Original Article

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Persistent Air Leaks in Spontaneous Pneumothorax: Risk Factors and The Role of Autologous Blood Pleurodesis

Dashab Hannan[1*] Md. Ataur Rahman[2] Md. Resalat Chowdhury[3] Mainul Hasan Sohel[4]
Sowrabh Biswas[5] Muhammad Karim Hossain[6]

Abstract

Background: Persistent Air Leaks (PAL) complicate Spontaneous Pneumothorax (SP) prolonging hospitalization and morbidity. Autologous Blood Pleurodesis (ABP) is a minimally invasive option, but its efficacy versus chemical pleurodesis needs evaluation. The purpose of the study is to identify PAL risk factors in SP and compare ABP with tetracycline pleurodesis.

Materials and methods: In this prospective study at NIDCH, Dhaka, 176 SP patients requiring chest tube drainage were enrolled and equally divided into PAL (Air leak >5 days) and non-PAL groups. Clinical, radiological and procedural factors were analyzed. PAL patients received ABP or tetracycline. Outcomes included leak resolution, cessation time, complications, hospital stay and recurrence. Analysis used SPSS v26, p 0.05 was significant.

Results: PAL was associated with older age, low BMI, COPD, smoking, bullae and lung collapse >50%. Independent predictors were BMI <20 (OR=2.94) COPD (OR=2.72) bullae (OR=2.59) and collapse >50% (OR=2.87). ABP showed comparable resolution to tetracycline (95.45% vs. 88.64%, p=0.361) but faster cessation (2.4±1.3 vs. 3.6±1.7 days, p=0.003) and fewer complications (4.55% vs. 59.09%, p<0.001).

Conclusion: PAL in SP is linked to clinical and radiological factors. ABP is safe, effective, and better tolerated, ensuring faster resolution and fewer complications.

1. Registrar (Surgery) of Thoracic Surgery
NIDCH, Dhaka.
2. Assistant Professor of Thoracic surgery
Mainamoti Medical College, Cumilla.
3. Thoracic Surgeon
Bangladesh Specialized Hospital, Dhaka.
4. Associate Professor of Orthopedics
Central Medical College, Dhaka.
5. Junior Consultant of Thoracic Surgery
Chattagram Maa Shishu-O-General Hospital, Chattogram.
6. Assistant Professor of Thoracic Surgery
Bangladesh Medical University, Dhaka.

***Correspondence:** **Dr. Dashab Hannan**
Cell : 01817 58 34 20
E-mail: drdashab@gmail.com

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Introduction

Spontaneous Pneumothorax (SP) is a common thoracic emergency characterized by the presence of air in the pleural space without antecedent trauma or intervention, leading to partial or complete lung collapse.[1] Globally, the incidence of spontaneous pneumothorax ranges from 17 to 24 cases per 100,000 individuals annually, making it a relevant clinical concern across diverse healthcare settings.[2] While initial management with oxygen supplementation and intercostal tube drainage is often effective, a significant number of patients experience complications, the most prominent of which is Persistent Air Leak (PAL).[3] Defined as an ongoing escape of air from the lung parenchyma into the pleural cavity beyond the usual healing period—commonly accepted as five to seven days—PALs pose substantial clinical challenges.[4] They not only prolong hospital stay and delay recovery but also increase the risk of infection, patient discomfort and resource utilization.[5,6] PALs are more frequently observed in individuals with underlying structural lung disease or secondary spontaneous pneumothorax, though they may also complicate primary cases, particularly in smokers or those with subpleural blebs and bullae.[7] The identification of factors predisposing to PAL is therefore critical in tailoring early interventions, selecting appropriate therapeutic modalities and anticipating prolonged clinical courses. Risk factors may be intrinsic—such as age, body habitus, smoking history, and pre-existing lung pathology—or extrinsic, including procedural techniques, timing of intervention, and tube size or position.[8] In clinical practice, timely resolution of PAL is a priority, yet surgical intervention is not always feasible, especially in patients with comorbidities, limited pulmonary reserve, or surgical reluctance. In such cases, alternative, non-surgical methods of

