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Factors influencing recurrence in patients operated for primary spontaneous pneumothorax

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Abstract

Background: This study aims to evaluate preoperative, perioperative, and postoperative parameters in patients with primary spontaneous pneumothorax (PSP) to minimize recurrence and improve predictability.

Methods: This single-center retrospective cohort study included 207 patients who underwent surgery for PSP between 2016 and 2020. Recurrence data were obtained from the national electronic health record system and the institutional hospital information system. Pneumothorax size was calculated preoperatively on posteroanterior chest radiographs using the Collins method.

Results: The mean age of the patients was 24.54±6.98 years and 87% of the patients were male. The overall recurrence rate was 9.7%. A higher Collins percentage ($p<0.001$), age ≤20 years ($p=0.015$), and continued smoking postoperatively ($p=0.036$) were found to be significantly associated with increased recurrence.

Conclusion: The findings suggest that a high Collins percentage on posteroanterior chest radiography, young age at the time of surgery, and continued smoking postoperatively are significant risk factors for recurrence.

Keywords: Primary spontaneous pneumothorax, Collins percentage, recurrence.

Primary spontaneous pneumothorax (PSP) is a clinical condition characterized by the accumulation of air between the parietal and visceral pleura, leading to lung collapse.[1-3] The incidence of PSP has been reported as 18-28 per 100,000 in men and 1.2-6 per 100,000 in women.[4]

PSP typically occurs in healthy individuals as a result of the rupture of subpleural blebs or bullae in the lung tissue.[5] In contrast, secondary spontaneous pneumothorax generally develops due to underlying lung diseases.[6] Surgical intervention is often required in the management of recurrent or complicated pneumothorax. Surgery is one of the most effective treatment options for preventing recurrence in PSP.[7] However, despite advancements in surgical techniques, pneumothorax recurrence remains a significant clinical problem. Some studies have reported recurrence rates as high as 30%.[8]

Postoperative recurrence of PSP is influenced by multiple factors, including the surgical technique, structural characteristics of the lung tissue, the patient's preoperative risk factors (such as smoking), and the quality of postoperative care.[9]

Recent studies have examined surgical techniques such as video-assisted thoracoscopic surgery (VATS) and pleurodesis, investigating their effectiveness in reducing recurrence rates.[10] In addition, patient-related factors such as smoking, genetic predisposition, and comorbidities have been identified as potential contributors to the development of recurrence.[11-13]

Evidence on prognostic factors for recurrence in PSP is limited in the Turkish population, where smoking habits and surgical practices may differ from Western cohorts. This study therefore aimed to evaluate these factors, with a particular focus on the predictive value of the Collins percentage.

Methods

This study was conducted through a retrospective evaluation of patients who underwent pneumothorax surgery at a single-center between 2016 and 2020. Ethics committee approval was obtained the University of Health Sciences Türkiye, Yedikule Chest Diseases and Thoracic Surgery

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Training and Research Hospital (approval number: 2023-467, date: 28.12.2023). A total of 207 patients who had surgery for PSP were included. Demographic data were obtained from the national patient database. Postoperative recurrence data were collected through follow-up visits, patient files, and the hospital database system. Patients whose data could not be accessed were excluded from the study. The Collins method was used to calculate pneumothorax size preoperatively,[14] which is a routinely applicable measurement scale.

The Collins method estimates pneumothorax volume based on the degree of lung collapse (Figure 1). The approximate percentage of pneumothorax is determined according to the extent of lung collapse. It is commonly used for practical calculations and can aid in treatment decisions, especially in symptomatic pneumothorax cases. The Collins percentage is calculated using the formula: % =4.2+4.7×(A+B+C), where:

A= maximum apical interpleural distance,

B= interpleural distance at the midpoint of the upper half of the lung,
C= interpleural distance at the midpoint of the lower half of the lung.

To standardize Collins percentage measurements, two thoracic surgeons independently performed all measurements, blinded to clinical data and to each other's readings. Inter-observer agreement was high (intraclass correlation coefficient >0.9). Discrepancies >5% were reviewed and resolved by consensus.

Preoperative Evaluation

Each patient underwent a posteroanterior chest radiograph at the time of hospital admission. Surgical intervention was decided based on factors such as recurrence of pneumothorax, sequential episodes, presence of prolonged air leak, and failure of lung re-expansion despite drainage. Informed consent form was obtained from all patients. A chest tube remaining in place for more than five days was defined as a preoperative prolonged air leak. Patients' occupations and their exposure to risk factors also played a role in the surgical decision-making process. All patients scheduled for surgery were evaluated with computed tomography prior to the operation. Complications occurring within the first 30 days postoperatively were considered postoperative complications and included in the study.

