	1 (1.89%)	8 (17.02%)	5.241	0.022
Pleurodesis Procedure	29 (54.72%)	23 (48.94%)	0.334	0.564

Note: VATS, video-assisted thoracic surgery.

dicating potential areas for intervention and postoperative care improvement to mitigate the risk of recurrence and associated complications.

Binary Logistic Regression Analysis

Indicators that were statistically different in the single-factor analysis were included in the binary logistic regression analysis. The binary logistic regression analysis showed that CRP (odds ratio (OR) = 2.144, $p < 0.001$), WBC count (OR = 2.493, $p = 0.011$), NLR (OR = 3.031, $p < 0.001$), and chest tube duration (OR = 9.716, $p = 0.010$) were independent risk factors for the recurrence of PSP (Table 4).

Discussion

This study aimed to analyze the risk factors for recurrent pneumothorax after surgery for PSP. We conducted a retrospective analysis of 100 patients from our hospital, focusing on demographic, clinical, and perioperative variables. Key findings revealed that elevated CRP, WBC count, and NLR and prolonged chest tube duration were significantly associated with the risk of recurrent pneumothorax. These factors were identified as independent predictors of recurrence, suggesting their potential roles in the pathophysiology and management of postoperative PSP.

Our results align with those of previous studies, emphasizing the importance of inflammatory markers and surgical variables in predicting pneumothorax recurrence. For instance, Saricam *et al.* [19] reported the correlation between inflammatory parameters and pneumothorax recurrence, supporting our findings.

Adhesion is a response to surgery or injury, usually caused by a local inflammatory reaction. During surgery, tissue damage leads to the aggregation of inflammatory cells and the release of various inflammatory mediators. These mediators stimulate the proliferation of fibroblasts

Table 4. Binary logistic regression analysis of various risk factors and recurrence of PSP postsurgery.

Parameters	B	Std. Error	Wald	*p* value	Odds ratio	95% confidence interval (CI)
CRP	0.763	0.141	29.051	<0.001	2.144	1.625–2.829
WBC Count	0.913	0.357	6.534	0.011	2.493	1.237–5.021
NLR	1.109	0.297	13.940	<0.001	3.031	1.693–5.425
Intraoperative Air Leak	1.706	1.654	1.065	0.302	5.508	0.216–140.755
Chest Tube Duration	2.274	0.880	6.672	0.010	9.716	1.731–54.547
Need for Reoperation	4.822	2.490	3.751	0.053	124.184	0.944–16,341.091
Asthma	1.417	1.550	0.836	0.361	4.124	0.198–86.031
Chronic Obstructive Pulmonary Disease	1.507	2.652	0.323	0.570	4.512	0.025–816.825
Smoking-related Lung Disease	3.345	1.792	3.485	0.062	28.370	0.846–951.241
Type of Surgery	2.090	1.169	3.195	0.074	8.082	0.817–79.906

Note: PSP, primary spontaneous pneumothorax; Std., standard.

and the synthesis of collagen, ultimately forming fibrous adhesions. Studies by Saito *et al*. [20] and Motono *et al*. [21] have shown that intraoperative adhesions are a factor influencing pneumothorax recurrence. CRP is an important inflammatory marker, and its postoperative elevation typically reflects the intensity and duration of the inflammatory response. Postoperative lung inflammation and tissue damage may lead to the reaccumulation of air in the pleural cavity, causing pneumothorax recurrence. Miyahara *et al*. [22] demonstrated that elevated CRP levels are significantly associated with the recurrence rate of pneumothorax, underscoring its importance in predicting recurrence. High CRP levels not only reflect the severity of surgical trauma but may also directly affect the healing process of lung tissue. Our data show that NLR is higher in the recurrence group. This ratio is considered an indicator of inflammatory status and immune system activity. A high ratio may indicate postoperative immune dysfunction, which could affect the risk of pneumothorax recurrence. Akboga *et al*.'s study [23] supports this view, finding that NLR is associated with mortality in pneumothorax patients. Postoperative WBC count often increases significantly, reflecting the activation of the immune system and the exacerbation of systemic inflammatory response. Overactivated immune cells can release inflammatory mediators, such as cytokines and interleukins, which may further damage lung tissue and delay the healing process, thereby increasing the risk of pneumothorax recurrence. Riveiro-Blanco *et al*.'s study [24] also found that elevated WBC count is closely associated with an increased risk of pneumothorax recurrence. These findings support our conclusion that a high WBC count is an important predictor of PSP recurrence.