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promoting pleural adhesion and sealing air leaks become necessary. Among these, Autologous Blood Pleurodesis (ABP) has emerged as a simple, minimally invasive and cost-effective option.[9] This technique involves instillation of a patient's own venous blood into the pleural cavity via the existing chest tube, with the aim of forming a fibrin clot or initiating an inflammatory reaction that encourages pleurodesis and closure of the alveolar-pleural fistula.[10] Unlike chemical pleurodesis, which often involves sclerosing agents that can induce systemic side effects or intense pleuritic pain, ABP offers a more physiologic and generally well-tolerated approach, making it especially suitable for high-risk or debilitated patients.[11,12] Furthermore, the ease of administration at the bedside without the need for general anesthesia adds to its appeal in resource-limited environments or in patients unfit for surgery.[13] Despite its apparent benefits, ABP remains underutilized and lacks standardized protocols, with considerable variation in clinical practice regarding timing of administration, volume of blood used and patient positioning.[14] This study aimed to investigate the risk factors associated with persistent air leaks in spontaneous pneumothorax and to evaluate the therapeutic role of autologous blood pleurodesis in their management.

Materials and methods

This prospective study was conducted in the Department of Thoracic Surgery, NIDCH, Dhaka, Bangladesh, from 15 May 2022 to 30 June 2023, including 176 patients with spontaneous pneumothorax requiring chest tube drainage. Patients were divided into PAL (Air leak >5 days, n=88) and non-PAL groups (Air leak ≤5 days, n=88). Inclusion criteria were age ≥18 years, primary or secondary spontaneous pneumothorax and chest tube treatment. Exclusion criteria included traumatic/iatrogenic pneumothorax, active infection or malignancy, prior pleurodesis or thoracic surgery, immunosuppression or refusal to consent.

Data collected included age, sex, smoking, BMI, COPD, previous pneumothorax, lung collapse, bullae on CT, chest tube size, re-expansion time, air leak and tube duration, and suction use. PAL patients received pleurodesis after conservative management: ABP (50–100 mL autologous blood, 2-hour clamping) or tetracycline (500 mg in 20 mL saline). Outcomes assessed were air leak resolution, chest tube removal, hospital stay, 30- and 90-day recurrence, and complications. Ethical approval and informed consent were obtained. SPSS v26 was used for analysis; continuous data were mean ± SD, categorical as frequencies/percentages, compared using t-test, chi-square, or Mann–Whitney U. Multivariate logistic regression identified independent PAL predictors; $p \leq 0.05$ was significant. Ethical clearance was obtained from the institutional review board and all participants provided written informed consent before enrollment.

Results

A total of 176 patients were included, evenly split into PAL and non-PAL groups (n=88 each). The PAL group was older (52.6±10.8 vs. 48.3±11.2 years) and predominantly male (98.9% vs. 93.2%). Smoking history was higher in PAL patients (76.1% vs. 59.1%, p=0.018) while mean BMI was lower (19.6±2.7 vs. 21.3±2.5 kg/m², p=0.005). Comorbid COPD was more common in PAL patients (70.5% vs. 44.3%, p=0.001). (Table I). Radiologically, PAL patients had greater lung collapse (>50%, 68.18% vs. 43.18%, p=0.002) and more bullae on CT (63.64% vs. 37.50%, p=0.001). They required larger chest tubes (32.0±0.0 vs. 28.0±2.0 Fr, p<0.001) and had longer lung re-expansion times (3.6±1.8 vs. 2.1±1.0 days, p<0.001) (Table II). Table III showed PAL patients had longer air leak (4.1±1.7 vs. 1.8±0.7 days) and chest tube duration (3.93±2.45 vs. 2.12±1.04 days, p<0.001) higher suction use (70.5% vs. 32.95%) and all required intervention (100% vs. 13.64%). Table IV identified BMI <20 kg/m² (OR 2.94), COPD (OR 2.72) bullae on CT (OR 2.59) and lung collapse >50% (OR 2.87) as independent predictors of PAL. In PAL patients receiving ABP or tetracycline pleurodesis (n=44 each) ABP shortened air leak cessation (2.4±1.3 vs. 3.6±1.7 days, p=0.003) and had fewer minor complications (4.5% vs. 59.1%, p<0.001) (Table V). Table VI presented longer hospital stay in PAL patients (13.58±4.4 vs. 6.82±2.75 days, p<0.001). Recurrence at 30 and 90 days was higher in PAL (5.7% and 7.9%) but not statistically significant.