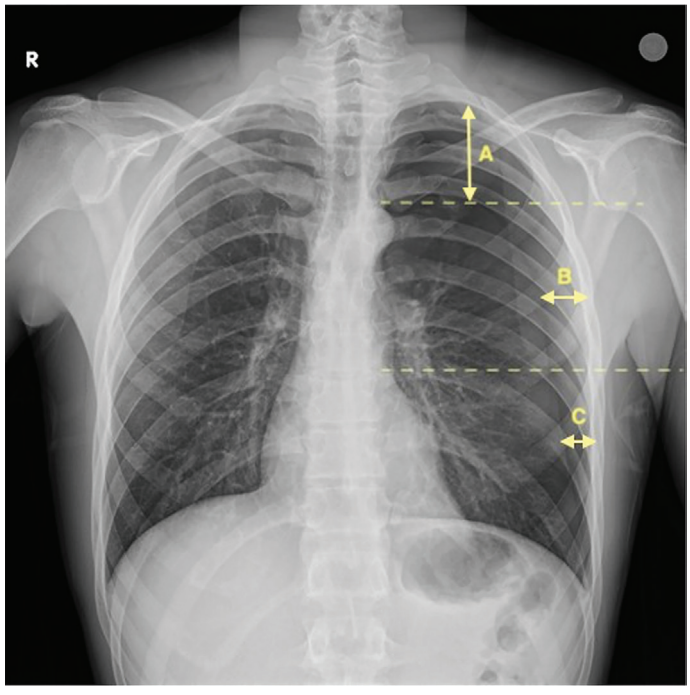

Figure 1. Collins percentage calculation method.

Surgical Technique

A total of 97.1% of the patients were operated on using the VATS technique. The procedure was typically performed through a utility incision at the 4th intercostal space in the anterior axillary line, with an additional port incision at the 7th intercostal space in the mid-axillary line. Apical partial parietal pleurectomy was performed as the pleurectomy method. The extent of apical pleurectomy was determined by the attending surgeon. During pleural abrasion, the entire inner thoracic wall was abraded. Wedge resection was performed in areas with visible air leaks or blebs/bullae until the air leak was completely controlled or all blebs were resected. In patients without visible air leaks or blebs, an apical wedge resection was also performed. The extent of wedge resection was determined by the attending surgeon.

Statistical Analysis

Statistical analysis was conducted using IBM SPSS (Windows version 22.0). For descriptive statistics, normally distributed continuous variables were presented as mean and standard deviation, while non-normally distributed variables were presented as median and interquartile range. Categorical variables were expressed as frequency and percentage. Receiver operating characteristic (ROC) curve analysis was performed to assess the predictive value of the Collins percentage for recurrence. The optimal cut-off value was determined using the Youden index, which maximizes the sum of sensitivity and specificity. A p-value of <0.05 was considered statistically significant.

Results

A total of 207 patients who underwent surgery for PSP were included in the study. Of these, 180 patients (87%) were male and 27 (13%) were female. The mean age was 24.54±6.98 years. The average follow-up period was 73.11±27.01 months. The recurrence rate was found to be 5.8% at one year, 8.2% at five years, and 9.7% overall. Among patients with recurrence, two underwent reoperation, while the others were treated with tube thoracostomy. A body mass index (BMI) of <18.5 was observed in 30.4% of the patients. Right-sided surgery was performed in 54.5% of the cases, and 42% of the patients were operated on after their first pneumothorax episode (Table 1). A total of 97% of the surgeries were performed using the VATS technique.

Prognostic factors contributing to recurrence were evaluated. In univariate statistical analysis, a higher Collins percentage was found to significantly increase the risk of recurrence (p<0.001). According to the ROC curve, when the Collins percentage cutoff value was set at 67.88, it was found to be predictive of recurrence with 75% sensitivity and 71.1% specificity (Table 2, Figure 2).

The effect of gender on recurrence was evaluated, and although recurrence was more frequently observed in female patients, the difference was not statistically significant (Table 3). The side of surgery did not influence the recurrence of pneumothorax. Similarly, the type

of surgical approach (VATS vs. thoracotomy) was not associated with recurrence.

There was also no significant difference in recurrence between patients who underwent partial pleurectomy and those who underwent pleural abrasion.

Furthermore, the area of lung wedge resection (calculated by multiplying the two longest edges) and the pleural thickness and area (in pleurectomy cases) did not affect recurrence. Additionally, the presence of bullae observed in postoperative pathology was not found to be associated with recurrence.

Among the 73 patients aged ≤20 who underwent surgery, 16.4% experienced recurrence, which was found to be statistically significant (p=0.015). Recurrence was also detected in 17.7% of the 62 patients who continued smoking postoperatively, indicating a significant increase in recurrence incidence (p=0.036).