Furthermore, our study analyzed the effect of chest tube duration on PSP recurrence. Prolonged chest tube placement may increase the risk of postoperative infection and inflammatory response, thereby affecting the healing process and increasing the likelihood of recurrence. This finding underscores the importance of managing chest tube duration in clinical practice to reduce recurrence risk and promote patient recovery. Studies by Gaunt *et al*. [25] and Chambers and Scarci [26] found that prolonged chest tube duration is significantly associated with increased pneumothorax recurrence rates, consistent with our findings.

Although this study provides an in-depth analysis of the effects of CRP, WBC count, NLR, and chest tube duration on PSP recurrence, some limitations remain. For instance, the sample size is relatively small, and the study is a single-center retrospective design. Therefore, further multicenter large-sample studies are needed to validate our results. Additionally, future research could explore other potential influencing factors. Our findings emphasize the importance of monitoring and controlling inflammatory response in postoperative management. Regular evaluation of inflammatory markers such as CRP, WBC count, and NLR can help physicians identify high-risk patients for recurrence and implement effective interventions, such as enhanced postoperative pleurodesis treatment or adjustment of postoperative chest drainage management strategies, to reduce recurrence rates and improve long-term outcomes for patients.

Conclusion

This study demonstrates that elevated CRP, WBC count, and NLR and prolonged chest tube duration are independent predictors of recurrence following surgery for PSP. These findings underscore the importance of postoperative inflammatory response and suggest that clinicians should monitor and manage these markers to reduce recurrence risk and improve long-term patient outcomes. Future research should further validate these results and explore additional potential influencing factors to optimize postoperative management strategies.

Availability of Data and Materials

The dataset used and/or analyzed during the current study is available from the corresponding author upon rea-

sonable request. Any materials used in the study, such as software or tools, have been clearly identified and their availability specified.

Author Contributions

Conceptualization, Methodology: TC, YX, LY. Data curation, Analysis: YL, YX. Writing — Original draft preparation: TC, YX. Writing — Review & Editing: TC. Visualization, Supervision: YX, LY. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This study has been approved by the ethics committee of The Third Affiliated Hospital of Sun Yat-sen University, Approval No. II2023-183-03. Because this study is a retrospective study, it is not necessary to sign informed consent.

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Conflict of Interest

The authors declare no conflict of interest.

References

[1] Adekoya AO, Adekoya AO, Amosu LO, Olatunji AA, Olusola-Bello MA, Ashaolu OO. Primary spontaneous pneumothorax in a term neonate. African Health Sciences. 2022; 22: 178–181.

[2] Ennis SL, Dobler CC. Conservative *versus* interventional treatment for spontaneous pneumothorax. Breathe (Sheffield, England). 2020; 16: 200171.

[3] Gilday C, Odunayo A, Hespel AM. Spontaneous Pneumothorax: Management and Prognosis. Topics in Companion Animal Medicine. 2021; 45: 100582.

[4] Gilday C, Odunayo A, Hespel AM. Spontaneous Pneumothorax: Pathophysiology, Clinical Presentation and Diagnosis. Topics in Companion Animal Medicine. 2021; 45: 100563.

[5] Jouneau S, Vuillard C, Salé A, Bazin Y, Sohier L, Kerjouan M, *et al*. Outpatient management of primary spontaneous pneumothorax. Respiratory Medicine. 2021; 176: 106240.

[6] Marquette CH. Primary spontaneous pneumothorax: We have time to get some fresh air…. Revue des Maladies Respiratoires. 2023; 40: 206–208. (In French)

[7] Hung WT, Cheng YJ, Chen JS. Video-Assisted Thoracoscopic Surgery Lobectomy for Lung Cancer in Nonintubated Anesthesia. Thoracic Surgery Clinic. 2020; 30: 73–82.

[8] Lin CW, Huang KY, Lin CH, Wang BY, Kor CT, Hou MH, *et al*. Video-Assisted Thoracoscopic Surgery in Community-Acquired Thoracic Empyema: Analysis of Risk Factors for Mortality. Surgical Infections. 2022; 23: 191–198.

[9] Lu CW, Liu WD, Hsu HH, Wu UI, Jeng YM, Chen YC, *et al*. Video-assisted thoracoscopic surgery for primary pulmonary cryptococcosis. Journal of the Formosan Medical Association. 2022; 121: 2237–2247.

[10] M Castro P, Lareiro S, Rei J, Miranda J, Neves F, Guerra M. Video-assisted thoracoscopic surgery without chest drain placement. Portuguese Journal of Cardiac Thoracic and Vascular Surgery. 2021; 28: 35–38.