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Table I Baseline Demographic and Clinical Characteristics of Patients (n=176)

Characteristics	PAL (n=88) Frequency (n)	PAL (n=88) Percentage (%)	Non-PAL (n=88) Frequency (n)	Non-PAL (n=88) Percentage (%)	p value
	Age (Years)				
Mean ± SD	52.6 ± 10.8		48.3±11.2		0.019
Gender					
Male	87	98.86	82	93.18	0.092
Female	1	1.14	6	6.82	
Smoking history	67	76.14	52	59.09	0.018
	BMI (kg/m²)				
Mean ± SD	19.6±2.7		21.3±2.5		0.005
COPD	62	70.45	39	44.32	0.001
Previous pneumothorax	17	19.32	9	10.23	0.09

Table II Radiological and Procedural Findings (n=176)

Findings	PAL (n=88) Frequency (n)	PAL (n=88) Percentage (%)	Non-PAL (n=88) Frequency (n)	Non-PAL (n=88) Percentage (%)	p value
Pneumothorax side (Right)	49	55.68	46	52.27	0.686
Lung collapse >50%	60	68.18	38	43.18	0.002
Bullae on CT	56	63.64	33	37.50	0.001
	Chest tube size (Fr)				
Mean ± SD	32.0±0.0		28.0±2.0		<0.001
	Time to lung re-expansion (Days)				
Mean ± SD	3.6±1.8		2.1±1.0		<0.001

Table III Duration and Management of Air Leak (n=176)

Parameters	PAL (n=88) Frequency (n)	PAL (n=88) Percentage (%)	Non-PAL (n=88) Frequency (n)	Non-PAL (n=88) Percentage (%)	p value
	Duration of air leak (Days)				
Mean ± SD	4.1±1.7	1.8±0.7	<0.001		
	Chest tube duration (Days)				
Mean ± SD	3.93±2.45		2.12±1.04		<0.001
Use of suction	62	70.45	29	32.95	<0.001
Intervention needed	88	100.00	12	13.64	<0.001

Table IV Predictors of Persistent Air Leak (Multivariate Logistic Regression) (n=176)

Variables	Adjusted OR	95% CI	p value
BMI <20 kg/m²	2.94	1.32–6.54	0.008
COPD	2.72	1.35–5.49	0.005
Bullae on CT	2.59	1.24–5.43	0.011
Lung collapse >50%	2.87	1.42–5.82	0.003

Table V Outcomes of Autologous Blood Pleurodesis (ABP) in PAL Patients (n=176).

Outcomes	ABP Group (n=44) Frequency (n)	ABP Group (n=44) Percentage (%)	Tetracycline Group (n=44) Frequency (n)	Tetracycline Group (n=44) Percentage (%)	p value
Resolution of air leak	42	95.45	39	88.64	0.361
Time to air leak cessation (Days)	2.4±1.3		3.6±1.7		0.003
Time to chest tube removal (Days)	3.65±2.93		4.20±1.91		0.312
Recurrence within 30 days	1	2.27	4	9.09	0.361
Minor complications	2	4.55	26	59.09	<0.001

Table VI Hospital Stay and Recurrence Rates (n=176)

Outcome	PAL (n=88) Frequency (n)	PAL (n=88) Percentage (%)	Non-PAL (n=88) Frequency (n)	Non-PAL (n=88) Percentage	p value (%)
	Length of hospital stay (Days)				
Mean ± SD	13.58±4.4		6.82±2.75		<0.001
Recurrence within 30 days	5	5.68	1	1.14	0.213
Recurrence within 90 days	7	7.95	2	2.27	0.089