Postoperative complications were observed in 29 patients (14%), but no surgical mortality was recorded. Among these, 22 patients developed prolonged air leak; 7 were discharged with a Heimlich valve, and 1 required revision surgery. Hemorrhage occurred in 2 patients postoperatively but did not require surgical intervention. Wound site infection was noted in 5 patients, one of whom underwent surgery due to wound dehiscence.

Although recurrence rates were lower in male patients, those with a BMI ≥18.5, patients who underwent thoracotomy, those operated after the first pneumothorax episode, patients without bullae on pathology, and those who developed postoperative complications, these differences were not statistically significant in univariate analysis.

Table 1. Patient demographics and surgical details

Variables		N	%
Age group	≤20	73	35
	>20	134	65
Gender	Female	27	13
	Male	180	87
BMI category	<18.5	63	30.4
	≥18.5	144	69.6
Post-operative smoking status	Continued smoking	62	30
	Quit smoking	49	23.6
	Never smokers	96	46.4
Pneumothorax status	First episode	87	42
	Recurrent	120	58
Side of surgery	Right	113	54.5
	Left	94	45.5
Pre-operative prolonged air leak	Yes	57	27.5
	No	150	72.4
Operation	Thoracoscopic	201	97
	Thoracotomy	6	3

BMI: Body mass index.

Discussion

Recurrence remains a significant issue in the management of PSP. Addressing this challenge is crucial to improving long-term outcomes for affected patients. Despite numerous comprehensive studies identifying various recurrence-related factors, a reliable clinical tool to accurately predict recurrence has not yet been developed.[15-17]

In our study, recurrence was more frequently observed among patients aged 20 years and under. Several studies have similarly reported that younger age is associated with a higher risk of recurrence following surgical intervention for PSP. Noh et al.[18] demonstrated that patients aged 16 years and younger had higher recurrence rates after wedge resection. Likewise, studies by Huang et al.,[19] Nakayama et al.[20] and their colleagues also reported increased recurrence in younger patients after surgery. In the meta-analysis by Huang et al.,[19] which included 23.531 patients who underwent surgery for primary spontaneous pneumothorax, the recurrence rate was reported as 10%. This study also demonstrated that a lower BMI and younger age were associated with an increased risk of recurrence. Similarly, Nakayama et al.[20] reported a recurrence rate of 9.6% in their study. Although the youngest patient in our study was 15 years old, the recurrence rate was significantly higher among those aged 20 years and under. One possible explanation for this is the rapid physical growth during adolescence. The vertical dimension of the thoracic cage increases more rapidly than the horizontal dimension, promoting the development of apical blebs, which may lead to pneumothorax.[21]

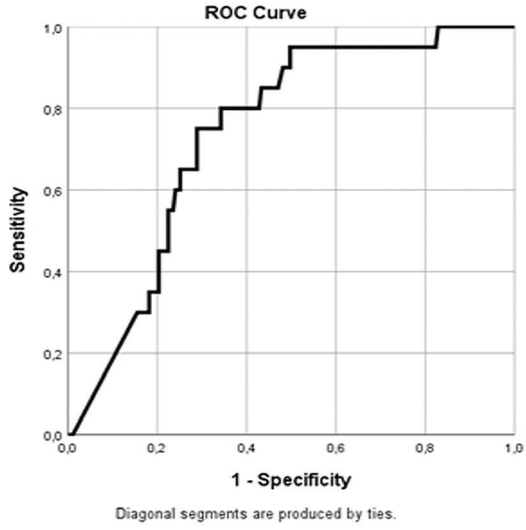

Figure 2. Collins percentage ROC curve.
ROC: Receiver operating characteristic.

Table 2. ROC curve analysis result for collins percentage in predicting recurrence

Risk factor	AUC	AUC (95% CI)	Cut-off	p-value	Sensitivity	Specificity
Collins percentage	74.1	0.741 (0.649-0.833)	67.88	<0.001	75%	71.1%

CI: Confidence interval; AUC: Area under the curver; ROC: Receiver operating characteristic.

The Collins percentage is a widely accepted method for estimating pneumothorax size. Evaluating pneumothorax size plays an important role in predicting the risk of recurrence. Several studies have indicated that larger pneumothorax size is associated with a higher recurrence risk.[22] A study by Sayar et al.[23] also concluded that an increase in pneumothorax size is linked to increased recurrence. Our findings are consistent with these reports in the literature.[14,22,23]

Smoking promotes the formation of subpleural blebs and bullae in the lungs, increasing the risk of pleural rupture and leading to both the development and recurrence of pneumothorax. Cigarette smoke weakens alveolar structures and enhances inflammation, thereby decreasing lung resilience. In our study, recurrence was significantly more frequent among patients who continued smoking postoperatively. This finding aligns with numerous studies in the literature demonstrating the role of smoking in both the onset and recurrence of PSP.[11,24] For example, Cheng et al.[11] reported that smoking adversely affects both the development and recurrence of PSP. Our results support this, showing a higher recurrence rate among patients who continued smoking after surgery.