[11] Qaqish TR, Cox S, Carr R, Katlic M. Treatment of Pleural Effusions with Nonintubated Video-Assisted Thoracoscopic Surgery. Thoracic Surgery Clinics. 2020; 30: 25–32.

[12] Wong A, Galiabovitch E, Bhagwat K. Management of primary spontaneous pneumothorax: a review. ANZ Journal of Surgery. 2019; 89: 303–308.

[13] Fung S, Ashmawy H, Safi SA, Schauer M, Krieg A, Schauer A, *et al*. Effectiveness of Video-Assisted Thoracoscopic Surgery with Bullectomy and Partial Pleurectomy in the Treatment of Primary Spontaneous Pneumothorax-A Retrospective Long-Term Single-Center Analysis. Healthcare (Basel, Switzerland). 2022; 10: 410.

[14] Hallifax RJ, McKeown E, Sivakumar P, Fairbairn I, Peter C, Leitch A, *et al*. Ambulatory management of primary spontaneous pneumothorax: an open-label, randomised controlled trial. Lancet (London, England). 2020; 396: 39–49.

[15] Lieu N, Ngo P, Chennapragada SM, Fitzgerald DA, Karpelowsky J, Pandit C, *et al*. Update in management of paediatric primary spontaneous pneumothorax. Paediatric Respiratory Reviews. 2022; 41: 73–79.

[16] Mei Z, Wang Q, Zhang Y, Liu P, Ge M, Du P, *et al*. Risk Factors for Recurrence after anal fistula surgery: A meta-analysis. International Journal of Surgery (London, England). 2019; 69: 153–164.

[17] Kong SS, Hosterman T, Bhanusali N. Recurrent Pneumothorax in a Patient With Poorly Controlled Systemic Lupus Erythematosus: A Case Report and Review of the Literature. Journal of Clinical Rheumatology: Practical Reports on Rheumatic & Musculoskeletal Diseases. 2021; 27: e153–e155.

[18] Lee YCG. Primary Spontaneous Pneumothorax: Treat the Patient, Not the X-Ray. American Journal of Respiratory and Critical Care Medicine. 2023; 207: 1416–1417.

[19] Saricam M, Guven O, Ozkan B. Utilizing the lymphocyte-monocyte ratio in predicting the recurrence of spontaneous pneumothorax. Cirugia Y Cirujanos. 2023; 91: 725–729.

[20] Saito Y, Suzuki Y, Demura R, Kawai H. The outcome and risk factors for recurrence and extended hospitalization of secondary spontaneous pneumothorax. Surgery Today. 2018; 48: 320–324.

[21] Motono N, Mizoguchi T, Ishikawa M, Iwai S, Iijima Y, Uramoto H. Adhesion is a risk factor for postoperative recurrence of spontaneous pneumothorax. Journal of Thoracic Disease. 2023; 15: 6788–6795.

[22] Miyahara E, Ueda D, Kawasaki Y, Ojima Y, Kimura A, Okumichi T. Polyglycolic acid mesh for preventing post-thoracoscopic bullectomy recurrence. Surgery Today. 2021; 51: 971–977.

[23] Akboga SA, Gokce A, Hatipoglu M, Beyoglu MA, Inan K, Sezen AI, *et al*. The relationship between mortality and inflam-

matory markers and the systemic immune inflammatory index in patients in the intensive care unit with a pneumothorax as a complication of COVID-19 disease. Irish Journal of Medical Science. 2022; 191: 1931–1936.

[24] Riveiro-Blanco V, Pou-Álvarez C, Ferreiro L, Toubes ME, Quiroga-Martínez J, Suárez-Antelo J, *et al*. Recurrence of primary spontaneous pneumothorax: Associated factors. Pulmonology. 2022; 28: 276–283.

[25] Gaunt A, Martin-Ucar AE, Beggs L, Beggs D, Black EA, Duffy JP. Residual apical space following surgery for pneumothorax increases the risk of recurrence. European Journal of Cardio-thoracic Surgery: Official Journal of the European Association for Cardio-thoracic Surgery. 2008; 34: 169–173.

[26] Chambers A, Scarci M. In patients with first-episode primary spontaneous pneumothorax is video-assisted thoracoscopic surgery superior to tube thoracostomy alone in terms of time to resolution of pneumothorax and incidence of recurrence? Interactive Cardiovascular and Thoracic Surgery. 2009; 9: 1003–1008.