Discussion

Persistent air leaks represent a challenging complication in spontaneous pneumothorax, with varying etiologies and clinical presentations that significantly impact management strategies.[15] This prospective analysis highlights key demographic, clinical, radiological, and procedural predictors of Persistent Air Leak (PAL) in Spontaneous Pneumothorax (SP) and evaluates the efficacy of Autologous Blood Pleurodesis (ABP) compared to tetracycline pleurodesis. In our study the PAL group were significantly older (p=0.019) with lower BMI (p=0.005) higher prevalence of COPD (p=0.001) and a more frequent smoking history (p=0.018). These findings align with prior studies where aging lung parenchyma, nutritional status and smoking-related lung damage—especially COPD—were identified as predisposing factors for delayed healing and alveolar-pleural fistula formation.[16,17] The association of low BMI with PAL is consistent with Drewbrook et al. who found that underweight status impairs tissue healing and predisposes to prolonged leaks.[18] Radiological assessments revealed that the Persistent Air Leak (PAL) group exhibited a significantly higher prevalence of bullae on Computed Tomography (CT) scans (p=0.001) and more frequent lung collapse exceeding 50% (p=0.002). These results mirror the previous studies which showed that large bullae and greater collapse extent impair visceral pleural apposition, increasing the likelihood of prolonged air leaks.[7,19] Additionally, larger chest tube sizes and delayed re-expansion in PAL patients (p<0.001 for both) suggest a more severe parenchymal compromise and the need for more aggressive drainage strategies.[9] PAL patients had significantly prolonged air leak duration (4.1±1.7 vs. 1.8±0.7 days), extended chest tube use (3.93±2.45 vs. 2.12±1.04 days), and higher suction requirement (70.45% vs. 32.95%,

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p<0.001). This aligns with the study of Lazarus et al. that PAL increases intervention needs, hospital costs, and patient morbidity.[20] Multivariate analysis identified BMI <20 kg/m² (OR 2.94) COPD (OR 2.72) bullae (OR 2.59) and lung collapse >50% (OR 2.87) as independent predictors of PAL. These are consistent with previous studies which showed pre-existing lung pathology and anatomical distortion from bullae were found to independently prolong leak duration.[7,18,21] The therapeutic efficacy of Autologous Blood Patch Pleurodesis (ABP) was comparable to that of tetracycline, achieving resolution rates of 95.45% and 88.64%, respectively (p=0.361) but superior in faster air leak cessation (2.4±1.3 vs. 3.6±1.7 days, p=0.003) and markedly lower complication rates (4.55% vs. 59.09%, p<0.001). These findings echo the experience of Apilio ullar et al. who described ABP as a safe and effective bedside method that avoids the pain, fever and systemic symptoms often associated with chemical agents.[22] Our study showed PAL significantly prolongs hospitalization (13.58±4.4vs. 6.82±2.75 days, p<0.001) although recurrence rates at 30 and 90 days did not reach statistical significance. Still, the numerical trend toward higher recurrence in the PAL group supports close post-discharge monitoring. The shorter hospital stays with ABP support its practical advantage, especially in resource-constrained settings.[7,23]

Limitations

This single-center study may limit generalizability across populations and healthcare settings. The sample size, though adequate, restricted subgroup analyses. Variations in timing and volume of autologous blood pleurodesis were not standardized, possibly influencing outcomes. Follow-up beyond 90 days was lacking, limiting late recurrence assessment. The observational design may also introduce selection bias.

Conclusion

Persistent air leaks in spontaneous pneumothorax are linked to low BMI, COPD, bullae, and extensive lung collapse, leading to longer leaks and hospital stay. Autologous blood pleurodesis matched tetracycline in efficacy but achieved faster leak cessation with fewer complications. It is a safe, effective, minimally invasive option, especially for patients unfit for surgery or in resource-limited settings. Early risk factor recognition and timely ABP can improve outcomes and reduce healthcare burden.

Recommendation

Autologous blood pleurodesis should be considered a preferred option for managing persistent air leaks in spontaneous pneumothorax due to its safety, faster resolution and fewer complications. Early identification of risk factors such as low BMI, COPD, bullae and extensive lung collapse can help optimize patient outcomes.

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Contribution of authors

DH-Conception, acquisition of data, manuscript drafting, data analysis & final approval.

MAR-Data analysis, manuscript drafting & final approval.

MRC-Design, acquisition of data, manuscript drafting & final approval.

MHS-Acquisition of data, drafting & final approval.

MKH-Acquisition of data, data analysis, interpretation of data & final approval.

SB-Data analysis, manuscript drafting, critical revision of content & final approval.

Disclosure

All the authors declared that there is no conflict of interest.

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