This study has several limitations. First, its retrospective design inherently carries the risk of selection and information bias. Second, the single-center nature of the study may limit the generalizability of the findings to broader populations. Third, the surgical technique was not fully standardized, as the extent of apical pleurectomy and wedge resection was left to the discretion of the operating surgeon, which may have introduced variability affecting recurrence rates. Fourth, due to the limited number of cases, logistic regression analysis could not be performed, which restricted the ability to identify independent

Table 3. Prognostic factors affecting recurrence

Variables		No recurrence		Recurrence		p-value
		n	%	N	%	
Age group	≤20	61	83.6	12	16.4	**0.015**
>20	126	94	8	6		
Gender	Female	24	88.9	3	11.1	0.078
Male	163	90.6	17	9.4		
BMI category	<18.5	54	85.7	9	14.3	0.136
≥18.5	133	92.4	11	7.6		
Postoperative smoking	Continuing	51	82.3	11	17.7	**0.036**
Quit	47	95.9	2	4.1		
Never smokers	90	93.7	6	6.3		
First pneumothorax episode	Yes	82	94.3	5	5.7	0.105
No	105	87.5	15	12.5		
Side	Right	102	90.3	11	9.7	0.969
Left	85	90.4	9	9.6		
Preoperative prolonged air leak	Present	54	94.7	3	5.3	0.183
Absent	132	88.6	17	11.4		
Surgical approach	VATS	181	90	20	10	1
Thoracotomy	6	100	0	0		
Surgical technique	Partial pleurectomy	134	89.9	15	10.1	1
Pleural abrasion	51	91.1	5	8.9	0.828	
Presence of bullae on pathology	Present	124	89.2	15	10.8	0.432
Absent	63	92.6	5	7.4		
Postoperative complications	Present	27	93.1	2	6.9	0.746
Absent	160	89.9	18	10.1		
Wedge resection area (median [IQR], cm^2)		9 (6-14) cm^2		11.50 (6.5-17.75) cm^2		0.210
Pleural measurements (area & thickness)	Pleural area (cm^2)	12.5 (6-22) cm^2		8 (5-18) cm^2		0.173
	Pleural thickness (cm)	0.3 (0.3-0.5) cm		0.3 (0.3-0.3) cm		0.229
Pneumothorax size (Collins %)	Collins percentage	45.09 (29.11-78.93)		80 (54.19-100)		**<0.001**

BMI: Body mass index; IQR: Interquartile range; VATS: Video-assisted thoracoscopic surgery.

predictors of recurrence. Finally, despite efforts to ensure complete follow-up using national and institutional databases, the possibility of data loss during long-term follow-up cannot be entirely excluded. To reduce recurrence rates in patients operated for primary spontaneous pneumothorax, our findings suggest that centralized follow-up may be beneficial. Patients with a high Collins percentage, those aged 20 years or younger, and those who continue smoking postoperatively are at higher risk for recurrence and therefore should be monitored at shorter intervals.

To better understand and minimize recurrence, it is necessary to investigate additional parameters and identify the specific postoperative risk factors contributing to recurrence. Only through such measures can improved clinical outcomes be achieved. The literature contains a limited number of studies evaluating postoperative recurrence, highlighting the need for multicenter studies and larger datasets to facilitate comprehensive meta-analyses.

Ethics

Ethics Committee Approval: Ethics committee approval was obtained the University of Health Sciences Türkiye, Yedikule Chest Diseases and Thoracic Surgery Training and Research Hospital (approval number: 2023-467, date: 28.12.2023).

Informed Consent: Informed consent form was obtained from all patients.

Footnotes

Authorship Contributions

Concept: A.S.A., İ.Y., E.K., T.Ö., D.A., Ö.İ., K.K., C.B.S.; Design: A.S.A., İ.Y., E.K., T.Ö., D.A., Ö.İ., K.K., C.B.S.; Data Collection or Processing: A.S.A., İ.Y., E.K., T.Ö., D.A., Ö.İ., K.K., C.B.S.; Analysis or Interpretation: A.S.A., İ.Y., E.K., T.Ö., D.A., Ö.İ., K.K., C.B.S.; Literature Search: A.S.A., İ.Y., E.K., T.Ö., D.A., Ö.İ., K.K., C.B.S.; Writing: A.S.A., İ.Y., E.K., T.Ö., D.A., Ö.İ., K.K., C.B.S.

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